出國報告（出國類別：其他）

環保署 105 年參訪德國及荷蘭「循環型社會」活動

服務機關：行政院環境保護署
姓名職稱：李應元署長、陳鴻達簡任秘書、陳世偉執行秘書、魏盟巽組長、宋欣真簡任技正、倪炳雄簡任技正兼副執行秘書、許永興技監兼執行秘書、蔡蓬培簡任技正、吳盛忠處長、李宜樺科長、何春玲專員
派赴國家：德國、荷蘭
出國期間：105 年 9 月 03 日至 105 年 9 月 10 日
報告日期：105 年 11 月 30 日

摘要

此次拜會德國西法倫邦環境廳與荷蘭基礎建設與環境部，兩方皆對去年歐盟的循環經濟套案進行相關事務推動，其中綠色協定(Green Deal)促進公私部門間結合，是我方頗注重的項目。如荷蘭對所有 WtE 廠(Waste to Energy)的焚化底灰的協定為：在西元（下同）2017 年減少 50％ IBC(應用焚化底灰成分的工程，需加上包覆工程避免滲出)的應用，到 2020 年完全停止 IBC 的應用，亦即所有處理後的焚化底灰都可 100％應用於一般工程中，不須特別處理。在工業循環實務部分，參觀了 REMODIS 集團旗下的 Lippe Plant 資源回收中心、Erfstadt 燃料客製化廠，以及 REMEX 焚化底灰篩分後再利用廠，以及 Inashco 公司的焚化底灰篩分再利用廠，以 ADR(Dry Ballistic Separation)技術為主。參訪重點在於瞭解金屬回收、再生粒料製造與化石燃料替代等主題，以利國內推動資源循環實務參考。在生物循環實務部分，參觀了 Refood 的食物廢棄物收集系統與處理廠, HoStBioEnergy Installation 的農業廢棄物厭氧消化處理廠，與 Waternet 的下水污水處理再生與磷回收。參訪重點在於瞭解歐洲生質物的處理，以及後續如何回收其中重要元素與產生如生質氣、生質甲烷或直接發電之技術。由於歐洲禁止食物廢棄物做成飼料，故歐洲的生質物處理多是以如厭氧消化技術處理後，產生能源或燃料為主。

目錄

圖目錄

一、內容摘要

(一)目的

遵依蔡總統環保政策指示及行政院核定本署施政方針：「推動將廢棄物轉換為再生資源，建立資源循環型社會，逐步達成資源循環零廢棄目標」辦理。

目前各國推動循環型經濟推動模式，已逐漸著重於跨部門合作，整合各處資源，藉由參訪瞭解政府於循環經濟推動可扮演之角色，利於本署參考。

參訪主題包括：1.畜牧業廢棄物的厭氧發酵發電 2.底渣、爐石或污泥的處理與再利用 3.再生粒料與海事工程應用等工作，期藉由本次參訪，瞭解荷蘭及德國的處理與做法，俾供本署未來施政參考。

(二)出國期間及主辦單位(行程紀要)

日期	工作內容概要
9 月 03 日	啟程前往阿姆斯特丹
9 月 04 日	會面外交部駐荷與駐德代表處人員
9 月 05 日	上午：參訪 Refood 都市廚餘資源化方案(Marl)
	下午：參訪都市固體廢棄物分選,客製化燃料廠(Erftstadt)
9 月 06 日	上午：前往 Lunen，參訪 Lippe Plant，並進行資源回收處理過程技術討論與交流會議
	下午：拜會德國西法倫邦環境廳
9 月 07 日	上午：參訪 REMEX 底渣處理場(荷蘭)

	下午：參訪 HoSt Bio-Energy Installations (Den Bommel, 鹿特丹)
9 月 08 日	上午：拜會荷蘭建設環境部(海牙)
	下午：Inashco (Boskalis 共同與會) (鹿特丹)
9 月 09 日	上午：參訪 Waternet 阿姆斯特丹污水處理廠
	下午：荷蘭阿姆斯特丹返回台北
9 月 10 日	抵達臺北

二、過程

本次參訪行程含括三個主題：德荷政府循環經濟因應作法，以及循環經濟之工業循環與生物循環實務作法。

圖 1 德荷政府考察項目與內容

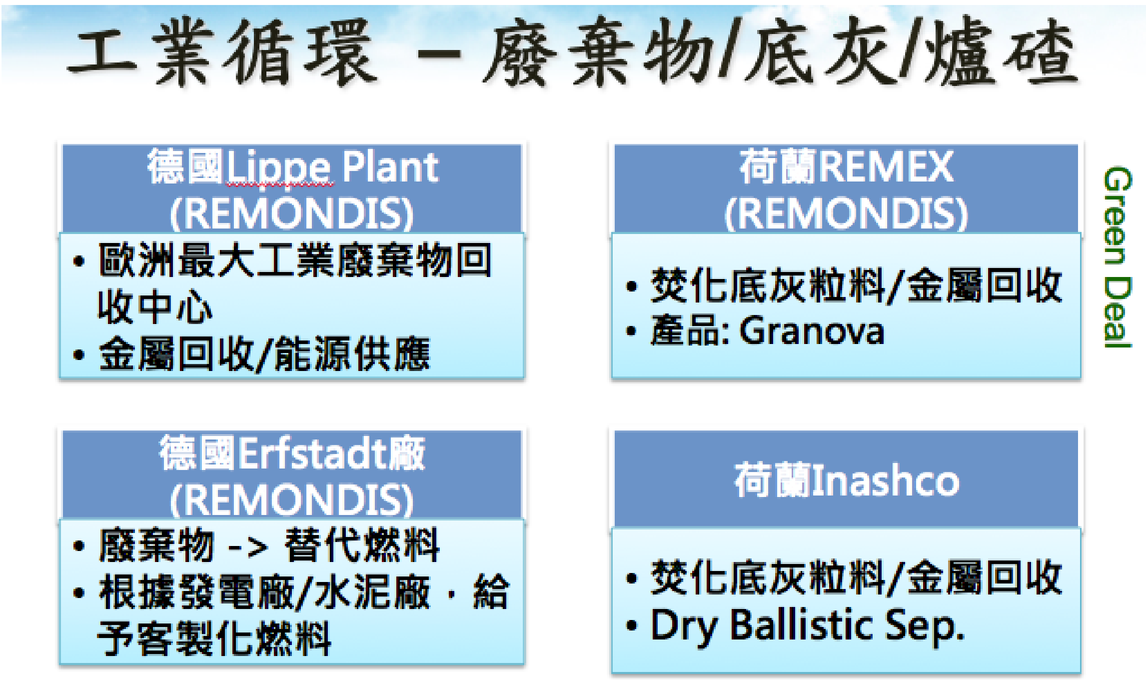

圖 2 工業循環考察項目與內容

圖 3 生物循環考察項目與內容

(一)德荷政府循環經濟因應作法

此次拜會德國西法倫邦環境廳，以及荷蘭基礎建設與環境部，兩方皆對去年歐盟的循環經濟套案進行相關事務推動，其中綠色協定(Green Deal)促進公私部門間結合，是我方頗注重的項目。如荷蘭對所有 WtE 廠(Waste to Energy)的焚化底灰的協定為:在 2017 年減少 50% IBC(應用焚化底灰成分的工程，需加上包覆工程避免滲出)的應用，到 2020 年完全停止 IBC 的應用，亦即所有處理後的焚化底灰都可 100%應用於一般工程中，不須特別處理。

1. 德國北萊茵--西法倫邦環境廳

德國北萊茵--西法倫邦環境廳，主要與我方討論廢棄物管理如何轉向循環經濟。北萊茵--西法倫邦人口約 1 千 800 萬人，境內亦有許多工業與製藥業公司，過去的廢棄物管理與我國類似，以 3R 為主，以源頭減量為先。廢棄物處理上，2005 年德國推出一條法令，所有廢棄物都須處理，不可存在有機物，以減少掩埋時甲烷的產生。目前廢棄物成分，有 43%是家戶產生的有機物，29%為紙板，12%為輕包裝。目前有機垃圾於總垃圾產出的分離量為每人每年 109 公斤，希望未來在 2021 年達到 150 公斤的目標。該邦對於循環經濟的呼應，正針對設計、消費、商業模式與二次使用等環節積極討論中，過去的廢

棄物處理已奠基不錯基礎。會議中對於邦內的焚化設施進行討論，該邦有 16 座焚化廠，每年處理約 600 萬噸垃圾，有 60 座有機廢棄物處理設施，其收費標準約每人 94.39 歐元，含垃圾車清運費用與木質廢棄物清運費用。廢棄物的處理仰賴地方自治，地方自行制定收費與管理細節。

圖 4 與德國北萊茵西法倫邦會後留影

2.荷蘭基礎建設與環境部

荷蘭基礎建設與環境部由 2014 年起，推動第一階段「由廢棄物變資源」(From waste to resource)，目標在於十年內，將焚化量由 1,000 萬噸減少為 5 萬噸，家戶垃圾在 2020 年要達到 75%回收率，每人每年垃圾產生量不超過 100 公斤，最終希望達成零廢棄目標。

荷蘭基礎建設與環境部為達前述目標，有三項重點工作：1. RACE-coalition: 包括循環設計、高品質再使用(high quality reuse)、盤點障礙(Inventory obstacles)、最佳實務操作(best practices)等; 2. 降低法規障礙(reducing legal barriers)：包括廢棄物終止認定、化學品回收、副產品與廢棄物認知等; 3. 綠色協定(Green Deal)：以公私部門合作方式，促進資源使用效率。此部分可納入署內制定永續物料管理或廢棄物管理相關政策時參考。

荷蘭基礎建設與環境部另外也報告了因應歐盟循環經濟的進度，其循環經濟潛力包括藉由資源節省而達每年73億歐元的經濟效益，創造超過 5 萬 4,000 個工作機會，每年減少 1 仟 7,00 萬噸的溫室氣體。其願景在於 2050 年達到循環經濟目標，澈底改變經濟系統，作

法為利用政府干預以克服各種障礙，如利用法規、利用市場工具減少環境負面效應、引進專業以消弭知識落差、減少不符循環型態之行為、缺乏物料鏈協調性(lack of coordination within material chains)，以及有技巧的製造私部門誘因以引導投資效益，以及由政府觀點影響國際影響力等。其中優先的部門包括生物質(Biomass and food)、塑膠、製造業、建築業、以及消耗性貨品部門(consumption goods)。國內的對應部門相關資訊，包含於永續物料管理資料庫與系統工具，可再進一步分析。

圖 5 與荷蘭建設與環境部會後留影

(二)工業循環實務作法

此次在工業循環實務部分，參觀了 REMODIS 集團旗下的 Lippe Plant 資源回收中心、Erfstadt 燃料客製化廠，以及 REMEX 焚化底灰篩分後再利用廠，以及 Inashco 公司的焚化底灰篩分再利用廠，以 ADR(Dry Ballistic Separation)技術為主。參訪重點在於了解金屬回收、再生粒料製造與化石燃料替代等主題，以利國內推動資源循環實務參考。

1. Lippe Plant

Lippe Plant 為歐洲最大工業廢棄物資源回收中心，工廠占地 230 公頃，有 1,400 名員工，1993 年以來共投資 40 億歐元。每年進料 1.6 百萬噸，出廠產品約 1.1 百萬噸，產生 3 億度(KWh)的電力與蒸

汽。廠內處理方式包括廢電子電器回收、廢木材回收、鋁渣回收等，其產品皆申請專用名稱，如 ALUMIN(鋁酸鈉), CASUL(白色礦物，用在顏料或紙張), PLANOLEN(建築用接著劑), HUMERRA(堆肥後產品), ecoMotion(生質柴油)等，並符合高品質標準。

圖 6Lippe Plant 中待處理底灰

圖 7 自動堆肥場、採負壓方式防止臭味

2. Erfstadt 燃料客製化廠

Erfstadt 燃料客製化廠，收集城市垃圾、大型廢棄物、商業廢棄物與工業廢棄物四類，每年約 145,000 噸，其中產出焚化用碎片約占 39%，燃料約占 36.5%，惰性成分物質 5%，可回收物質約 3.5%，非鐵金屬約 5%，雜質約 0.5%，腐植流失約 15%。透過整合風選、近紅外線的分選設備，主要產品分為三類：SBS(供給發電站的替代燃料、氯含量控制在 0.5-0.7%)、BioBS(供給發電站、氯含量控制在 0.4%)、BPG(供水泥廠使用、氯含量控制在 1.0%以下)。該廠會視通路需求，客製化適合之燃料，是其特點。我國曾發展 RDF，若能將客製化以通路觀點為主的方式作調整，應可提高使用性。

圖 8Erfsdat 分選設備一隅

圖 9 進場車輛需先過磅

圖 10 紙張塑料暫存區

圖 11 暫存區，進料前分類儲存

圖 12 消防設施一隅，該廠十分注重消防安全

圖 13 該廠採負壓廠房，以避免污染往外逸散

圖 14 垃圾破碎篩分分為大中小三類，大為高熱值塑膠，小為高有機成分，後分別輸送至磁選、風選、渦電流分裝置

圖 15Titechpolysort 分離 PVC

3. REMEX 焚化底灰篩選廠

REMEX 焚化底灰篩選廠，每年進料 65 萬噸焚化底灰，利用篩選、磁選、渦電流分選、風選、人工分選的整合性系統，產出焚化底灰再生粒料產品 Granova，其品質為自由使用，且可基於工程需求，再進行產品製作，符合歐盟土壤標準(SQD)，其獲利方式主要為回收的金屬價值，一年可回收 5 萬噸。

圖 16 REMEX 底灰篩選設備一隅

4. Inashco

Inashco 亦為焚化底灰篩選廠，整個集團每年處理 500 萬噸焚化底灰，荷蘭部分處理 30 萬噸(由當地的 AEB 焚化廠而來)。Inashco 公司主要是透過複合式分選飛灰或底渣廢棄物，達到全資源化的目標，其關鍵技術主要是透過慣性分離（又稱彈道分離）改良傳統小於 12mm 廢棄物不易透過渦電流分選之缺點。

Inashco 根據底灰的處理潛力(包括數量、金屬含量、金屬組成)、品質(Bottom/Boiler/Fly ash、水分、不可燃物比例、污染物比例)與最終處置需求(Disposal requirements)，利用不同底灰分離處理策略(包括 Dry conventional, Dry ballistic, Wet separation 三類)，客製化出不同產品，並也簽訂綠色協議(Green Deal)。在討論時問荷蘭政府是否有特別補助，回答穩定的政府執政方向、穩定的政策，對他們公司而言是最重要，不需特別補助。另外 Boskalis 為 Inashco 的合作廠商，利用 Inashco 的底灰分離技術進行土壤清洗進行復育，每年處理 4 千萬噸的土壤。

Inashco 的技術如圖 17 所示，透過初篩與磁選後，進入主要的分離策略：a. 傳統乾式分離(Conventional Dry Separation)、b. ADR(Dry Ballistic Separation)分離、c. 濕式分離(Wet Separation)。在傳統乾式分離後，會再透過渦電流分選方式，將非鐵金屬初步篩出，之後到下游去提升非鐵金屬的純度，再交由 Inasho 的協力公司 Fondel 進行販賣。

ADR 分離是一項特別的技術，係利用高速轉盤結合輸送帶使廢棄物顆粒產生水平方向之運動，因不同大小、密度及幾何形狀之粒子受重力、空氣摩擦阻力雲運動過程將形成各種二維曲線之拋物線運動軌跡，在相同之垂直落下距離條件下，將產生不同之水平移動距離，並配合磁選及乾、濕分離，產生骨料（石料，玻璃，陶瓷）、非鐵有色金屬、及鐵金屬，後端則使用渦電流將重/輕非鐵金屬分類為鋁及銅鉛鋅等 2 類，而達到分離之效果。可進一步分離出底灰中其他的非鐵金屬，以及磁選未分離出的鐵金屬。

剩下的部分透過濕式分離技術，以及法規要求，處理為適合的粒料品質進行販賣。根據 Inachso 與其他廢棄物能源轉換中心(WtE)跟荷蘭政府簽訂的綠色協定，需在 2017 年替代原來 50%的 IBC(底灰應用工程)為 IBAA(焚化底灰粒料)，2020 年則為100%。其中，超過 6mm 的非鐵金屬需達 75%回收率。

總結而言，Inashco 公司的底灰處理技術以 ADR 最為特別，其重點在於操作參數的校調，國內如要引進底灰處理技術，可根據我國底灰特性，整合考量 Inashco 與前述德國技術的搭配。

前述提及 Boskalis 利用 Inashco 技術進行土壤復育，與荷蘭相關政策有關，本報告在此略述荷蘭土壤復育相關情形。荷蘭是歐盟成員國中最早就土壤保護立法的國家之一，於 1970 年就著手起草《土壤保護法》。政府並規定"土壤改善"目標值和啟動值。目標值表示低於或處於這個水準的土壤具備人類、植物和動物生命所需的全部功能特徵，土壤品質是優良；啟動值表示超過這個水準的土壤，其具備的人類、植物和動物生命所需的功能特徵已經被嚴重破壞或受到嚴重威脅，必須接受強制改善。荷蘭所有受污染的土壤中，90%的土壤納入可持續管理。

國土面積 4.5 萬平方公里的荷蘭，每年要花費 4 億歐元用於近 2,000 個污染場地的管理，其"土壤污染改善"技術也日趨成熟，目前主要分為"現地改善"和"離場改善"兩大類。現地改善是指在不挖土、運土情況下，採用直流電對重金屬等污染物進行提取和處理，或採用交流電來加熱土壤和地下水，使難溶污染物迅速溶解或汽化，或通過向被污染土壤內層注入強氧化劑，使有機污染物與強氧化劑接觸發生化學反應產生水、二氧化碳等無毒無害物質，直接改善受污染的土壤。這些方法適用於建築物下方、人口密集地、醫院等敏感區域等特殊場所。

離場改善是將受污染土壤挖出後轉移至臨時場所，用熱處理、清洗、生物處理、固化處理和填埋等化學和物理方法進行改善，可應用於任何土壤類型。

荷蘭不提倡填埋處理，填埋處理只適用於處理成本高、技術上難以處理的土壤，而且還要徵收每噸 17 歐元的稅。因此，荷蘭土壤改善多採用熱脫附、清洗或生物處理等處理技術。

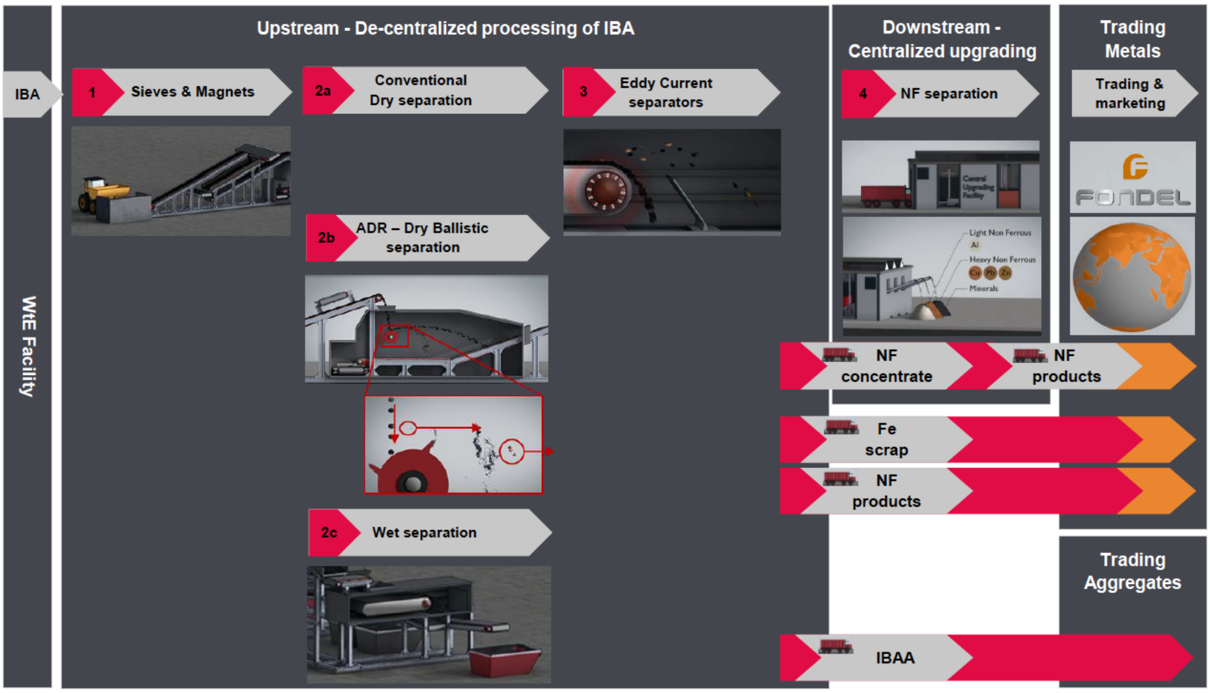

圖 17Inashco 技術簡圖

圖 18Inashco 金屬回收成品

(三)生物循環實務作法

此次在生物循環實務部分，參觀了 Refood 的食物廢棄物收集系統與處理廠, HoStBioEnergy Installation 的農業廢棄物厭氧消化處理

廠，與 Waternet 的下水污水處理再生與磷回收。參訪重點在於瞭解歐洲生質物的處理，以及後續如何回收其中重要元素與產生如生質氣、生質甲烷或直接發電之技術。由於歐洲禁止食物廢棄物做成飼料，故歐洲的生質物處理多是以如厭氧消化技術處理後，產生能源或燃料為主。

先進國家厭氧消化技術成熟，有機廢棄物(廚餘/農業廢棄物/過期食品/廢食用油等)經由厭氧消化技術成功轉化為能源產品，有效解決此類廢棄物處理去處並減少碳排放,為廢棄物能資源化及推動循環經濟最佳示範。

1. Refood

Refood 在德國共有 18 個回收中心，此次參訪的 Refood 所在地，與鄰近的厭氧消化廠以及肉品處理廠結合為一個合作系統，收集方圓 150 公里範圍內的食物廢棄物，每年處理 5 萬 7,000 噸廠商提供的食物廢棄物，包括 54,500 噸廚餘及 2,300 噸廢食用油。收集系統包括了 50 輛卡車，每個月處理 5 萬 8,000 個收集桶，收集桶包括收集包裝後或未包裝的食物(120 與 240 公升兩種尺寸)，以及廢食用油收集(有防臭處理)兩種，清運量能可達 58,000 桶/月及 2,500 桶(廢食用油)。

料源分為五大類型，包括生熟廚餘、果菜殘渣、麵包、過期食品肉品骨頭、屠宰下腳、廢食用油及食品加工業有機廢棄物，如下圖：

圖 19 處理種類

收集過程包括收集桶清洗、貨車消毒、乾燥等，令食物廢棄物的收集過程令人感到清潔且不產生異味，且每次收集資訊皆會上傳給政府單位；而處理過程包括粉碎、加熱、滅菌等過程，廠房通過 ISO 9001 與食品安全管制系統(HACCP)標準。而後送到隔壁的厭氧消化廠處理。處理後的產品可有肥料、燃料，要看當地的需求，有不同因應方式，此次參訪地點，隔壁的厭氧消化廠有 1.5 百萬瓦(MW)與 1.6 百萬瓦(MW)兩個發電系統，可作為進料數量波動時的調節，其可產生的電力約可供 5 萬 6,000 用戶使用，每年約產生 1,114 萬度電。沼渣與沼液可提供鄰近農田使用。

圖 20Refood 收集系統一隅

因應不同客戶端，該公司廚餘收集桶採三種規格：

型一　120 公升一般餐飲業客戶使用

型二　240 公升大型餐飲業超市或食品加工業客戶端使用

型三　90 公升廢食用油專用

其中 90 公升廢食用油專用回收桶為一特色，除頂蓋加裝鎖扣裝置防止液漏外，材質耐熱 90 度採半透明，方便客戶辨視液位，詳如下圖：

圖 21Refood 廢食用油專用收集桶

該公司進料收集過程建立一完善標準作業程序，從客戶端收集廚餘回收桶→登錄→卡車運送→進廠→洗桶→風乾→空桶配送，確保廚餘收集運送過程達到最高衛生標準，並確保空桶送至客戶端時，不會有異味或髒污的情形，如下流程圖：

圖 22 廚餘回收桶清洗情形

進廠廚餘傾卸進料後，先經(1)破碎程序，再(2)除去雜物，將無法消化之塑膠金屬骨頭木屑等分離出，此部分即所謂 Bio-Separation 過程，將有機物與無機物分離，經(3)70°C/1 小時加熱衛生除菌化，去除有機物中會影響厭氧消化進行的雜菌，再進行(4)除油程序，將油脂部分分離，再進入(5)酸化調整槽(約 7 天容量 pH3.6)，再持續打入(6)厭氧消化槽(容量 3,400m^3)，產出沼氣經(7)除硫程序後，送入(8)CHP 系統發電，消化槽內(9)沼液另有收集系統供作農業用途(土壤肥分改良)，廠內處理流程如下圖：

圖 23 主要處理程序圖

有機物進消化槽之前，係透過前處理(酸化)槽調控，約可容量 7 天進料量，以連續式供應主消化槽所需。

主消化槽容量 3,400m^3，槽體內設有攪拌裝置以維持消化程序均勻，槽內溫度維持 42°C 屬中溫消化，消化過程定期監測槽內 pH 值及固形物含量，以掌控厭氧消化情形，產出甲烷濃度約 58%，消化時間平均 35 天。槽內沼液及沼渣另有管線排出收集。

業者表示，每噸進料消化後約可產出 90~110 m3 甲烷，主消化槽外觀如下圖:

圖 24 厭氧消化槽外觀與基本資料圖說

廠內設置沼氣發電機 2 組，裝置容量分別為 1.5 百萬瓦(MW)及 1.6 百萬瓦(MW)，採一大一小設計，總發電量 1272Kw/h(度)換算年最大發電量約 1,114 萬度/年，足供應 56,000 戶家庭用電。

售電收益部分，業者表示德國每度收購電價 0.09 歐元(折新臺幣 3.24 元/度，較國內 3.6~3.7 元/度為低) ，如以每年最大發電量 1,114 萬度/年估算,售電收益最高新臺幣 3,610 萬元/年，以年處理量換算每噸廚餘發電量約 195.5 度。

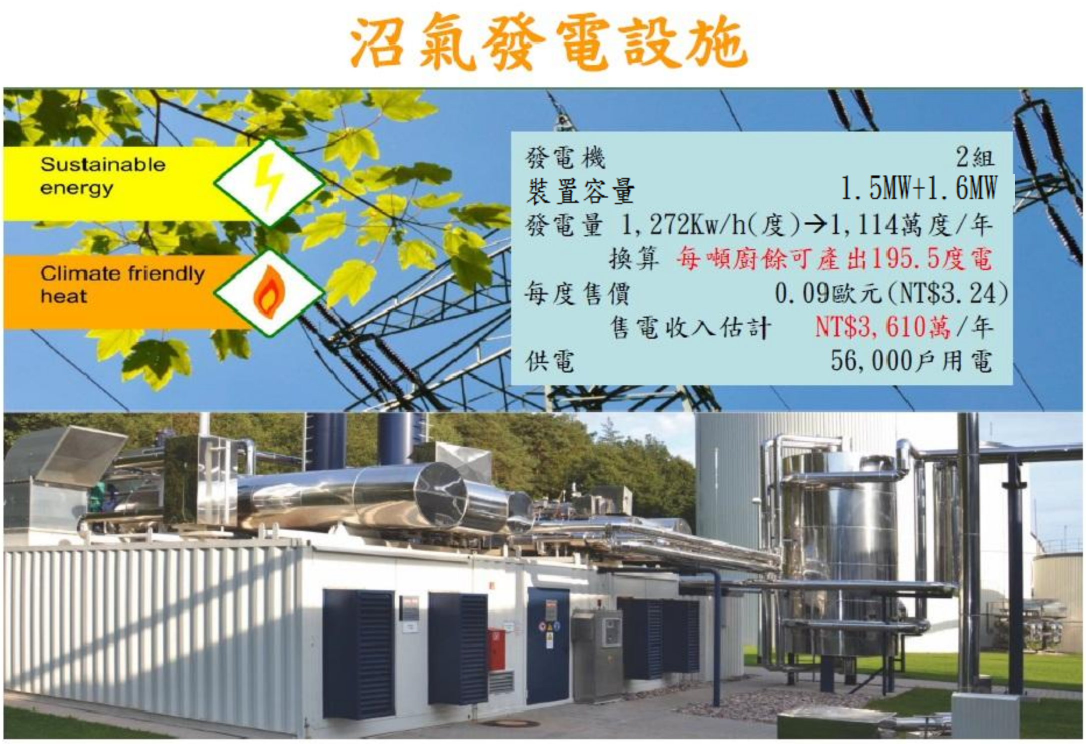

圖 25 沼氣發電設施外觀與基本資料圖說

最後總結收益與產出：

1. 廚餘委託處理費(依種類及數量不同收費標準)
2. 沼氣發電:售電收益最高可達 NT$3,610 萬元/年
3. 生質燃料：收受廢食用油及廚餘除油程序產出，經初煉程序後，售予後端生質燃料業者。
4. 沼液:產量 2.3 噸萬/年，免費供農業土壤肥分改良使用(用量平均 300 公斤/公頃)

由 Refood 參訪所總結的心得與建議如下：

1.本廠收受處理廚餘與廢食用油,油脂部分轉製生質燃料,其餘有機物厭氧消化產出沼氣發電(平均 195.5 度/噸),沼液提供農業土壤改良,為有機廢棄物能資源化最佳範例,亦與循環經濟推動精神相符。

2.因國情不同，本廠進場廚餘及廢食用油皆可收受處理費，因此減低業者操作營運成本，而沼氣發電售價，僅 0.09 歐元/度(折新臺幣約 3.24 元)，較國內生質能躉購費率(約 3.6~3.7 元/度)為低，業者表示，主要先滿足自己發電所需再考慮售電，

因此除電力自我供應與少量的售電收益外，尚需仰賴生質燃料收入，以提高經濟效益。

3.反觀國內，熟廚餘多數出售養豬，因此推動厭氧消化將面臨收購費用負擔，造成營運成本劇增，以售電甚至加上生質燃料收益，尚不足以抵銷營運成本，經濟效益明顯不足，因此，國內如推動厭氧消化，應以生廚餘(可收受委託處理費)為優先考量。

4.先進國家對廚餘厭氧消化技術與設備成熟，但國內處理對象如為生廚餘，非熟廚餘時，其消化菌種與操作條件將有所差異，所幸國內(例如成功大學)對生廚餘厭氧消化已累積數十年研究成果，應可配合國外設備與技術引進，推動設立生廚餘專用或其他有機物(如下水道污泥、農業污泥)共消化之厭氧消化設施，同時解決生廚餘處理去處問題並將廢棄物有效轉化為能源，同時減少碳排放並符合推動循環經濟精神。

5.另本廠收集廚餘所採之標準作業程序(包括容器/登錄/進料/清洗/空桶配送等)，以及廢食用油專用密封容器設計，亦值得國內借鏡參考。

2. HoSt Bio-energy installation

HoSt Bioenergy 亦是一厭氧消化廠，年處理量 5 萬噸，投資 800 萬歐元，預計 7 年回收，收受稻草/果菜渣(生廚餘)/超市過期食品為主，經厭氧消化後產出甲烷，廠址選擇臨近天然氣供應管線，沼氣經 90%純化後直接納入天然氣供應管線，免除成品運輸成本，其 7 年的回收年限頗令人欽羨。本廠沼氣薄膜純化專利技術，為另一特色。由於該廠鄰近土地肥力足夠，故其沼渣沼液不易利用，是較可惜之處，以下將介紹該廠的技術內容。

圖 26 儲槽與與純化系統一隅

本廠主要收受稻草/果菜渣(生廚餘)/超市過期食品，年處理量 5 萬噸，經厭氧消化後生產甲烷，主消化槽容量為 3,000m^3，後消化槽 2600m^3，每小時產氣量為 500m^3；除消化槽外，另有 6 個 150 立方米儲槽。本廠處理流程如下圖：

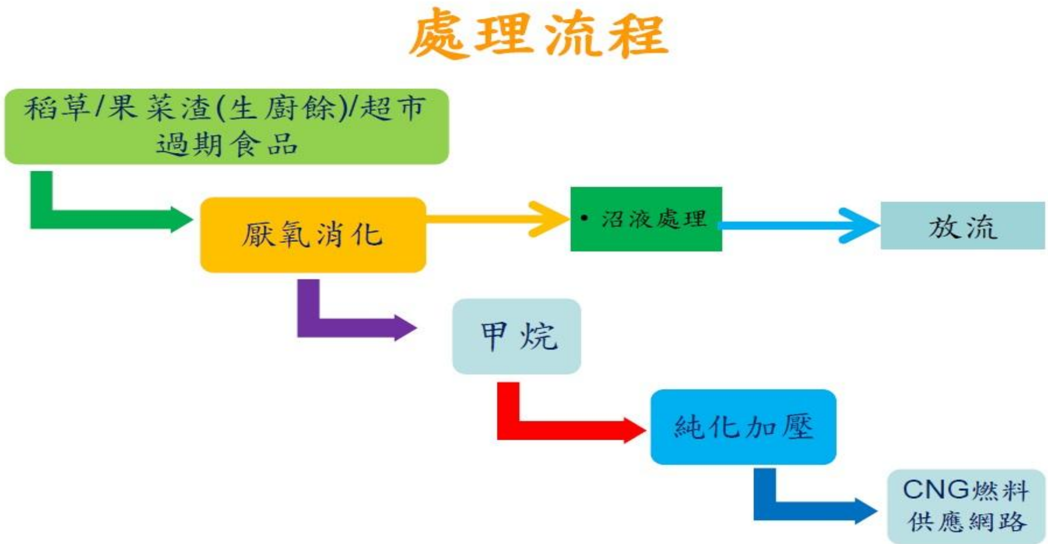

圖 27 處理流程圖

不同於德國 ReFood 廠沼氣發電方式，本廠進料經厭氧消化後，產出沼氣經由純化加壓設備，納入壓縮天然氣(CNG)燃料管網出售，為一特色。

與發電相較,純化後甲烷出售作為CNG燃料經濟效益較高，惟純化設施相對需投入經費，以本廠為例，此部分設備佔總投資將近三分之一。

另外，厭氧消化出之沼液，亦不同於德國 ReFood 廠，本廠消化槽產出沼液並未供作農業利用，而係處理至符合放流水標準後排放至附近水體，相關設施照片如後。

圖 28 沼液處理設備

圖 29 原料(稻草)堆置區

圖 30 廠方專業人員解說(後方為主消化槽)

本廠產出甲烷經純化後濃度達 90%，純化設施係採用該公司自行開發專利薄膜技術，設計處理能量每小時可達 $850m^3$，消化槽所產出濃度 55-60%之甲烷經純化處理後，濃度高達 90%以上，再經加壓之後，接到廠旁 CNG 燃料管網出售。

至於 CNG 輸送管線投資經費問題，該廠表示，當初廠址選擇時即以鄰近 CNG 管網為考量，因此省下產品運送與管線佈設經費，產品經濟效益極高。該廠表示，本廠總投資成本 800 萬歐元，預估營運 7 年可回本，投資報酬率甚高。

圖 31 沼氣薄膜純化設施外觀(設備置於三座貨櫃屋中)

沼氣純化加壓設備

圖 32 沼氣純化加壓設備

本廠參訪後其他心得與建議如下：

1.本廠收受稻草/果菜渣(生廚餘)/超市過期食品，經厭氧消化後產出甲烷，加上廠址選擇臨近 CNG 燃料供應管線，沼氣經 90%純化後直接送入 CNG 燃料供應管線，除成品運輸成本，創造最大經濟效益。

2.本廠甲烷純化後產品加壓直接送至供應管線，與傳統沼氣發電相較，經濟效益較高，年處理量 5 萬噸(每日平均137 噸),但業者投資 800 萬歐元成本,卻預估可於 7 年回收，堪稱生質物能源化最佳示範。

3.本廠沼氣薄膜純化專利技術，為另一特色，惟消化後沼液未作為農業用途，而經設備處理符合標準後逕行放流，為美中不足。

4.本廠不論從設置規模(每日 137 噸)，處理對象(生廚餘/過期食品/農業稻草)，處理技術(薄膜純化)到能源產品用途(燃料供應鏈)，均足以做為國內借鏡優先考量。

5.目前國內未設置垃圾焚化廠(如南投縣)或農業大縣(如雲林縣/彰化縣)，可優先考量設置推動.廠址選擇如能配合臨近工業區能源(甲烷燃料)需求或車用 CNG 燃料貯存供應站，應有足夠經濟效益吸引民間投資設置，同時解決農業稻草/生廚餘/過期食品處理問題，並提供能源貢獻，減少碳排。

3. Waternet Strategic Center

Waternet 以基金會運行，每年預算 4 億歐元，員工共 1850 位，受政府授權處理荷蘭各種水資源，範圍包括 1 千 200 萬居民，20 個直轄市，自來水每年供應 9,000 萬立方公尺，漏水率 2-3%；廢水處理每年 1 億 2,500 萬立方公尺，目前下水道接管率為 100%。此次討論的磷回收議題，主要是在解決污水處理廠與 AEB 廠(能源轉化廠)協作時，在汙泥脫水運送時所造成管路阻塞的磷酸銨鹽(Struvite 或 magnesium ammonium phosphate, MAP)，Waternet 不但解決此問題，且也將原來認為的阻塞物轉為可用的肥料，獲取資源。在討論中，我方也提出 20 年前也有除磷的處理經驗，但當時的時空背景下，磷問題不如現在重視，時至今日，我國有潛力處理類似問題，目前營建署正進行下水道污泥磷回收的示範計畫。

圖 33 與 Waternet 工作人員合影

三、心得

1.本次參訪德國北萊茵西法倫邦及荷蘭，其面積、人口、產業結構、廢棄物問題，皆有與我國相似之處，且對於廢棄物、能源轉化(減碳)與底灰資源再取得等議題，皆有系統化的推動方式，如以綠色協議促進底灰粒料的品質，重新檢視法規障礙等，我國可借鏡於如何系統性解決廢棄物及減碳的議題進行研析，惟仍兼顧我國特殊情況，如氣候多濕，颱風亦多，則露天處理情況需做調整。

2. 我國既有的廢棄物相關法規，尚未能有 Erfstadt 的未成錠之客製燃料販賣形式，過去國內政策常以補貼或獎勵方式進行，然而綠色協定較注重目標的設定與行政的穩定性，一旦推出是否造成企業的誤解，也需考量。

3.資金是經濟活動的血液，金融是支持經濟產業的動能。因此當我們希望經濟往綠色經濟與永續發展轉型時，我們的金融政策也應跟著調整。如何運用公私部門的資源進行綠色投資，並運用政府政策來克服綠色金融的障礙，以加速全球經濟的轉型，是當務之急。因為大型基礎建設以及工業投資都會對人們與環境帶來影響，若無法完全避免，至少也要儘可能降低，或是提出補償方案。由於減少污染、碳排放、廢棄物或提高資源使用效率與生物多樣性等等，都需要長期與穩定的投資。過去一些人希望公部門的預算，能扮演綠色投資的角色，但規模更大的民間部門則更為重要。因此如何讓政府的金融政策來動員民間資金，當作綠色投資的觸媒，同時調整相關法規來降低綠色投資的障礙，才能發揮最大的綜效。

4.本次拜訪的企業與廠商，皆優先對他們產品通路的需求作商業模式規劃，並引進高度技術或新建設備以兼顧處理的品質，如 Lippe plant、Refood、HoSt Bio-energy 的負壓系統，Refood 的收集運送的清洗系統與通過高度衛生標準的實驗室，REMEX 與 Inashco 於底灰篩選設備與技術的投資。相較於我國實驗室新技術與實廠操作間的過度階段，仍有待參考國外經驗以積極克服。

5.根據國內現況，若能於國內設立一大型且系統整合型的回收處理廠，如 Lippe Plant、Refood、Inashco 或 Waternet 的系統整合方

式，於後續通路再規劃與創造其商業獲利模式，並保留後續技術升級可能性，進行實廠規劃，亦是我國廢棄物管理逐漸提升為經濟循環建議解決方案之一。

6.國內如推動厭氧消化處理,應可針對生廚餘/過期食品/農業稻草，從料源供應(來源/收集成本)，厭氧消化技術本土化(菌種/操作條件)及能資源產品通路(售電/沼氣/熱能/純化燃料)進行較詳細評估後,規劃最具經濟效益之推動模式與設置區位，可望吸引國內業者結合國外先進技術，以促參方式成功推動一座處理量約 200 噸規模之示範廠環境污染、灌溉水污染、農業資材污染(農藥、肥料)、農畜牧水產生產環境污染以及農漁牧水產品污染間之關係複雜，攸關人民生活環境品質、食品安全及身體健康，應加強農委會、衛生署及環保署 3 者間的橫向聯繫，成立跨部會之專案小組，建立共同基線資料庫，方足以解決上市農業產品、農漁牧水產品生產環境及環境介質之上、中、下游聯串影響問題。

四、建議

1.推動主軸及願景

（1）「循環經濟」為國家整體發展方向，需中央部會、地方政府、產業、學術及民眾之共同配合。本署依權責將積極推動 2 大項重要工作：將以「永續物料」管理，作為國家循環經濟推動之重要基石；並致力推動「資源循環」策略，作為國家循環經濟推動之重要環節。

（2）國家推動「循環經濟」成果，亦可作為「永續物料」及「資源循環」推動之價值動力，互助互補，相輔相成；並透過各項新經濟效益，以創造經濟永續、環境永續及社會永續之「永續台灣」。

2.「循環經濟」方向：以「經濟」為觀點發展以下六大發展契機創造價值，成為可恢復且可再生的產業體系。

（1）重新設計(ReDesign)。

（2）循環加值(Circular Processing)。

（3）循環農業(Circular Agriculture)。

（4）封閉循環(Closing the Loop)。

（5）合作(Collaboration)。

（6）創新商業模式(Innovative Business Model)。

3.「永續物料」策略及措施：以涵蓋物料之生命週期思維管理模式，以「高自主」、「高效益」、及「高循環」，促進我國物料之「供給穩定」、「經濟發展」及「環境永續」。

（1）高自主：「物料高自主低依賴」。減少原生物料供應需求，提高再生物料利用。

（2）高效益：「生產高效益低消耗」。提高生產資源使用效益，以最少物料消耗創造最大價值(或附加價值)。

（3）高循環：「回收高循環低排放」。充分物料回收再生循環，減少環境影響衝擊。

4.生質能：國內 24 座垃圾焚化廠目前處理容量近飽和，國內有機廢棄物處理去處，除熟廚餘多數出售供養豬用途外，其他如生廚餘/農業稻草/過期食品/廢食用油等亦面臨處理瓶頸，應可優先考量推動厭氧消化設施解決之。國內如推動厭氧消化處理，應可針對生廚餘/過期食品/農業稻草，從料源供應(來源/收集成本)、厭氧消化技術本土化(菌種/操作條件)及能資源產品通路(售電/沼氣/熱能/純化燃料)進行較詳細評估後，規劃最具經濟效益之推動模式與設置區位，可望吸引國內業者結合國外先進技術，以促參方式成功推動一座處理量約 200 噸規模之示範廠。示範廠成功之後，未來進而將努力目標擴大到全部有機廢棄物(各類有機廢棄物初估每年約產出 400~500 萬噸)，除有效解決有機廢棄物處理，減低傳統能源依賴及減少碳排之外，可同時帶動相關產業與技術升級，將有機廢棄物生質能源化產業納入循環經濟之一環。此次出國看到德荷兩國對沼渣沼液作肥料之考量，建議我國使用時，也需視沼渣沼液成分(含原始進料狀況)、土壤污染標準與土壤肥力情形，訂定相關二次料使用標準。

5.「資源循環」策略及措施：以減量、再使用、再利用、能源回收、國土再造及重新設計推動。

（1）減量(Reduction)：源頭減量，減少製造端原料使用量及消費端廢棄資源產生量。

（2）再使用(Reuse)：物品丟棄前應予以再使用。

（3）再利用(再生利用) (Recycling)：將廢棄資源物資源化為可用之物質。

（4）能源回收(Energy Recovery)：經前述減量、再使用及再利用後仍無法資源再利用者，續進行能源回收。

（5）國土再造 (Land Reclamation)：安定物質推動新生土地利用，並竭盡前述方式仍無法再利用或回收之剩餘物(最小化)進行處置。

（6）重新設計(Redesign)：以搖籃到搖籃理念設計。鼓勵「資源循環」創造經濟價值。

6.執行問題及挑戰

（1）法規面：法令限制及障礙、跨部會機關權責及管理、地方自治支持度、執法配套等。

（2）經濟面：經濟效益及財務收益、投資誘因或獎勵補助(貼)等。

（3）環境面：環境影響及衝擊的避免、二次污染等。

（4）社會面：社會大眾的共識及接受度、社會正義及教育宣導等。

7.他山之石(國外政策達成及降低障礙參考)

（1）達到目標及降低推動障礙：荷蘭「建設環境部」自 2014 年起推動「由廢棄物變資源」(From waste to resource)方案，其中 3 項作法，分別為：

（a）採聯盟策略，以加速實現循環經濟（RACE-coalition）。

（b）檢討增修法規，以降低法令障礙(reducing legal barriers)。

（c）簽訂綠色協定(Green Deal)，以提高投資意願。

（2）推動循環經濟相關作法：荷蘭「建設環境部」，包含：

（a）利用政府干預以克服各種障礙。

（b）利用市場工具減少環境負面效應。

（c）引進專業以消弭知識落差。

（d）減少不符循環型態之行為。

（e）缺乏物料鏈協調性(lack of coordination within material chains)。

（f）有技巧的製造私部門誘因以引導投資效益。

（g）由政府觀點影響國際影響力等。

（h）其中優先的部門包括生物質(Biomass and food)、塑膠、製造業、建築業、以及消耗性貨品部門(consumption goods)。

（3）以上或可納入我國循環經濟、資源循環及永續物料管理等相關政策推動之參考。

8.建立國際合作及交流

（1）推動循環經濟之資訊交流：建議我國與荷蘭或德國等國，在循環經濟之政策、法規及技術等領域，雙方可建立進行資源交流及合作管道。

（2）推動循環經濟之人才培育：

（a）建議我國產官學研各界，可至荷蘭或德國等國進行實地培訓教育，以瞭解當地政經背景及商業模式的配合情形；

（b）或邀請荷蘭或德國等國循環經濟執行人員到我國，辦理相關循環經濟培訓教育及技術指導。

（3）後續可在資訊交流及人才培育合作基礎上，再逐步擴大其他領域如投資及技術移轉等之合作交流，提升我國經濟循環技術實力。

9.我國過去已有一般廢棄物、事業廢棄物管理的基礎，且具有廢棄物管制中心以及永續物料管理資料庫為資料分析來源，如今循環經濟風潮興起，我國既有之環保科技園區的資源循環鏈結、最後存匯(Final Sink)概念下的填海造陸，以及搖籃到搖籃概念的產業聯盟與產品推動，皆是開創我國循環經濟進步的契機，未來建議在明確的規範、穩定且系統性的政策、綠色協定與二次料產品認證、創新商業模式與市場，以及綠色工作與綠色人才培訓等五方面上，實現我國的循環經濟。

10.可參考荷蘭循環經濟作法，如創造清楚一致跨部會(部門)的循環經濟策略、發展有關循環經濟的一致性教育與研究計畫、完整評估現行法規中有利與不利的條件、強化原物料價值鏈的知識與認知、確保相關前驅者利益，例如價值鏈管理、評估經濟誘因在財

務與會計上的有效性、鑑別循環商業案例對焚化廠的衝擊並採取適當措施、發展政府角色成為積極且專業的「啟動客戶」與利用國際場域來協助循環經濟的推動，並根據我國國情酌以調整，例如我國既有靜脈產業頗為完整，應儘量以鼓勵創新或產業結盟方式促成循環經濟轉型。

五、G20 的新亮點 -- 綠色金融

1. 前言

正當本循環經濟訪問團在德國參訪時，在杭州召開的 G20 高峰會(9 月 4 日)中，中國國家主席習近平在開幕致詞中大談永續發展與全球經濟金融治理，會後許多國際媒體也認為「綠色金融(Green Finance)」是其致詞內容的主要亮點之一。習近平在此重要場合宣揚此概念並不突發奇想，而是經過長時間籌備的國家發展戰略。

例如在 2016 年 1 月 25-6 日，中國與英國共同主持召開「G20 綠色金融研議小組(Green Finance Study Group)」會議，共有 5 個國家與 6 個國際組織參加，並獲得聯合國環境規劃署(UNEP)的協助。該小組並完成「綠色金融綜合報告（G20 Green Finance Synthesis Report）」，提報給 G20 大會。

2. 為什麼要推動綠色金融

資金是經濟活動的血液，金融是支持經濟產業的動能。因此當我們希望經濟往綠色經濟與永續發展轉型時，我們的金融政策也應跟著調整。如何運用公私部門的資源進行綠色投資，並運用政府政策來克服綠色金融的障礙，以加速全球經濟的轉型，是當務之急。

因為大型基礎建設以及工業投資都會對人們與環境帶來影響，若無法完全避免，至少也要儘可能降低，或是提出補償方案。由於減少污染、碳排放、廢棄物或提高資源使用效率與生物多樣性等等，

都需要長期與穩定的投資。過去一些人希望公部門的預算，能扮演綠色投資的角色，但規模更大的民間部門則更為重要。因此如何讓政府的金融政策來動員民間資金，當作綠色投資的觸媒，同時調整相關法規來降低綠色投資的障礙，才能發揮最大的綜效。

3. 綠色金融的範圍

綠色金融大致上包括綠色信貸、綠色債券以及綠色投資機構三大類。

(1) 綠色信貸

銀行在進行放貸等業務時，必須考量客戶所涉及的環境因素。對於環境友善的投資貸款給予較為優惠條件，反之對環境有負面影響的投資，則限制其貸款。例如根據赤道原則，銀行應該拒絕提供貸款給不符社會與環境標準的企業。積極調整信貸結構，有效防範環境與社會風險。

而中國銀行業監督管理委員會所頒布的「綠色信貸指引」可供參考，該指引第三條指出: 銀行業金融機構應當從戰略高度推進綠色信貸，加大對綠色經濟、低碳經濟、循環經濟的支持，防範環境和社會風險，提升自身的環境和社會表現，並以此優化信貸結構，提高服務水平，促進發展方式轉變。除加大綠色信貸的發放力度，並明確貸款人的盡職免責要求和環境保護法律責任。

(2) 綠色債券

為了提供資金用於有益於環境保護的投資計畫，像是世界銀行或亞洲開發銀行等機構會發行所謂的綠色債券。有些國家為了鼓勵投資綠色債券，給予所得稅減免。例如 2013 年美國麻州發行用於環境保護設施的公債所得免稅，又如 2004 年美國聯邦政府發行用於發展新能源的公債所得免稅。

除了提供租稅誘因外，各國也可利用金融監理手段，要求發債機構必須揭露其環境責任的相關資訊。包括這些資金支應的投資項目，對環境有何衝擊，該機構又做了哪些努力來降低衝擊。讓投資者清楚其投資可能面臨的環境風險。

(3) 綠色資本市場相關制度建設

編製綠色股票指數，鼓勵設立綠色指數型基金等相關投資產品，滿足社會上越來越多具綠色意識的投資者。建立上市公司環保資訊強制性披露機制，並在環境高風險領域建立環境污染強制責任保險制度。建立綠色評級體系以及公益性的環境成本核算和影響評估體系。

4. 台灣應加速綠色金融的推動

目前國內各界對綠色金融可說是相當陌生，不管是積極面讓更多的金融資源投入綠色經濟，或是消極面讓金融業避開因環境問題引發的經營風險，各界對此的認識都有待加強。

例如 2014 年初金管會要求國內銀行公會研商，在銀行業的授信相關準則規範中納入「赤道原則」。之後銀行公會也增訂授信準則，讓銀行辦理專案融資審核時，考量貸款者是否善盡環境保護之責任，並做為是否放款之依據。但這兩年來所獲得之迴響並不熱烈，也反映出國內金融業對環境風險與責任的低估。

事實上依據「土壤及地下水污染整治法」規定，土地污染者所應繳交的整治費用，優於一切債權及抵押權。也就是說銀行若貸款給某家有污染土地行為的公司，其求償順序是在整治費用的後面，銀行極可能求償無門。此外受污染整治的土地，不得辦理處分之登記，若在進行拍賣程序者，必須停止其程序。

此外為了有效抑制碳排放成長，越來越多的國家採納「碳定價(Carbon Pricing)」的政策，也就是說企業的排碳不再是無償，而必須依其排放量負擔成本。這也就是為什麼一些國際大公司非常注重「碳風險」這個議題，因為一旦政府採納碳定價，勢必影響企業的財報。因此金融業對於能源或碳排放密集產業的放款，應該要特別謹慎，以降低自身的經營風險。

5. 結語

過去一般都認為中國是經濟掛帥，在環境保護上是比較落後的，但從十八大後他們不斷強調綠色發展、循環發展以及低碳發展，並把它提升到國家發展的戰略。近年來他們陸續完成相關典章制度，雖然各界都認為其實務與制度有不小的差距。或許這些都是中國為吸引下一波全球資金來帶動其經濟轉型，但不可諱言的這些「企劃內容」都扣緊世界主流的思想，值得彼此相互勉勵與學習。

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公務出國期間國外人士個人資料彙整表

	姓名	單位及職稱	國別	專長領域	會晤日期	聯絡電話	電子郵件	我方接洽者姓名職稱	交流內容	備註
參訪 Refood 都市廚餘資源化方案(Marl)	H. Gilsbach	ReFood	德國	資源循環	9/5	02365-92489-86 0170-578-0149		何春玲專員	都市廚餘資源化方案	
	Jan Gilsbach	ReFood	德國	資源循環	9/5	+49(0)23 65/9 24 89-86 +49(0)1 70/5 78 01 49	Jan.gilsbach@refood.de	何春玲專員	都市廚餘資源化方案	
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參訪 Lippe Plant,並進行資源回收處理過程技術討論與交流會議	H. Assadi	Remondis	德國	資源循環	9/6	01713327264		何春玲專員	資源回收處理過程技術	
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European Commission

HORIZON 2020
in brief

The EU Framework Programme for Research & Innovation

Research and Innovation

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EUROPEAN COMMISSION

HORIZON 2020

in brief

The EU Framework Programme for Research & Innovation

2014

Directorate-General for Research and Innovation

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Introduction

Horizon 2020 – delivering excellent science for Europe

Horizon 2020 is the biggest EU research and innovation programme ever. It will lead to more breakthroughs, discoveries and world-firsts by taking great ideas from the lab to the market. Almost €80 billion[1] of funding is available over 7 years (2014 to 2020) – in addition to the private and national public investment that this money will attract.

Horizon 2020 has the political backing of Europe's leaders and the Members of the European Parliament. They agreed that investment in research and innovation is essential for Europe's future and so put it at the heart of the Europe 2020 strategy for smart, sustainable and inclusive growth. Horizon 2020 is helping to achieve this by coupling research to innovation and focusing on three key areas: excellent science, industrial leadership and societal challenges. The goal is to ensure Europe produces world-class science and technology that drives economic growth.

EU research funding under previous framework programmes has already brought together scientists and industry both within Europe and from around the world to find solutions to a vast array of challenges. Their innovations have improved lives, helped protect the environment and made European industry more sustainable and competitive. Horizon 2020 is open to participation by researchers from all over the world.

Their experience has been essential for the development of this pioneering programme – the Commission collected their feedback and took into account recommendations from the Member States and the European Parliament, as well as lessons learned during earlier programmes. The message was clear – make Horizon 2020 simpler for users – and it is!

1) All figures are quoted in current prices

Getting to know Horizon 2020

Excellent science, competitive industry and tackling societal challenges are at the heart of Horizon 2020. Targeted funding will help to ensure that the best ideas are brought to the market faster – and are used in our cities, hospitals, factories, shops and homes as quickly as possible.

Excellent science

Horizon 2020 will bolster the EU's position as a world leader in science, attracting the best brains and helping our scientists collaborate and share ideas across Europe. It will help talented people and innovative firms boost Europe's competitiveness, creating jobs along the way, and contributing to a higher standard of living – benefiting everyone.

Frontier research funded by the European Research Council (ERC)

Some of today's most significant inventions are the result of our natural curiosity about the way the world works. Although curiosity driven research at the frontiers of knowledge is rarely explicitly in support of commercial products, its discoveries nonetheless stimulate countless innovations. However, frontier research is often the first area to face cuts in times of economic difficulty, which is why through the ERC the EU is boosting the level of investment. Excellence is the sole criterion here for EU funding, which is awarded to individual researchers or research teams.

Funding: €13.095 billion

Marie Skłodowska-Curie Actions

Training and career development helps produce leading researchers. Support is offered to young and experienced researchers to reinforce their career and skills through training, or periods of placement in another country or in the private sector. This gives them new knowledge and experience to allow them to reach their full potential.

Funding: €6.162 billion

Future and emerging technologies

Staying at the cutting edge of new technologies will keep Europe competitive and create new, high-skilled jobs – and this means being proactive and thinking one step ahead of the crowd. EU funding is helping to make Europe the best possible environment for responsible and dynamic multi-disciplinary cooperation on new and future technologies.

Funding: €2.696 billion

World-class infrastructure

Research equipment can be so complex and costly that no single research team – or even country – can afford to buy or construct or operate it alone. Examples include: the high powered lasers that serve a diverse research community spanning medicine, materials sciences and biochemistry; specialised high-tech airplanes; or a monitoring station at the bottom of the sea, used for observing climate change.

These can cost millions of euro, and need the skills of the world's top experts. EU funding helps to pool resources for such large-scale projects, and provides Europe's researchers with access to the very latest, state-of-the-art infrastructure – making new and exciting research possible.

Funding: €2.488 billion

Industrial leadership

To be the best at what it does, Europe needs to invest in promising and strategic technologies, such as those used in advanced manufacturing and micro-electronics. But public funding alone is not enough: the EU needs to encourage businesses to invest more in research, and target areas where they can work with the public sector to boost innovation.

Businesses gain by becoming more innovative, efficient and competitive. This in turn creates new jobs and market opportunities. Every €1 invested by the EU generates around €13 in added value for business. And increasing investment further to 3 % of GDP by 2020 would create a further 3.7 million jobs!

Leadership in enabling and industrial technologies

Horizon 2020 supports the ground-breaking technologies needed to underpin innovation across all sectors, including information and communication technology (ICT) and space. Key enabling technologies such as advanced manufacturing and materials, biotechnology and nanotechnologies, are at the heart of game-changing products: smart phones, high performance batteries, light vehicles, nanomedicines, smart textiles and many more besides. European manufacturing industry is a key employer providing jobs for 31 million people across Europe.

Funding: €13.557 billion

Small and medium enterprises (SMEs) – a key source of jobs and innovation – receive special attention in Horizon 2020. They can collaborate in projects as part of a consortium and can receive support through a dedicated instrument designed specifically for highly innovative smaller companies. The integrated and streamlined character of Horizon 2020 will boost SME participation to at least 20% (€8.65 billion) of the total combined budgets of the 'Leadership in enabling and industrial technologies' and the 'Societal Challenges' themes. The SME instrument will be pivotal in achieving this target by providing support to help single SMEs, or consortia of SMEs, assess the market viability of their ideas at the high-risk stage, and then to help them develop these ideas further. Funding is also available for business coaching and guidance on how to identify and attract private investors.

Funding: At least €3 billion allocated to the SME instrument

Access to risk finance

Innovative companies and other organisations often find it difficult to access financing for high-risk new ideas or their development. Horizon 2020 helps to fill this "innovation gap" through loans and guarantees, as well as by investing in innovative SMEs and small midcaps. This support acts as a catalyst to attract private finance and venture capital for research and innovation. It is estimated that every €1 the EU invests generates €5 in additional finance.

Funding: €2.842 billion

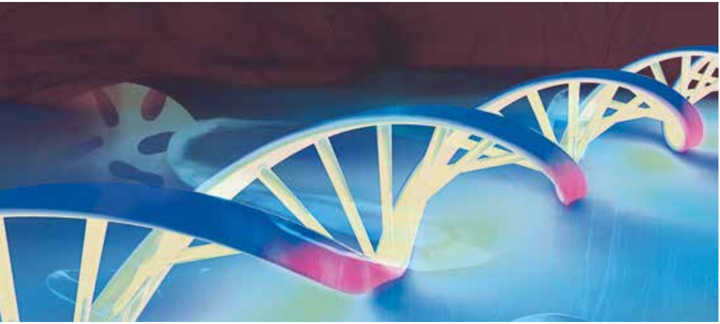
Societal challenges

The EU has identified seven priority challenges where targeted investment in research and innovation can have a real impact benefitting the citizen:

- Health, demographic change and wellbeing
- Food security, sustainable agriculture and forestry, marine and maritime and inland water research and the bioeconomy
- Secure, clean and efficient energy
- Smart, green and integrated transport
- Climate action, environment, resource efficiency and raw materials
- Europe in a changing world - inclusive, innovative and reflective societies
- Secure societies - protecting freedom and security of Europe and its citizens.

Health and wellbeing

Everyone wants a long, happy and healthy life, and scientists are doing their best to make this possible. They are tackling some of the major current health issues as well as emerging threats such as the increasing impact of Alzheimer's disease, diabetes and antibiotic-resistant 'super-bugs'. Investment in health research and innovation will help us stay active, develop new, safer and more effective treatments and help keep our health and care systems viable. It will give doctors the tools they



need for more personalised medicine, and it will step up prevention and treatment of chronic and infectious diseases.

Funding: €7.472 billion

Food security and sustainable use of biological resources

With the world population set to reach nine billion by 2050 we need to find ways to radically change our approach to production, consumption, processing, storage, recycling and waste disposal while minimising the environmental impact. This will include balancing the use of renewable and non-renewable resources from land, seas and oceans, transforming waste into valuable resources, and the sustainable production of food, feedstuffs, bio-based products and bioenergy. In the EU, agriculture and forestry and the food and bio-based industry sectors altogether employ 22 million people and play a key role in rural development and the management of Europe's natural heritage.

Funding: €3.851 billion

Sustainable energy

Energy drives the modern economy but even just maintaining our standard of living requires a huge amount of energy. As the world's second-largest economy, Europe is over-dependent on the rest of the globe for its energy – energy derived from fossil fuels that accelerate climate change. The EU has, therefore, set itself ambitious climate and energy targets. EU funding through Horizon 2020 will play a key role in achieving these goals.

Funding: €5.931 billion

Green, integrated mobility

Mobility drives employment, economic growth, prosperity and global trade. It also provides vital links between people and communities. However, today's transport systems and the way we use them are unsustainable. We rely too heavily on shrinking stocks of oil, which makes us less energy secure. And transport-related problems – congestion, road safety, atmospheric pollution – impact on our daily lives and health. To address these issues Horizon 2020 is contributing to the creation of a sustainable transport system that is fit for a modern, competitive Europe.

Funding: €6.339 billion

Climate action, environment, resource efficiency and raw materials

The era of never-ending cheap resources is coming to an end: access to raw materials and clean water can no longer be taken for granted. Biodiversity and ecosystems are also under pressure. The solution is to invest now in innovation to support a green economy – an economy that is in sync with the natural environment. Dealing with climate change is a cross-cutting priority in Horizon 2020 and accounts for 35 % of the overall budget across the programme.

Waste and water are particular priorities. Waste is currently responsible for 2 % of the EU's greenhouse gas emissions, while boosting growth in the water industry by just 1 % could create up to 20 000 new jobs.

Funding: €3.081 billion

Europe in a changing world – inclusive, innovative and reflective societies

In 2011 around 80 million people were at risk of poverty in Europe. Significant numbers of young people – on whom our future depends – are not in education, work or training. These are just two examples of challenges that threaten the future of Europe and individuals in large sectors of society. Research and innovation can help, which is why Horizon 2020 is funding research on new strategies and governance structures to overcome prevailing economic instability and ensure Europe is resilient to future downturns, demographic change and migration patterns. Funding also supports new forms of innovation such as open innovation, business model innovation, public sector and social innovation to meet social needs. By supporting research and innovation on European heritage, identity, history, culture and Europe's role in the world, the EU is also building 'reflective societies' – in which shared values and their contribution to our joint future are explored.

Funding: €1.309 billion

Secure societies – protecting freedom and security of Europe and its citizens

Today, keeping citizens safe means fighting crime and terrorism, protecting communities from natural and man-made disasters, thwarting cyber-attacks and guarding against illegal trafficking in people, drugs and counterfeit goods. EU research and innovation is developing new technologies to protect our societies, while respecting privacy and upholding fundamental rights – two core values at the heart of EU security research. These technologies have a significant potential to stimulate economic activity through new products and services and create jobs.

Funding: €1.695 billion

Spreading excellence and widening participation

Research and innovation are crucial to economic prosperity and so measures are needed to ensure that the innovation performances of all Member States and their regions converge and improve. Experience shows that when economic crises constrain national budgets, disparities in innovation performance across Europe become more apparent. Exploiting the potential of Europe's talent pool and maximising and spreading the benefits of innovation across the Union is therefore the best way to strengthen Europe's competitiveness and its ability to address societal challenges in the future.

Specific measures under Horizon 2020 include:

- 'Teaming' excellent research institutions with lower performing counterparts to create or upgrade centres of excellence
- 'Twinning' institutions, including staff exchanges, expert visits and training courses
- Establishing 'ERA Chairs' to attract outstanding academics to high-potential institutions
- A Policy Support Facility to help improve national and regional research and innovation policies
- Providing excellent researchers and innovators with better access to international networks
- Strengthening the transnational networks of National Contact Points to provide information to those seeking support.

Funding: €816 million

Synergies with other policies

A basic premise of the Europe 2020 strategy for smart, sustainable and inclusive growth is that all EU policies should work together to achieve its objectives. As regards research and innovation, the European Structural and Investment Funds are providing complementary support to Horizon 2020 to finance the upgrade of scientific infrastructure – from laboratory equipment to supercomputers, to high-speed data networks – and to boost research and innovation capacities where needed.

Science with and for society

Effective cooperation between science and society is needed to recruit new talent for science and to marry scientific excellence with social awareness and responsibility. This means understanding the issues from all sides. Horizon 2020 is, therefore, supporting projects that involve the citizen in the processes that define the nature of the research that affects their everyday lives. Broader understanding between the specialist and non-specialist communities on objectives and the means for achieving them will maintain scientific excellence and allow society to share ownership of the results.

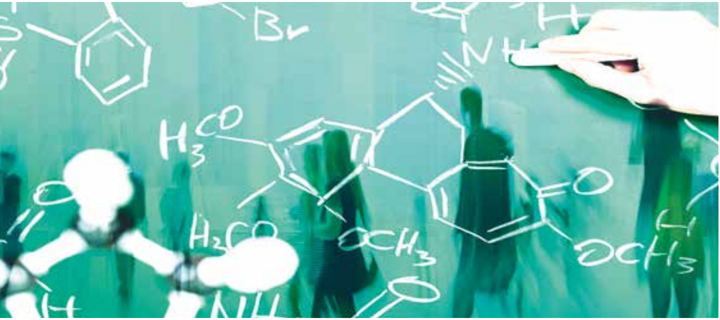
Funding: €462 million

Innovation actions in Horizon 2020

Substantial support for innovation is provided throughout Horizon 2020 for prototyping, testing, demonstrating, piloting, large-scale product validation and market replication. Significant support to demand side approaches is another important feature, notably pre-commercial and first-commercial public procurement of innovation, as well as regulation to foster innovation and standard-setting. New forms of public sector innovation and social innovation as well as pilot actions for private sector services and products are also covered.

Social Sciences and Humanities

As a cross-cutting issue of broad relevance, Social Sciences and Humanities (SSH) research is fully integrated into each of the general objectives of Horizon 2020. Embedding SSH research across Horizon 2020 is essential to maximise the returns to society from investment in science and technology. Integrating the socio-economic dimension into the design, development and implementation of research itself and of new technologies can help find solutions to societal problems. Indeed, the idea to focus Horizon 2020 around "Challenges" rather than disciplinary fields of research illustrates this new approach.



Nuclear research for all citizens

EU research on nuclear fission focuses on safety and security, medical research, radiation protection, waste management, industrial uses of radiation, and includes many other areas such as the use of radiation in the agricultural sector.

EU research on nuclear fusion aims at demonstrating that fusion can become a viable energy source for large-scale commercial exploitation within a reasonable timeframe, by gathering the efforts of all stakeholders into a unique European joint programme.

Funding: €1.603 billion

Science for policy – the role of the Joint Research Centre (JRC)

The Joint Research Centre is the Commission's in-house service providing independent, evidence-based scientific and technical support for EU policies. Its activities are funded through Horizon 2020 and many of its actions address the seven societal challenges. Through the research and training programme of the European Atomic Energy Community, the JRC also supports the EU's efforts to strengthen nuclear security, safety and radiation protection.

Further information: https://ec.europa.eu/jrc/.

How it works

Horizon 2020 is open to everyone. Under Horizon 2020 there is only one set of simplified rules and procedures to follow. This means that participants can focus on what is really important: research, innovation and results.

This focused approach makes sure new projects get off the ground quickly – and achieve results faster.

The rules are designed to guarantee fairness, protect participants and ensure public money is spent appropriately.

Who may apply?

- For standard research projects – a consortium of at least three legal entities. Each entity must be established in an EU Member State or an Associated Country.

- For other programmes – European Research Council (ERC) (p.23), SME Instrument (p.24), the co-funding of national or public sector calls or programmes (p.28), coordination and support (p.23), training and mobility (p.24) – the minimum condition for participation is one legal entity established in a Member State or in an Associated Country.

Additional conditions may apply. Check the Work Programme for details (see p.33).

In general, legal entities established in any country and international organisations, may participate.

Agreements between the EU and individual governments have created a number of associated countries, where legal entities can participate in Horizon 2020 on an equal footing to those of EU Member States.

For a list of associated countries, see http://bit.ly/H2020AC.

Participating legal entities from other countries may also be able to get EU funding in certain circumstances.

See http://bit.ly/H2020IPC.

Action types

Research and innovation actions

Funding for research projects tackling clearly defined challenges, which can lead to the development of new knowledge or a new technology.

Who? Consortia of partners from different countries, industry and academia.

Innovation actions

Funding is more focused on closer-to-the-market activities. For example, prototyping, testing, demonstrating, piloting, scaling-up etc. if they aim at producing new or improved products or services.

Who? Consortia of partners from different countries, industry and academia.

Coordination and support actions

Funding covers the coordination and networking of research and innovation projects, programmes and policies. Funding for research and innovation per se is covered elsewhere.

Who? Single entities or consortia of partners from different countries, industry and academia.

Frontier research grants – European Research Council

Funding for projects evaluated on the sole criterion of scientific excellence in any field of research, carried out by a single national or multinational research team led by a 'principal investigator'.

Who? The ERC funds excellent young, early-career researchers, already independent researchers and senior research leaders. Researchers can be of any nationality and their projects can be in any field of research.

Support for training and career development – Marie Skłodowska-Curie Actions

Funding for international research fellowships in the public or private sector, research training, staff exchanges.

Who? Early stage researchers or experienced researchers (of any nationality), technical staff, national/regional research mobility programmes.

SME Instrument

This instrument is aimed at highly innovative SMEs with the ambition to develop their growth potential. It offers lump sums for feasibility studies, grants for an innovation project's main phase (demonstration, prototyping, testing, application development...); lastly, the commercialisation phase is supported indirectly through facilitated access to debt and equity financial instruments.

Who? Only SMEs can participate. Either a single SME or a consortium of SMEs established in an EU or Associated Country.

Fast track to innovation

Funding is due to start in 2015 as a pilot action. Continuously open, innovator-driven calls will target innovation projects addressing any technology or societal challenge field. The pilot action will undergo an in-depth assessment half-way through Horizon 2020.

Who? Industry, including SMEs, with a minimum of three and maximum of five partners and a maximum EU contribution of €3 million per project.

Funding rates

In Horizon 2020 there is one single funding rate for all beneficiaries and all activities in the research grants. EU funding covers up to 100% of all eligible costs for all research and innovation actions. For innovation actions, funding generally covers 70% of eligible costs, but may increase to 100% for non-profit organisations. Indirect eligible costs (e.g. administration, communication and infrastructure costs, office supplies) are reimbursed with a 25% flat rate of the direct eligible costs (those costs directly linked to the action implementation).

Checks and audits

Only coordinators in projects requesting funding from the Union of €500000 or more will be subject to a financial viability check, in which they must prove that they have the resources to implement the project.

The European Commission audits project participants up to two years after payment of the balance. The audit strategy is focused on risk and fraud prevention.

Access rights

Access rights are a right to use results or background of another participant in a project.

Access rights are enjoyed by participants to implement the project or exploit their results, by the EU for non-commercial policy purposes, and by Member States in the area of Secure Societies for non-commercial policy purposes.

Sharing results while protecting IPR

Each participant must disseminate the results it produces – and therefore owns – as early as possible. Exceptions only apply to protect intellectual property rights (IPR), security or legitimate interests.

When publishing results in scientific publications, open access to the publication must be ensured. This guarantees that research results funded by EU taxpayers are available for free to everyone.

IPR belongs to the team that generates the results. In very specific circumstances, joint-ownership may apply. Once results have been generated the joint owners may agree on a different ownership system.

Ethics and research

Ethics is an integral part of research and a driver for research excellence. All activities funded under Horizon 2020 shall comply with ethical principles and relevant national legislation. The ethical principles include the need to avoid breaches of research integrity, in particular any form of plagiarism, data fabrication or falsification.

Other sources of funding through Horizon 2020

Through partnerships, Horizon 2020 will develop closer synergies with national and regional programmes, encourage greater private investment in research and innovation, and pool Europe's resources to tackle the biggest challenges.

Over seven years, EU funding of €8 billion will attract €10 billion from the private sector and another €4 billion from EU countries. Most of the funding will go to Joint Technology Initiatives (JTIs). These are run as joint undertakings and organise their own research agenda. JTIs are active in a number of areas of strategic importance for the EU: innovative medicines; fuel cells and hydrogen; cleaner, quieter aircraft; bio-based industries; and electronics manufacturing. An updated list can be found on this webpage http://bit.ly/H2020Partners

Public-Public Partnerships also allow public sector organisations in EU Member States to draw up joint research programmes. Areas covered include: support for high-tech SMEs; new treatments for poverty-related diseases; new measurement technologies; and technologies empowering the elderly and disabled to live safely in their own homes.

Programme co-fund

The main purpose of Programme co-fund actions is to supplement individual calls or programmes. For example:

- Calls for proposals between national research programmes (ERA-NET co-fund);
- Calls for tenders for Pre-Commercial Public Procurements or Public Procurement of Innovative solutions (PCP-PPI co-fund);
- Mobility programmes (Marie Skłodowska-Curie co-fund).

European Institute of Innovation and Technology (EIT)

The EIT integrates higher education, research and innovation through the ‘Knowledge and Innovation Communities’ (KICs) to generate new approaches towards innovation, trigger sustainable growth and competitiveness and promote entrepreneurship. These innovative partnerships must have a long-term vision of at least seven years, and be run with business logic following a results-oriented approach with

clear objectives and a focus on achieving economic and social impact to become global players.

For further information: http://eit.europa.eu/

Funding: €2.711 billion

Who? Consortia representing research, education and innovation/ business.

Thinking European – and globally

Borderless research

If Europe is to find solutions to societal challenges while boosting growth and competitiveness, it needs a fully functioning network of research excellence – a European Research Area (ERA). This single market for knowledge, research and innovation is being developed with the aid of EU funding and is helping researchers, their knowledge and results to circulate freely across Europe.

The ERA guarantees that knowledge and ideas are shared across Europe, reducing the risk of wasting money on duplicating research – scientists in different European labs carrying out the same research simultaneously. This coordinated approach – encouraged by Horizon 2020 – helps to ensure that every euro spent on research is invested strategically.

Open to the world

In line with the Union's strategy for international cooperation in research and innovation, Horizon 2020 is open to the participation of researchers from across the world. As more research and innovation is performed in international partner countries, it is crucial that Europe is able to access the best researchers and research centres worldwide. Not only does this provide sources of new ideas and expertise, it is also important to ensure that European researchers are able to collaborate worldwide with the best in the field.

Targeted international cooperation activities are included in the societal challenges, enabling and industrial technologies and other relevant parts of Horizon 2020. The areas and partners for cooperation are identified in the relevant Work Programme.

For more information on who is eligible, see p.20.

How to apply

Work programmes announce the specific research and innovation areas that will be funded. They are accessible through the Participant Portal (http://bit.ly/H2020PP) and indicate the timing of forthcoming Calls for Proposals. When ready each Call gives more precise information on the research and innovation issues that applicants for funding should address in their proposals.

Although details on all Calls can also be found in the EU's Official Journal, the Participant Portal goes further. It provides easy-to-follow guidance and all the tools needed to apply for funding and manage projects throughout their lifecycle. It covers every type of research and innovation action.

National Contact Points (http://bit.ly/H2020NCP) also provide a wealth of information and individual guidance on Horizon 2020. There is at least one in every EU country and some in other countries.
Specific questions can also be sent to the online Research Enquiry Service http://ec.europa.eu/research/enquiries.

Submitting a proposal

Proposals must be submitted before the deadline of the relevant Call. The Participant Portal provides clear instructions. The system is simpler than ever – no more paper! All proposals must be submitted online only.

Finding partners

Many Calls require a team to have at least three partners. The Participant Portal partner search function helps to identify potential partners with particular competences, facilities or experience.

Evaluation by experts

After the deadline passes, each proposal is evaluated by a panel of independent experts in the areas covered by the Call. The expert panels score each proposal against a list of criteria (see http://bit.ly/H2020Eval). On that basis, the best proposals are selected for funding.

Grant agreement

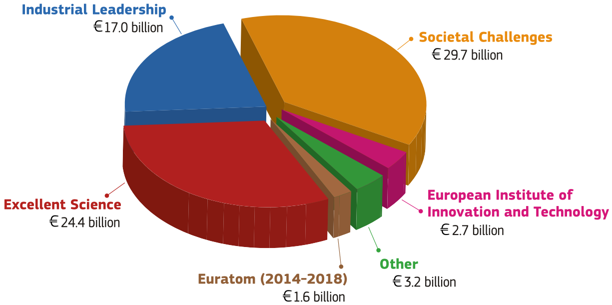
Once a proposal passes the scientific evaluation stage (duration five months), applicants are informed about the outcome. For the proposals which are selected for funding, the European Commission then draws up the grant agreement.

The time limit for signing the grant agreements is generally three months.

The grant agreement confirms the description of the research and innovation activities that will be undertaken, the project duration and budget, rates and costs, rights and obligations, division of roles, rules on suspending and terminating projects, and more.

Then the project can begin!

HORIZON 2020 Budget (in current prices 2013)



Useful links:

Participant Portal
http://bit.ly/H2020PP

Helpdesk
http://ec.europa.eu/research/enquiries

Learn more about Horizon 2020
http://ec.europa.eu/horizon2020

National contact Points (NCPs):
http://bit.ly/H2020NCP

Enterprise Europe Network:
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Register as an expert:
http://bit.ly/H2020Experts

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European Commission

HORIZON 2020 in brief

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KI-02-13-413-EN-C

Horizon 2020 is the biggest EU research and innovation programme ever. Almost €80 billion of funding is available over seven years (2014 to 2020) – in addition to the private and national public investment that this money will attract. Horizon 2020 will help to achieve smart, sustainable and inclusive economic growth. The goal is to ensure Europe produces world-class science and technology, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering solutions to big challenges facing our society. This guide explains the programme in more detail.

www.ec.europa.eu/horizon2020

Practical information

Publications Office

doi:10.2777/3719

Ministerium für Klimaschutz, Umwelt,
Landwirtschaft, Natur- und Verbraucherschutz
des Landes Nordrhein-Westfalen

Recycling Management in North Rhine-Westphalia

Gudrun Both, Referat IV-3
MKULNV NRW

Ministerium für Klimaschutz, Umwelt,
Landwirtschaft, Natur- und Verbraucherschutz
des Landes Nordrhein-Westfalen

North Rhine-Westphalia (NRW)

North Rhine-Westphalia (NRW)

- Location: In the West of Germany
- Highest population among the 16 German states
- Population: almost 18 million people
- Area: about 34.000 km²
- NRW is subdivided into five administrative districts
- There are 31 counties with 373 municipalities and 23 county-level cities

Waste management in North Rhine-Westphalia

- Promotion of waste prevention
- Strengthening of an ecological recycling economy
- Securing high ecological standards
- Better use of waste containing resource and energy

Waste management means resource conservation and climate protection

- In the last 20 years a significant reduction in green house gases especially in the field of „classic“ waste management has been achieved.
- The by far most important measure was completely abandoning landfill of biodegradable waste.
- Since 1st July 2005 in NRW there is no more untreated deposit of treatment requiring waste.

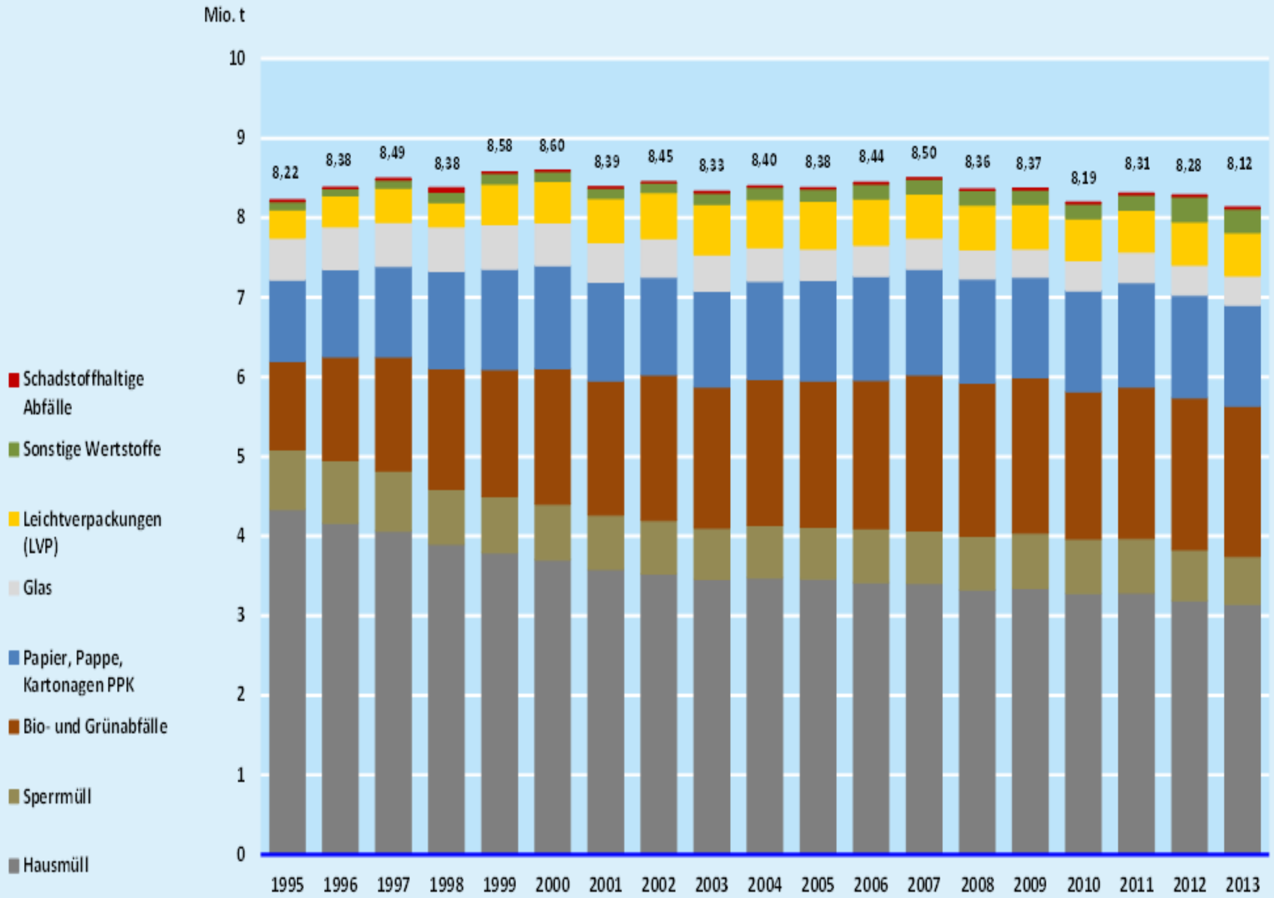
Municipal waste management in North Rhine-Westfalia

- Current situation in North Rhina-Westfalia:
  - Unavoidable waste is treated to a high degree according material and energy recycling guidelines.
  - Non-exploitable waste is disposed environment-friendly.
  - For recycling a network of highly differentiated facilities with sufficient capacity is provided.

Ministerium für Klimaschutz, Umwelt,
Landwirtschaft, Natur- und Verbraucherschutz
des Landes Nordrhein-Westfalen

Quantitative change in household waste 1995-2013

- **Largely constant total quantity** (approx.8,4 mio. t
- **Decline in household waste** (over 1 mio. t or 26 %)
- **Increase of separatly collected waste** (about 1.3 mio. t or 42 %)
- **Separately collected waste represents more than half of the total amount.**



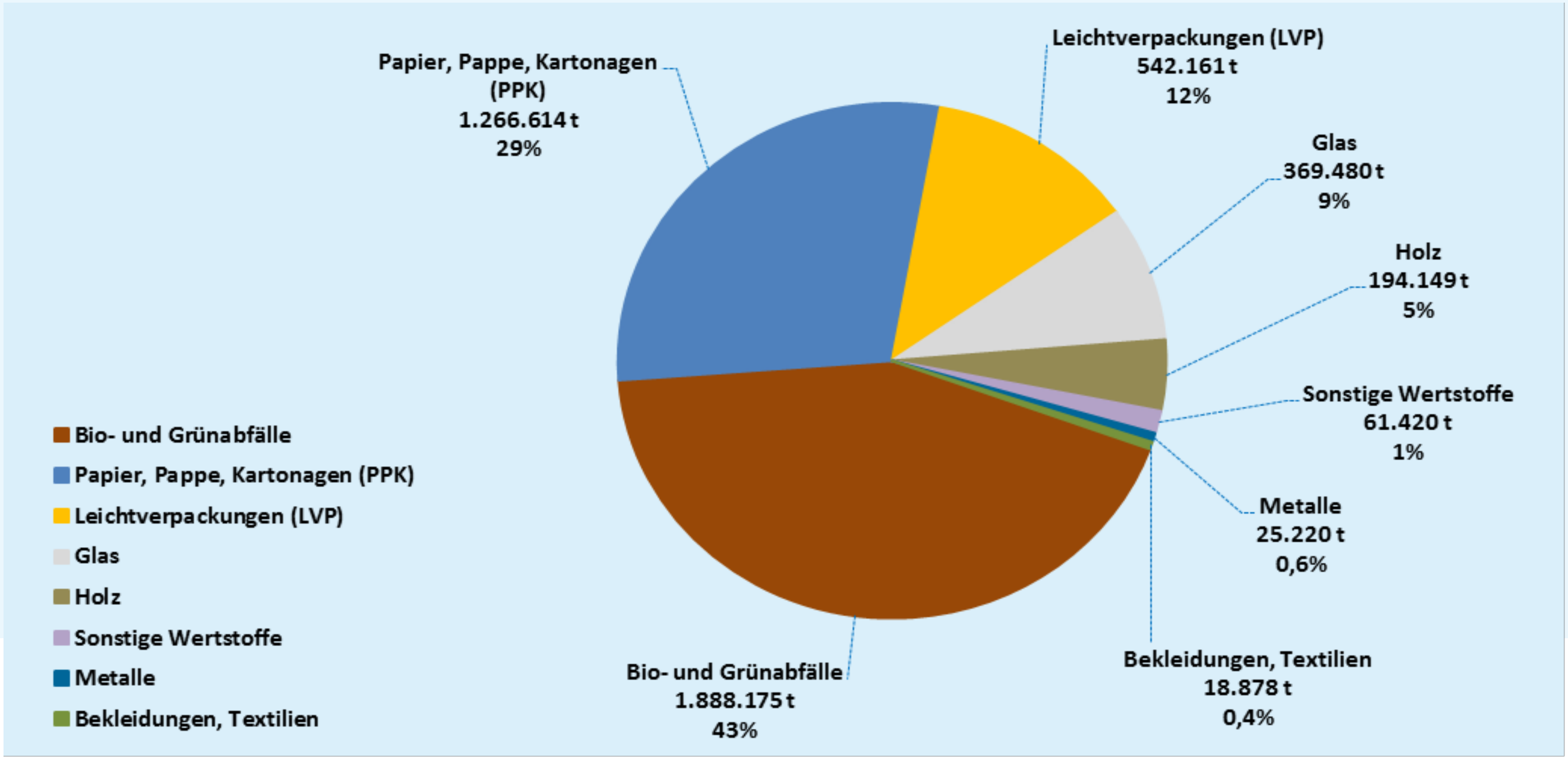
Quelle: Abfallbilanz Nordrhein-Westfalen für Siedlungsabfälle 2013

Separately collected waste 2013

43 % organic- and green waste ; 29 % paper, cardboard and cardboard boxes

12 % light wrappings; 9 % glas; 5 % wood; 2 % others (incl. Metalls, clothes, textiles)

Source: Waste balance NRW municipality waste 2013



Municipality waste management in North Rhine-Westfalia

- Due to separate waste collection organic- and green waste utilisation doubled from 1995 till 2013.
- In 2013 nearly half of the entire household waste like paper, glas, organic waste and metals underwent material utilisation.
- In 2013, 98 % of non-utilisable residual was thermally treated, in 1995 this share stood at only 47%.

Objectives of the new NRW waste management plan for municipal waste 12/2015 (planning period 2014 till 2024/2025)

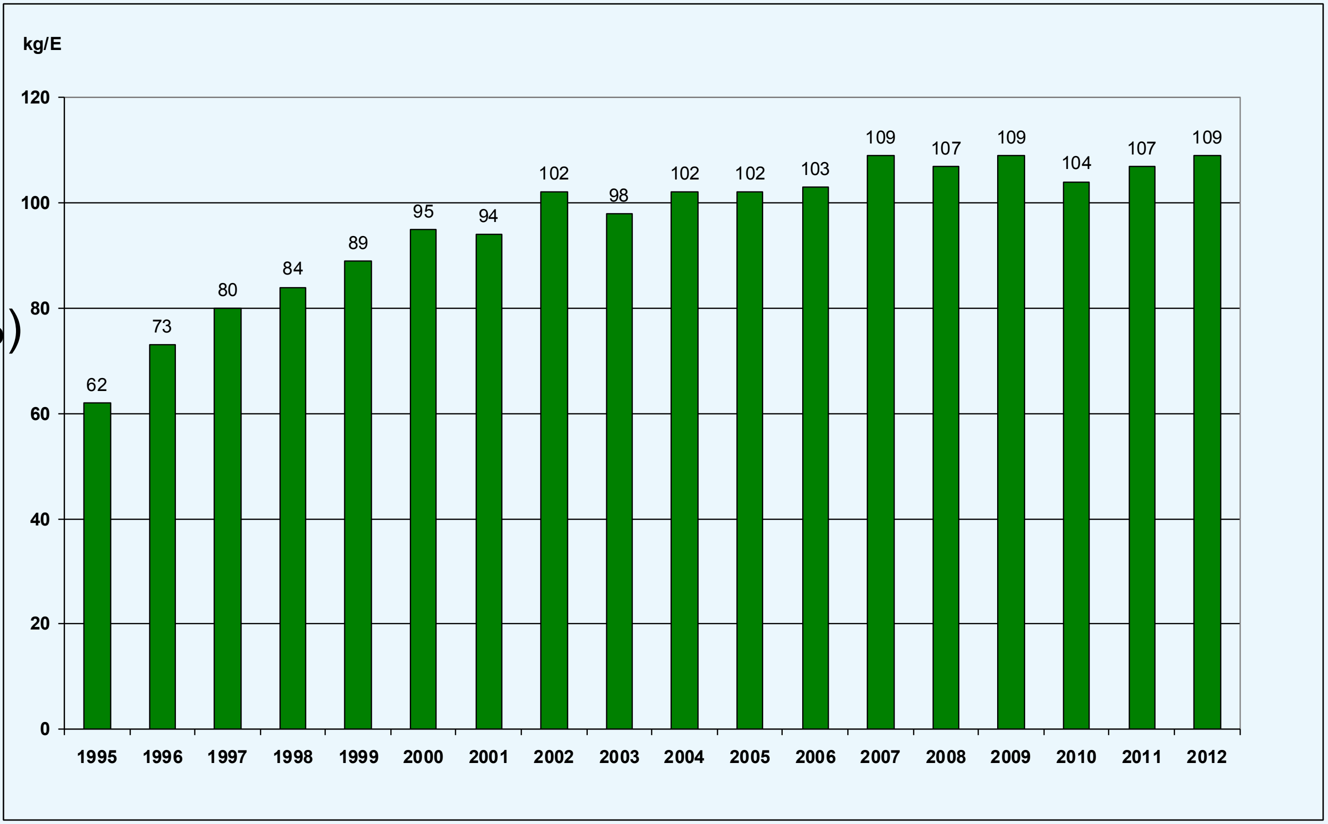
- **Implementation of the 5-level- waste hierarchy**
- **Promotion of waste prevention and reuse**
- **Intensification and optimization of the separate collection and recycling of organic waste**
- **Regional self-reliance in waste removal**
  disposal of municipal waste produced in NRW within NRW (principle of self-reliance) and as close as possible to the place of origin (principle of proximity)

Quantitative change of organic and green waste in NRW

Increased from

1,1 Mio. t or 62 kg/E
to 1,9 Mio. t /109 kg/E

Thereof 68 kg/E (62 %) collected via organic bin(1995 - 2012)



Source: Waste balance NRW municipality waste 2013

Optimization / intensification of organic and green waste collecting

Guide and target values for organic and green waste

Short-term goal (2016):

Achieving clusterrelated guide values

Medium-term goal (2021):

Achieving cluster-related target values

Cluster	Leitwert 2016	Zielwert 2021
	kg/E*a	
≤ 500 E/km²	**150**	**180**
> 500 - 1.000 E/km²	**130**	**160**
> 1.000 - 2.000 E/km²	**110**	**140**
> 2.000 E/km²	**70**	**90**

Long-term goal:
Achieving the ambitiuous country-target value:**150 kg/E*a**

Recommended actions for waste prevention within AWP

- Promotion of reuse/mulitple use i.e. swap/gift sites, bulky waste sites, computer return
- Support for repair networks
  i.e. Second Hand- or Social Department Stores, linkage of processing initiatives with recycling facilities, repair-cafés,
- Implementation of sustainable, resource conserving concepts at schools,
- Waste prevention as integral part in public event planning (i.e. use of multiple-use-dishes and tableware , deployment of mobile dish washers),
- Municipal waste prevention concepts/plans
  (Integration into municipal waste management concepts)
- Waste prevention campaignes / public relation acitivities
  (Information material, events, pilot projects)
- Consideration of waste prevention when awarding contracts or in public procurement activities (law for commitment to contractual agreements and procurement NRW)

Municipal waste management in North Rhine -Westphalia

- Wide range of waste treatment for energy production:
  - Use waste in waste incineration plants
  - Add waste to burn in power and cement plants
  - Fermentation of biowaste in biogas plants
  - Anaerobic treatment and incineration of sewage sludge
  - Use of landfill gas

Waste fees

- **Public waste management (private household, offices, small businesses etc.)**

- Home owner is tolled first, will be later levied on tenants
- mandatory use (green bin)
- Organic waste bin (since 1st January 2015 separate collection is mandatory)
- Paper ton (since 1st January 2015 separate collection is mandatory)
- Special waste in small amounts (collection of hazardous materials)
- SPECIFICS (return financed by manufacturer):
  Yellow bin for wrapping materials
  Electric- and electronic devices
  Batteries

Example: City of Wuppertal

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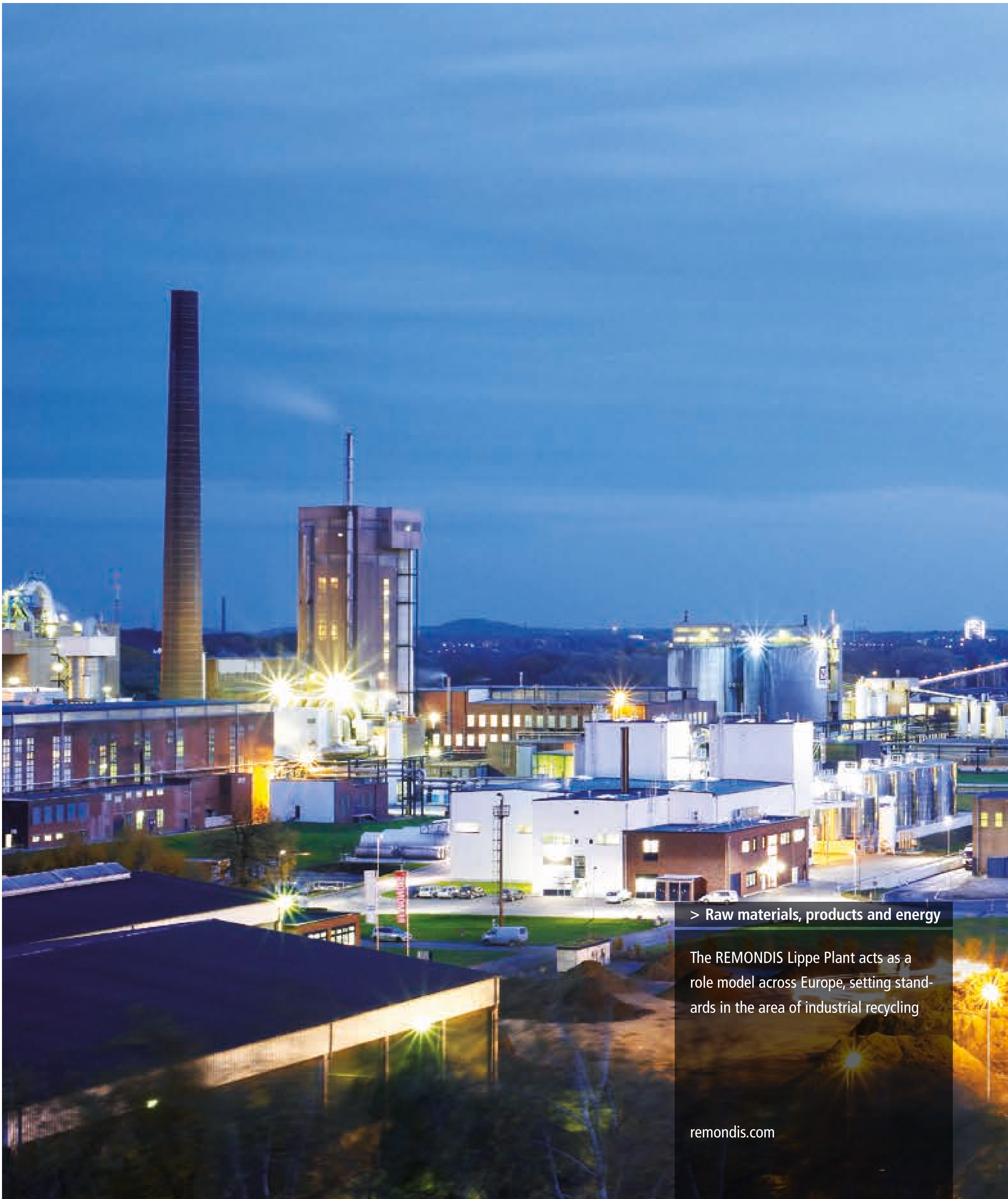
Waste management in North Rhein-Westfalia

REMONDIS®

WORKING FOR THE FUTURE

The REMONDIS Lippe Plant.
An industrial recycling centre



> Raw materials, products and energy

The REMONDIS Lippe Plant acts as a role model across Europe, setting standards in the area of industrial recycling

remondis.com

An industrial centre with an ideal infrastructure

The REMONDIS Lippe Plant covers an area of 230 hectares. REMONDIS has invested more than 400 million euros in the plant since taking it over in 1993 and has created an excellent infrastructure. This, in turn, enables the businesses located there to run their processing and production plants smoothly and efficiently. The plant complex provides numerous central services such as energy supply, wastewater treatment and laboratory services as well as its own plant security office and fire brigade.


REMONDIS®
IM AUFTRAG DER ZUKUNFT
138
REMONDIS

Systematic recycling to prevent climate change and conserve resources

No raw material is infinite, no source of energy inexhaustible. It is precisely for these reasons that we do everything in our power to recover every type of raw material that can be fed back into the economic cycle. Moreover, we carry out systematic research work to find alternative energy concepts and sources of fuel and ensure they are implemented rigorously and effectively.

Recycling activities carried out on an industrial scale help to conserve natural resources and prevent climate change

Raw materials come from the ground. Or from the REMONDIS Lippe Plant. Being a recycling company, REMONDIS feeds several million tonnes of raw materials back into economic and production cycles around the world every year

Energy can be generated from oil, gas, uranium or plutonium. Or from biomass. REMONDIS is already investing in the energy sources of the future. On an industrial scale and only of the very best quality

Recycling, services and water for millions of customers. The REMONDIS Group

Since its foundation in 1934, REMONDIS has become a leading international recycling, service and water company – built up on the solid foundations of a family-run business full of tradition. The Group employs over 30,000 people – at around 500 locations in 34 countries in Europe, Africa, Asia and Australia.

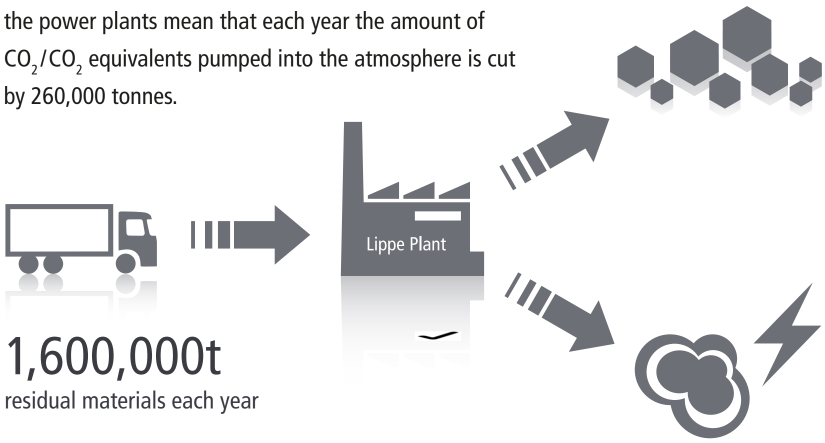
Processing & production – no compromises. The REMONDIS Lippe Plant

The experts at the REMONDIS Group are continuously working on further increasing the efficiency of the technology used to recover raw materials and energy from waste. Over the last few years, several new processing and production facilities have been opened up at the REMONDIS Lippe Plant alone. They play an important role helping to conserve primary raw material and energy resources and prevent climate change – and to make the REMONDIS Lippe Plant what it is today: a global role model.

Saving primary raw materials and energy at the Lippe Plant

- The two power plants on the site are fired using secondary fuels and timber. As a result, the demand for primary energy sources is reduced by 130,000 tonnes each year.
- In addition, the low-energy methods used to recover raw materials and the environmentally friendly fuels used in the power plants mean that each year the amount of CO_2/CO_2 equivalents pumped into the atmosphere is cut by 260,000 tonnes.

1,100,000t
raw materials + products per year

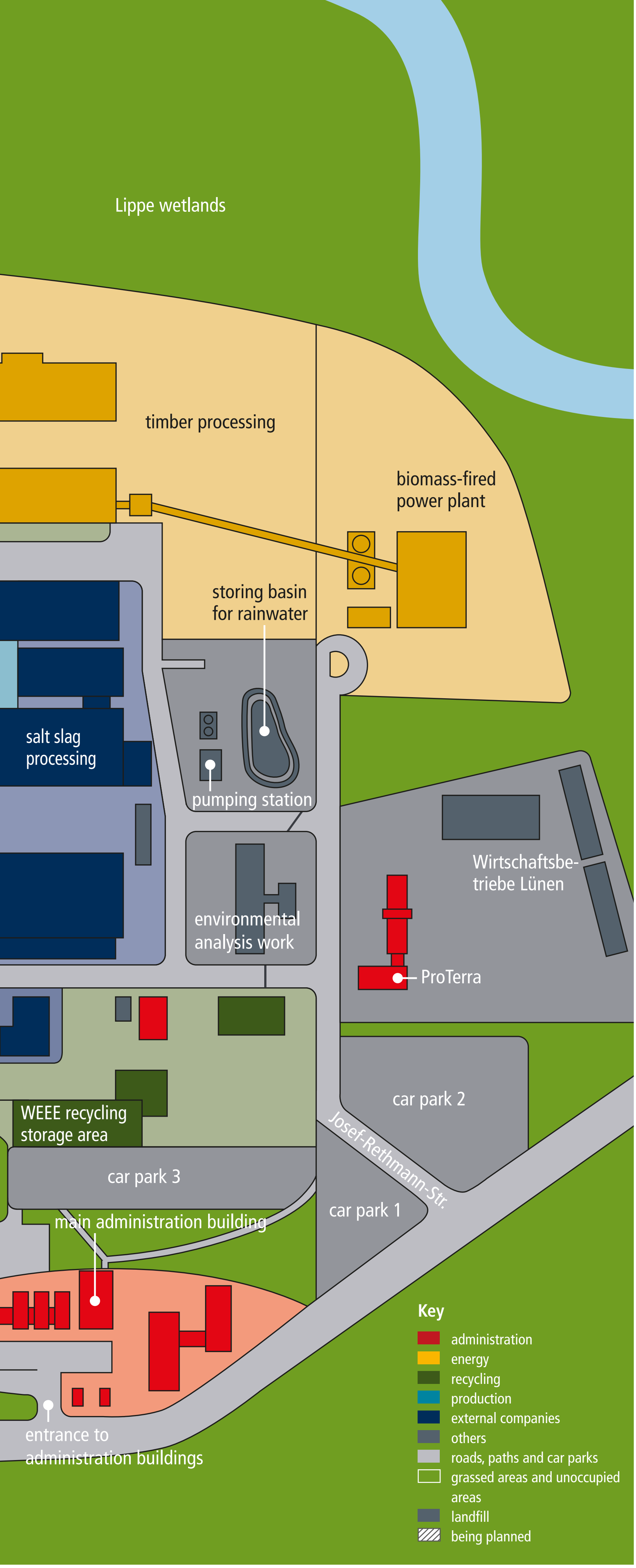


1,600,000t
residual materials each year

Each year, over 1.6 million tonnes of residual materials are treated in Lünen to produce more than 1 million tonnes of raw materials and products as well as 300,000 MWh of electricity and steam

300,000 MWh
electricity + steam per year

1) Production of fuels for thermal recovery



Central location, wide range of services, industrial infrastructure

The REMONDIS Lippe Plant has an excellent on-site infrastructure as well as extremely good transport connections. The harbour on the Datteln-Hamm Canal, the numerous direct railway connections, the plant's central location within the German motorway network and its proximity to Dortmund Airport all ensure that the company and its facilities can be reached by everyone – whatever their preferred means of transport may be.

One location, four segments

Raw materials	We process waste so that it can be fed back as raw material into economic or energy cycles.
Products	We produce high quality base materials, special products and industrial goods.
Energy	We produce biodiesel as well as substitute fuels and run eco-friendly power plants.
Industrial location	We offer industrial businesses, that wish to use our attractive infrastructure, the space they need to realize their ideas.

> Facts & Figures

Total area	230 ha
Production area	ca. 100 ha
Plant landfill	ca. 50 ha
Green / unused areas	ca. 80 ha
Employees	> 1,400
Input amount	1,600,000 t/a
Output amount	1,000,000 t/a
Output energy generation (electricity & steam)	300,000 MWh/a
Investments*	ca. 400 million EUR

* as in 2013

The REMONDIS Lippe Plant.
A location with many facets

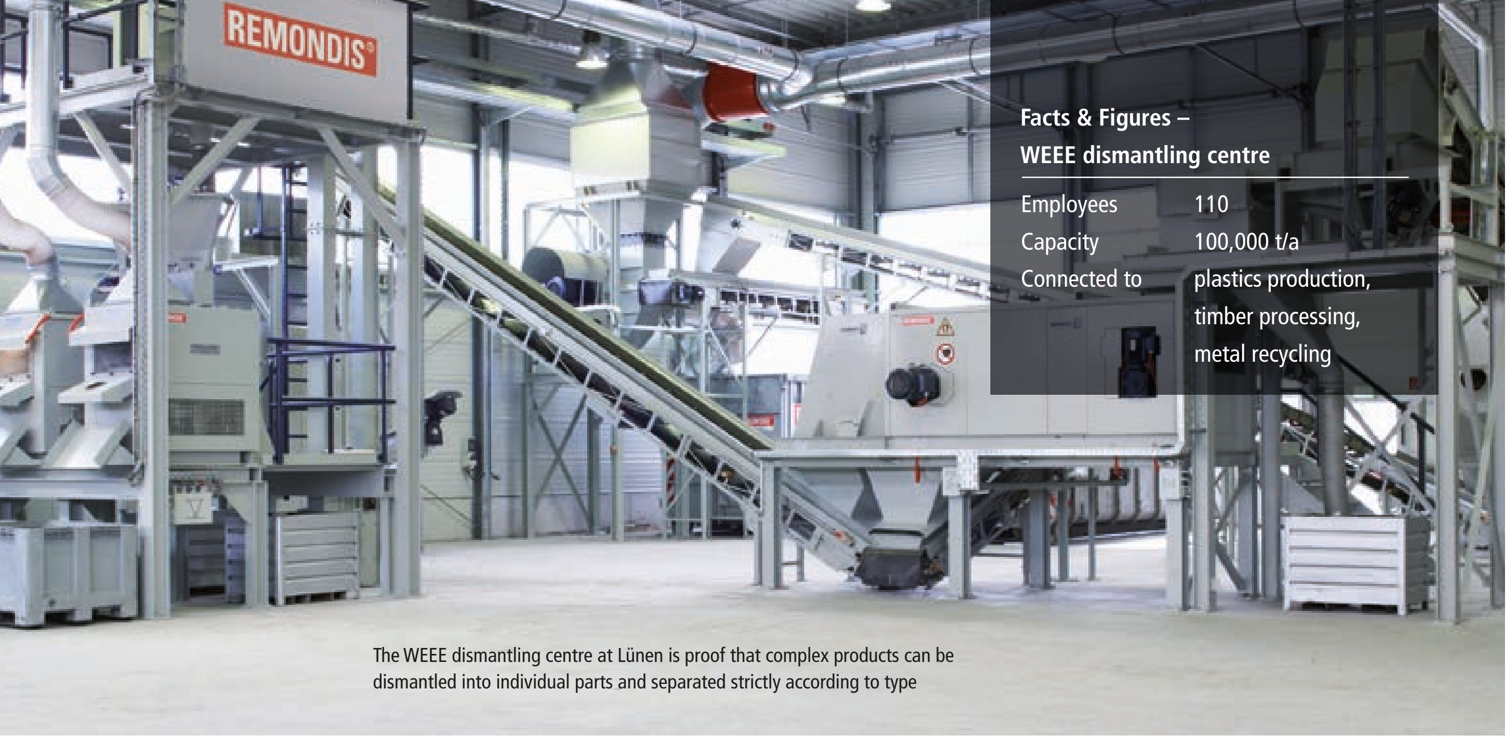

composting plant
timber processing
production of
binding agents
production
of biodiesel


plastics recycling
metal slag processing
WEEE dismantling centre
biomass-fired power plant
environmental analysis work
earthworks
SecAnim

The REMONDIS Lippe Plant produces high quality raw materials, base materials and special products. Over the years, many pioneering ideas have been tested here before being successfully introduced to the market

Top quality material recovery

REMONDIS works continuously towards ensuring that more and more residual waste and discarded products can be recycled – and not only so that such work is technologically possible but also so that it makes good economic sense. In Lünen – as at our other locations around Europe – we have built industrial-scale processing facilities and dismantling centres in which top quality raw materials are recovered once any hazardous substances have been carefully removed.



Facts & Figures – WEEE dismantling centre

Employees	110
Capacity	100,000 t/a
Connected to	plastics production, timber processing, metal recycling

The WEEE dismantling centre at Lünen is proof that complex products can be dismantled into individual parts and separated strictly according to type

Recovering raw materials from waste electrical and electronic equipment

At its WEEE dismantling centre in Lünen, REMONDIS Electrorecycling operates two recycling lines – for cooling appliances as well as for small electrical devices and consumer electronics – and a dismantling line for visual display units.

REMONDIS runs a total of seven such dismantling centres across Europe

Practically all of the recycling stages at the centre are now automated. First, any hazardous substances are removed from the equipment in an environmentally friendly manner and then the appliances are dismantled using mechanical processes. This multi-stage system, with its various kinds of shredding and separation technology, generates around 100 recyclable and special materials such as plastics, metals and glass. These can all be fed back into production cycles. These excellent results show that it is also well worth counting on REMONDIS' many years of experience when it comes to dismantling WEEE.

The dismantling and shredding processes used at the dismantling centre in Lünen generate top quality raw materials separated strictly according to type

Input 01
cooling and freezing appliances, TVs, VDUs, small household appliances, IT equipment, consumer electronics, tools, garden equipment etc

Processes 02
removing hazardous substances, shredding/crushing, sorting

Output 03
plastics, copper, iron, non-ferrous metals, composite materials, capacitors, batteries, waste oil, CFCs, timber, panel glass

Timber recycling and the production of substitute fuels

A modern timber recycling facility is located at the REMONDIS Lippe Plant. The different types of wood treated there are used as a carbon-neutral fuel for the neighbouring biomass-fired power plant (BMK).

The old furniture and other types of discarded wood must first be processed before they may be used to generate energy at the BMK. First, any iron pieces and other unwanted materials are removed. The waste timber is then sorted, cut up, screened and separated. Around a fifth of the treated waste timber is of the right quality and of the same type so that it can be re-used to produce chipboard. This material is sent to other timber processing facilities within the company group for further treatment.

The remaining wood chips are transported to the neighbouring BMK as a carbon-neutral fuel. As there are so many ways for the timber processing facility and the BMK to cooperate, they have joined together and are run by the company Biomassekraftwerk Lünen GmbH.

The old wood treated at the timber processing facility is used as a fuel by the neighbouring biomass-fired power plant

01 Input	02 Processes	03 Output
construction waste, packaging, bulky waste, screen overflow etc	sorting, shredding, screening, separating	substitute fuel for the BMK

The timber recycling facilities at Lünen use high performance shredders and quality control mechanisms

Facts & Figures – timber recycling

Employees	14
Capacity	430,000 t/a
Connected to	biomass-fired power plant (BMK)

High-grade steel and non-ferrous metals from slag

Slag and waste from kilns used for high-grade steel and non-ferrous metal production processes contain considerable amounts of high quality alloys. REMONDIS recovers these valuable materials at the Lippe Plant.

The processing methods result in the slag being separated into such pure fractions that the recyclable materials can be returned to the manufacturers to be used once again in the production processes.

Unwanted materials are carefully removed and processed separately so that, once all hazardous substances have been removed, they can be used for building landfills and embankments.

A multi-stage process is used to treat the slag

01 Input	02 Processes	03 Output
metal slag, waste from kilns	shredding/crushing, screening	high-grade steel and non-ferrous metal granulate, ground slag

Facts & Figures – metal slag processing

Employees	15
Capacity	250,000 t/a
Connected to	mineral recycling, metal recycling

The earthworks supply special types of soil for use in landscaping

Facts & Figures – earthworks

Employees	2
Capacity	100,000 t/a
Connected to	composting plant

Quality earth for landscaping work

The recycling of biological materials is perhaps the most natural of all recycling activities. In-depth expertise is needed here, too, if the best possible solutions are to be found for all stages of the supply chain.

At our earthworks, we produce arable soils from earth, cleaned grit chamber contents and additional materials such as volcanic rock flour and other nutrient suppliers. Once processed, the soils have the same physical characteristics and nutrient contents as normal topsoil. They are used in landscaping as well as for planting greenery on landfills and spoil dumps. For the soils to be a source of humus, additional substrates are also used from the composting division.

The careful processing techniques are subject to regular quality controls

The earthworks is connected to the composting plant on the site

Input 01
excavated earth, grit chamber contents, slag, sludge

Processes 02
crushing, screening, mixing

Output 03
humus soils


ALUMIN®

High-quality production processes

REMONDIS has built industrial production facilities in Lünen for high quality base materials, special products and industrial goods and is continuously extending this area. When developing new ideas, priority is always given to the marketability of the potential products. The company's own secondary raw materials are primarily used to manufacture such products as well as primary raw materials – and the success of these products on the market has proven that the developers were right: ALUMIN®, CASUL®, PLANOLEN® and other brand-name products are in high demand from a wide variety of sectors all across the world – from the chemical industry, to food production, to medical technology.

Facts & Figures – production of ALUMIN®

Employees	12
Capacity	100,000 t/a
Connected to	CASUL® production facilities

A number of complex procedures must be carried out to produce ALUMIN®

ALUMIN® – a special chemical for the water sector and construction chemicals

Sodium aluminate is not simply sodium aluminate. ALUMIN®, a REMONDIS product manufactured at the Lippe Plant, clearly stands out from other similar products thanks to its high purity, its very high levels of reactivity and its very great stability.

ALUMIN®

ALUMIN® has been marketed successfully for many years now

The processes used to treat the surfaces of aluminium parts and the production of catalytic converters result in the accumulation of solutions and sludge which contain aluminium. These substances are cleaned, concentrated and filtered by REMONDIS using a series of complex procedures. By adding a certain amount of primary raw materials, it is possible to produce varying qualities of pure ALUMIN®. ALUMIN® is a high-quality sodium aluminate with excellent product characteristics making this special chemical particularly interesting for the water branch. ALUMIN® is used, for example, as a flocculation agent for treating wastewater and producing drinking water. However, ALUMIN® is also used for construction chemicals, for producing chemicals and also to produce CASUL®, a white mineral developed by REMONDIS.

ALUMIN® is a high quality special chemical which is used, among other things, as a flocculation agent for treating wastewater and producing drinking water

01 Input	02 Processes	03 Output
sodium hydroxide solutions, aluminium hydroxide, solutions containing aluminium, filter cake and sludge	cleaning, concentration, filtration	ALUMIN® 7, ALUMIN® 8, ALUMIN® 10, ALUMIN® HQ

CASUL® – a white mineral for paint, plaster and paper

CASUL® is a remarkably white, synthetic mineral (ettringit) which has been developed by REMONDIS itself. The product is ecologically safe and, for many applications, enables production processes to be carried out without harmful biocides, preservatives or softeners.

Besides its high covering capacity, CASUL® is a highly sought-after product due to its gloss-giving qualities. CASUL® can be used in the following areas:

- paper industry – CASUL® as an ingredient or mineral in coating solutions for refining the surface of high quality glossy paper for art prints as well as for food packaging
- paint industry – CASUL® as a white mineral in dispersion paint with a high covering capacity as well as in eco-paints (paints containing CASUL® do not need harmful additives such as biocides and preservatives). The paints are also sold under the company's own brand, CasuBlanca
- construction chemicals – CASUL® as a white mineral in liquid plaster

CASUL® is an extremely white mineral which is delivered in both liquid and solid form and is found in, for example, the 'Royal' liquid plaster and 'Easy-Putz' plaster produced by the company Knauf

An important raw material used to manufacture CASUL® is ALUMIN® which is also produced at the REMONDIS Lippe Plant

Input	Processes	Output
ALUMIN® and other high quality raw materials	patented, multi-phase process: HSDP – High Solid Dispersion Process	casulwhite HSP 1®, casulbin HSP 2®, casulprint HSP 1®, CasuBlanca paints, casubin 30, casul powder H1i

Facts & Figures – production of CASUL®

Employees	3
Capacity	15,000 t/a
Connected to	ALUMIN® production facilities

PLANOLEN® and PLANOMID® – plastics from waste rather than crude oil

RE PLANO produces and sells different qualities of plastic granulates and compounds under its PLANOLEN® and PLANOMID® brand names. A large amount of the granulates are produced according to individual customer specifications fulfilling particular requirements concerning function and colour.

PLANOLEN®
PLANOMID®

Another plastics production plant can be found in Taipei

PLANOLEN® granulates conform to all important ISO and DIN industrial standards and provide a reliable quality. Several granulates of this brand have received the mark of quality from the RAL-GRS

PLANOLEN® is non-ageing, light and water-repellent; it can stand tension yet is still solid. This top quality granulate is also very pure so that the products made from it are of a consistently high standard. PLANOLEN® is, therefore, especially suitable for extrusion and injection-moulded products, cable ducts, pipes, pallets, building products, containers, films, bags, sacks etc.

PLANOMID® granulates stand out thanks to their high stability, long lifespan and the fact that they are resistant to petrol, oil as well as many kinds of alcohol. PLANOMID® is an ideal material for products manufactured through injection-moulding processes and which have to stand high levels of use, such as components for fans, ventilation systems, switch boxes, vehicle parts, Rawlplugs and casing for electrical appliances.

Input 01
waste packaging, production rejects and other high quality raw materials

Production 02
coarse & fine shredding, metal extraction, cleaning, compounding, granulation

Output 03
PLANOLEN® and PLANOMID® granulates, HPDE ground material

Facts & Figures – production of PLANOLEN® and PLANOMID®

Employees	36
Capacity	27,000 t/a
Connected to	WEEE dismantling centre

Facts & Figures – CASEA production

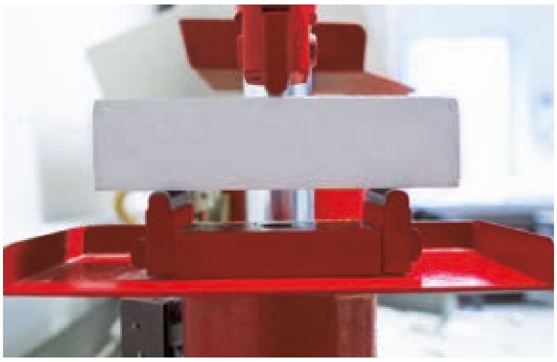
Employees	40
Capacity	350,000 t/a
Connected to	mineral recycling facilities

The storage hall at the REMONDIS Lippe Plant has the capacity to hold 35,000 tonnes of gypsum

CASEA – binding agents for construction materials, dental plaster and more

Large amounts of gypsum are produced as a result of the desulfurization of flue gases at power plants fired with fossil fuels. Around 350,000 tonnes of this gypsum are processed at the REMONDIS Lippe Plant each year and turned into additives and binding agents by CASEA.

One of the main reasons determining the quality of a plaster is the choice of binding agent. CASEA produces calcium sulfate binding agents from the purest FGD gypsum – using production technology that guarantees the products have excellent properties. These binding agents fulfil the most stringent of standards, are adapted to fulfil specific application requirements and can be used to produce liquid screed and porous concrete, fertilizers and cement as well as for materials used in dentistry.



CASEA
WORKING FOR THE FUTURE

The production processes that we use to make raw materials of such consistently high quality are unique across the world – a fact which quality tests have proven

Input 01
FGD gypsum from coal-fired power plants and chemical gypsum

Production 02
calcination, grinding, mixing, refinement

Output 03
Raddipor, Raddipur, Raddiplus B, Raddiplus C, Radditrans, Raddisprint, Raddichem, Raddiform, Raddident, Raddident SW, Raddifood, Raddikult D

HUMERRA® – compost products for good soils, earth and substrates

At the REMONDIS Lippe Plant, compost is produced for landscaping and horticulture businesses, for the agricultural sector as well as for growing special crops. These high quality products are marketed under the HUMERRA® brand name.

HUMERRA®

HUMERRA® produces specific types of compost for different sectors that always fulfil the exacting requirements of the various users

HUMERRA® supplies a comprehensive range of different quality-assured composts including special products such as substrates and mulch. They are all produced in Lünen using the Brikollare composting method, which was developed and patented by REMONDIS. Once the biologically degradable waste has been pre-sorted and freed of unwanted materials, it is first pressed into briquettes weighing between 50 and 60 kilos and then placed in an air-conditioned high-bay storage area where it decomposes at a temperature of up to 70 °C over four to six weeks. This means that each user receives exactly the right product to make their business a success.

Input 01	Production 02	Output 03
plant/tree cuttings, garden and kitchen waste from households	shredding, briquetting, decomposition	HUMERRA® Active Compost, Green Compost, Fine Compost, Structure-Improving Compost, Wood Chippings, Humus Soil, Substrates, Asparagus Compost, Mulch, Paddock Surface Material

Facts & Figures – HUMERRA® production

Employees	12
Capacity	58,000 t/a
Connected to	earthworks, biomass-fired power plant

The biodiesel is produced, as required, either from vegetable or animal fats and sold under the brand name, ecoMotion®

Facts & Figures – production of biodiesel

Employees	25
Capacity	100,000 t/a
Connected to	fleet of vehicles, pipeline to harbour and railway loading area

Biodiesel – energy from animal fats and used deep frying oils

Being one of the pioneers among the biodiesel producers, ecoMotion® uses vegetable and animal fats as well as processed deep frying oils from the restaurant trade to make the most eco-friendly and sustainable type of biodiesel currently being produced on an industrial scale.

Unlike the biofuels made from energy crops, the biodiesel produced from waste or residual materials at the Lippe Plant does not require any field space. This is an important advantage as far as its footprint is concerned but it is not the only one. Looking at the limited resources of natural crude oil, the dependency on crude oil imports and the needs of our environment, the biodiesel from Lünen has further advantages compared to mineral oil diesel:

- a reduction in hazardous emissions (lower particulate emissions, less carbon dioxide (CO_2), carbon monoxide, hydrocarbon)
- helps to conserve our fossil resources

Leading mineral oil companies use the biodiesel to fulfil the legal blending regulations.

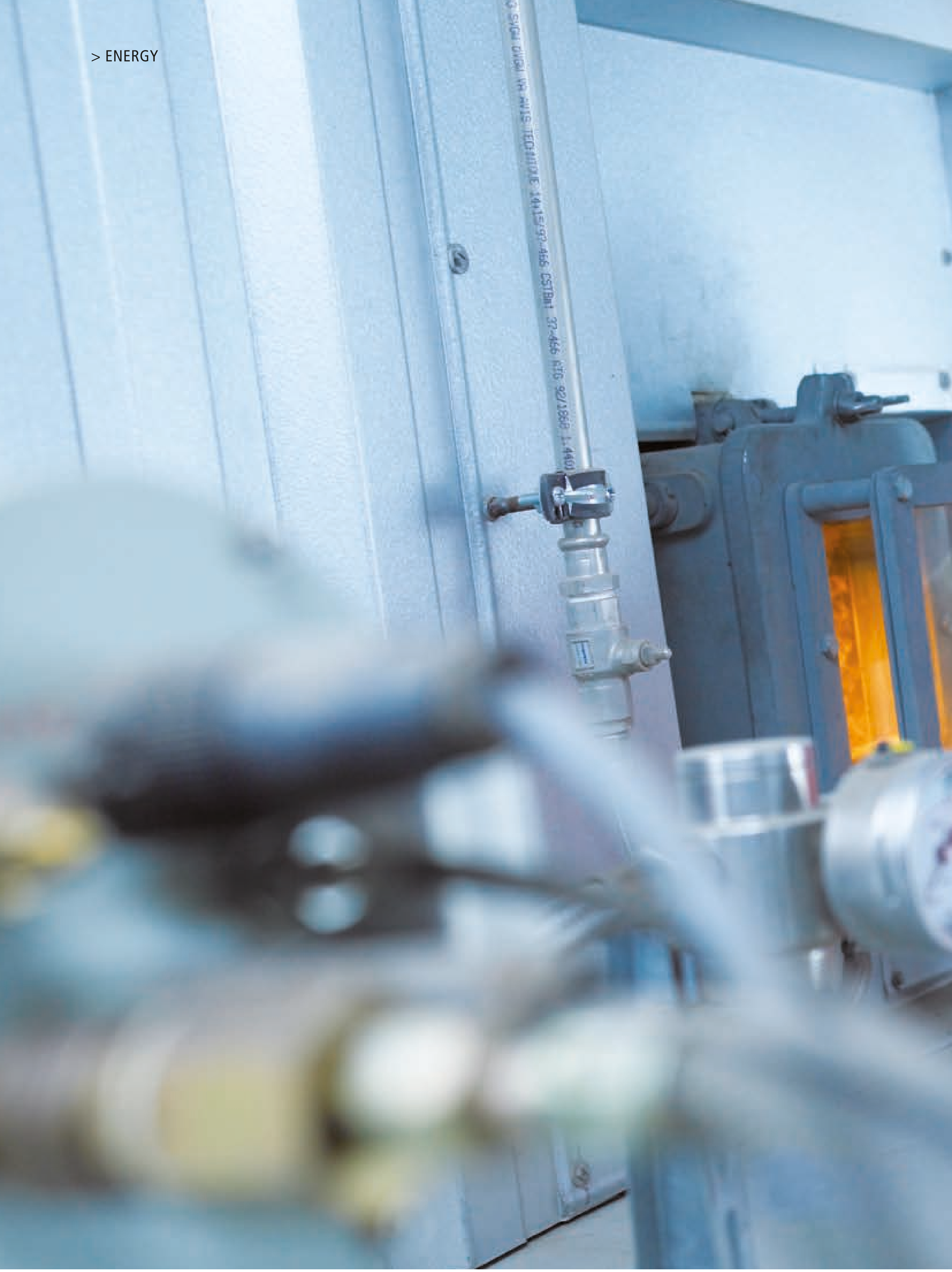
Across Germany, ecoMotion® has the capacities to produce over 240,000 million litres of biodiesel

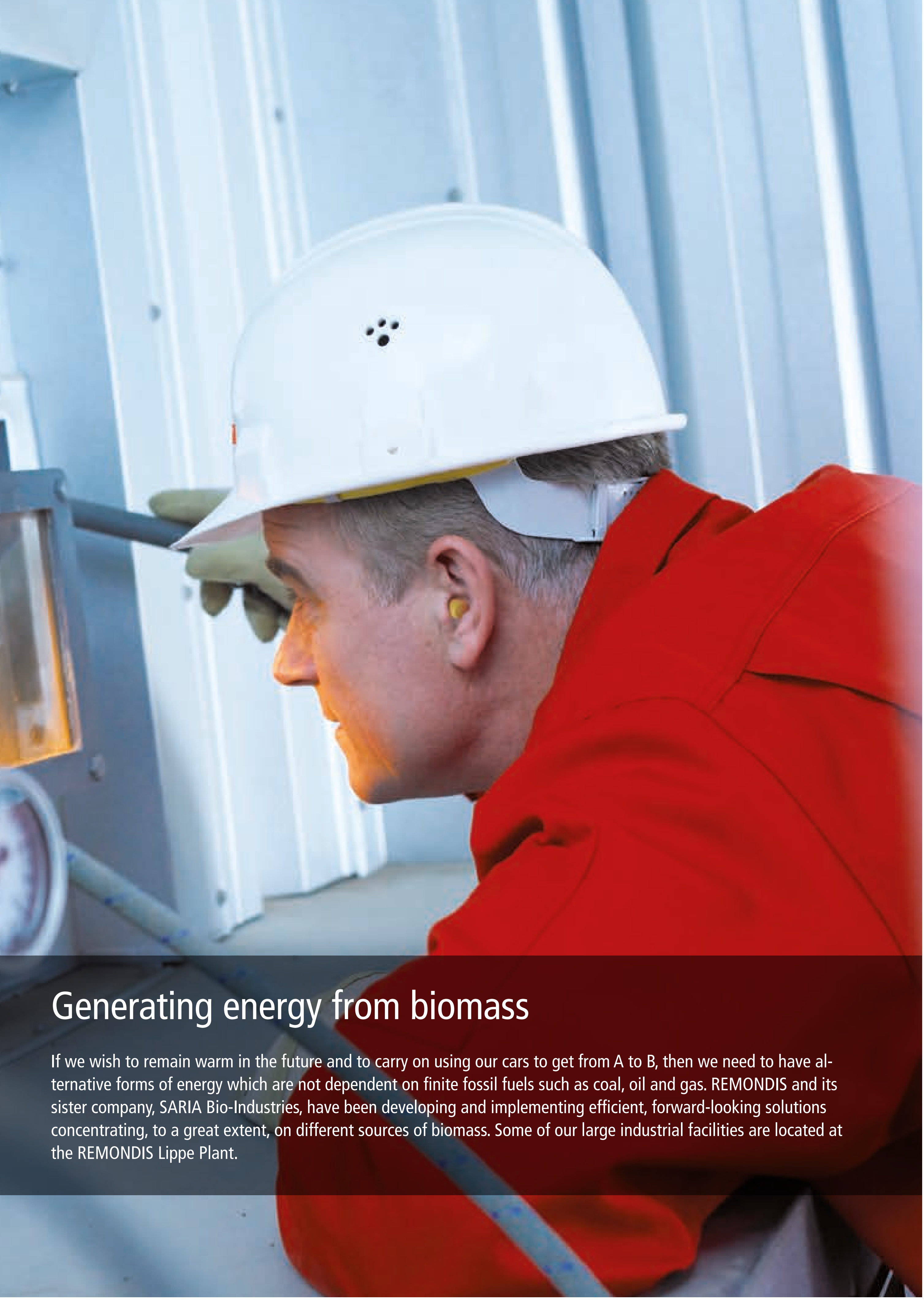
Compared to fossil fuels, the ecoMotion® biodiesel saves up to 83 percent CO_2

Input
vegetable and animal fats and oils
01

Production
multi-feedstock facilities
02

Output
biodiesel, glycerine, fertilizer
03





Generating energy from biomass

If we wish to remain warm in the future and to carry on using our cars to get from A to B, then we need to have alternative forms of energy which are not dependent on finite fossil fuels such as coal, oil and gas. REMONDIS and its sister company, SARIA Bio-Industries, have been developing and implementing efficient, forward-looking solutions concentrating, to a great extent, on different sources of biomass. Some of our large industrial facilities are located at the REMONDIS Lippe Plant.

Biomass-fired power plant – energy from waste timber and plant cuttings

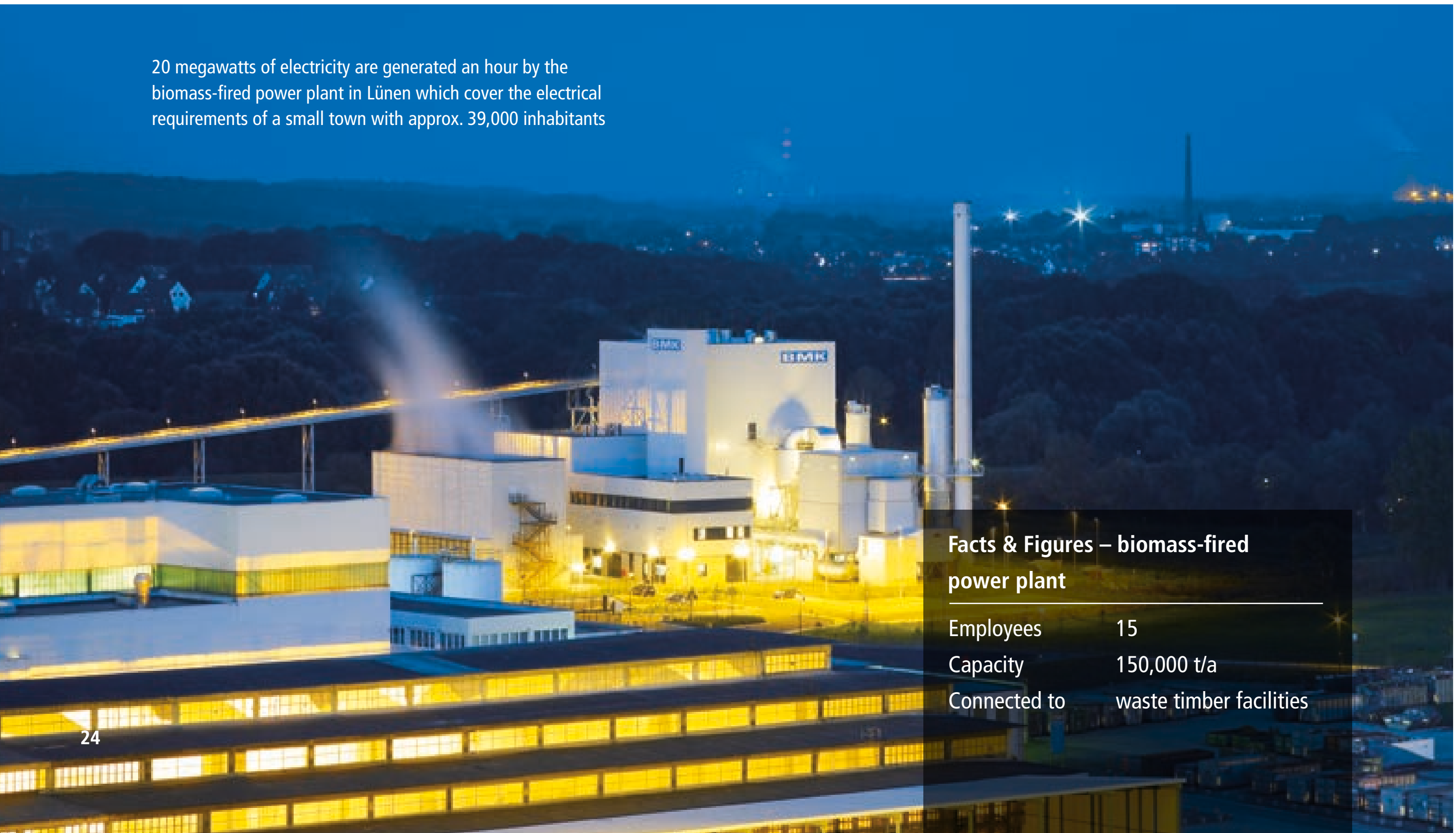
We have invested in an innovative and future-oriented market with our biomass-fired power plant (BMK), one of the most recent additions to the Lippe Plant. This facility is primarily run on waste timber and plant and tree cuttings.

The great advantage of generating electricity from biomass is the fact that economic and ecological factors have been united

Old wood must first be processed before it can be used to generate electricity. This work is carried out at the timber recycling facility at the Lippe Plant. The biomass is then transported by conveyor belt from the store to a feed bunker and then on into the grate furnace. The timber burns at over 850 degrees Celsius. The hot flue gases heat up water in a water-tube boiler to create steam. This, in turn, is fed into a condensing turbine to generate electricity. Following this, cooling water is used to condense the "used" steam in a wet cooling tower. Finally, the flue gases generated as a result of the incineration process are cleaned via the flue gas system using a dry process.

The generation of electricity at the BMK is carbon-neutral; CO_2 emissions are, therefore, cut by 100,000t a year

Input (01)	Verfahren (02)	Output (03)
waste timber, plant/tree cuttings, surplus materials from the composting plant	fuel-bed firing	155,000 MWh/a electricity



20 megawatts of electricity are generated an hour by the biomass-fired power plant in Lünen which cover the electrical requirements of a small town with approx. 39,000 inhabitants

Facts & Figures – biomass-fired power plant

Employees	15
Capacity	150,000 t/a
Connected to	waste timber facilities

The facilities used to treat and process abattoir waste and fallen animals are one of the most modern in Europe

Facts & Figures – fuels from animal raw material

Employees	48
Capacity	80,000 t/a
Connected to	fluidised-bed power plant

Innovative fuel production – energy from animal raw material

The SecAnim plant in Lünen sterilizes and thermally treats abattoir waste and fallen animals. SARIA, one of REMONDIS' sister companies, officially opened the plant on the site in 2003.

By processing high risk material from animal by-products, it is possible to recover fats and to create meat paste which can be used as an alternative fuel. The fats are marketed as a primary product for manufacturing biodiesel; the sterile meat paste is sent directly to the fluidised-bed power plant on the site as a fuel. It is essential to have the most stringent of hygiene standards in place when handling animal by-products which must, of course, be adhered to at all times. To ensure the system is absolutely safe, therefore, this special process is carried out in precise, pre-determined stages – from taking samples, to cutting up and sterilising the material, to removing the fats.

SARIA's subsidiary, SecAnim, guarantees that the highest possible safety standards are implemented when disposing of high risk material from animal by-products

Input 01	**Production** 02	**Output** 03
abattoir by-products and fallen animals	processing and conditioning facilities	fuels (fat and degreased meat paste)

Fluidised-bed power plant – energy from alternative sources

REMONDIS needs its own power plant to be able to provide the production facilities at the Lippe Plant with energy – be it electricity, process steam or compressed air. The fuels used to power the plant are primarily secondary and substitute fuels.

REMONDIS supplies itself with energy from its fluidised-bed power plant

All processes at the power plant are monitored via the central control room

It is not possible for the power plant to be fired completely (i.e. 100 %) with secondary and substitute fuels due to the conditions set down in its permit. The fuels used by the fluidised-bed power plant at the Lippe Plant include, among others, the sterilized liquid meat paste from the neighbouring rendering plant which processes abattoir waste and fallen animals – a process which is unique across the whole of Europe. Furthermore, approx. 170 types of waste listed in the European Waste Catalogue can be thermally treated in the fluidised-bed power plant. This covers both solid and liquid waste.

Input
sterilized meat paste, animal meal, waste from the chemical & pharmaceutical industry, substitute fuels, sewage sludge etc
01

Production
fluidised bed combustion
02

Output
50,000 MWh/a electricity, 135,000 t/a steam, 55,000,000 m³/a compressed air
03

The power plant at the Lippe Plant supplies the site with electricity, process steam and compressed air – generated from alternative energy sources

Facts & Figures – fluidised-bed power plant

Employees	42
Capacity	215,000 t/a
Connected to	the whole site

And finally a quick look back

Covering a total of 230 hectares, the REMONDIS Lippe Plant is the largest industrial recycling centre in Europe. Over the last few years, REMONDIS has invested more than 400 million euros and efficiently developed the site. This has resulted in the creation of a large number of jobs: 476 people were working at the site at the time of the takeover; this has increased to more than 1,400 – and the number continues to grow.

A successful structural change, a lively history, a lively area – the most important facts & figures:

1938	Production site is put into operation by the Vereinigte Aluminiumwerke (VAW)
1987	Production of aluminium oxide is closed down, first steps to find alternative uses
1993	Takeover of the site by REMONDIS – the start of the company's plan to set up an industrial recycling centre with activities in the area of gypsum, chemicals, wood, plastics and fuels
1996	Composting plant is put into operation
2003	The rendering plant for processing animal by-products into substitute energy goes into operation
2005	New facilities for recycling plastics and producing white minerals (CASUL®) are put into operation
2006	The WEEE dismantling centre, the biomass-fired power plant and the biodiesel production plant all go into operation
2008	Construction of the new Umwelt Control Labor (UCL) building for analysing and assessing materials
2010	Construction of a new administration building next to the main head office building
2010	Investment in turbine 4 in the FBC plant – to generate electricity from surplus steam to further reduce dependency on external power supplies
2010–2013	Renovation of diverse outer walls of the furnace buildings as a long-term maintenance measure
2011–2013	Comprehensive measures undertaken to reduce noise levels
2013	Wastewater pipeline cleaning system is altered as part of a project to revive the River Emscher
2013–2014	Redevelopment of the landfill's plateau including landscaping work
2013–2014	Construction of a new administration building

Delegations from Eastern Europe and Asia regularly visit the REMONDIS Lippe Plant to see for themselves how a truly effective recycling system is run

Group companies located on the site

- ecoMotion® – production of biodiesel
- REMONDIS Aqua – supplying drinking water / treating wastewater
- REMONDIS Electrorecycling – recycling of WEEE
- REMONDIS Industrie Service – full range of services covering hazardous waste
- REMONDIS Medison – recycling of photographic chemicals and hospital waste
- REMONDIS Production – production of high quality raw materials, base materials and products
- RE PLANO – plastics recycling / marketing
- REMEX ProTerra – remediation services
- RETERRA® – compost production / marketing

REMONDIS' main administration offices are also located at Lünen. It is from here that the family-owned business is run

- SecAnim – recycling of animal / vegetable products and residual materials
- UCL – environmental laboratories
- WBL – Wirtschaftsbetriebe Lünen
- XERVON – technical services for the process industry

REMONDIS®

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REMONDIS is one of the world's largest recycling, service and water companies. The company group has more than 500 branches and associated businesses in 34 countries across Europe, Africa, Asia and Australia. With over 30,000 employees, the group serves around 30 million people as well as many thousands of companies. The highest levels of quality. Working for the future.

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廢棄物處理場介紹

(德國)萊茵-埃爾夫特市回收中心

ABA-VZEK

廠區鳥瞰圖

ABA VZEK

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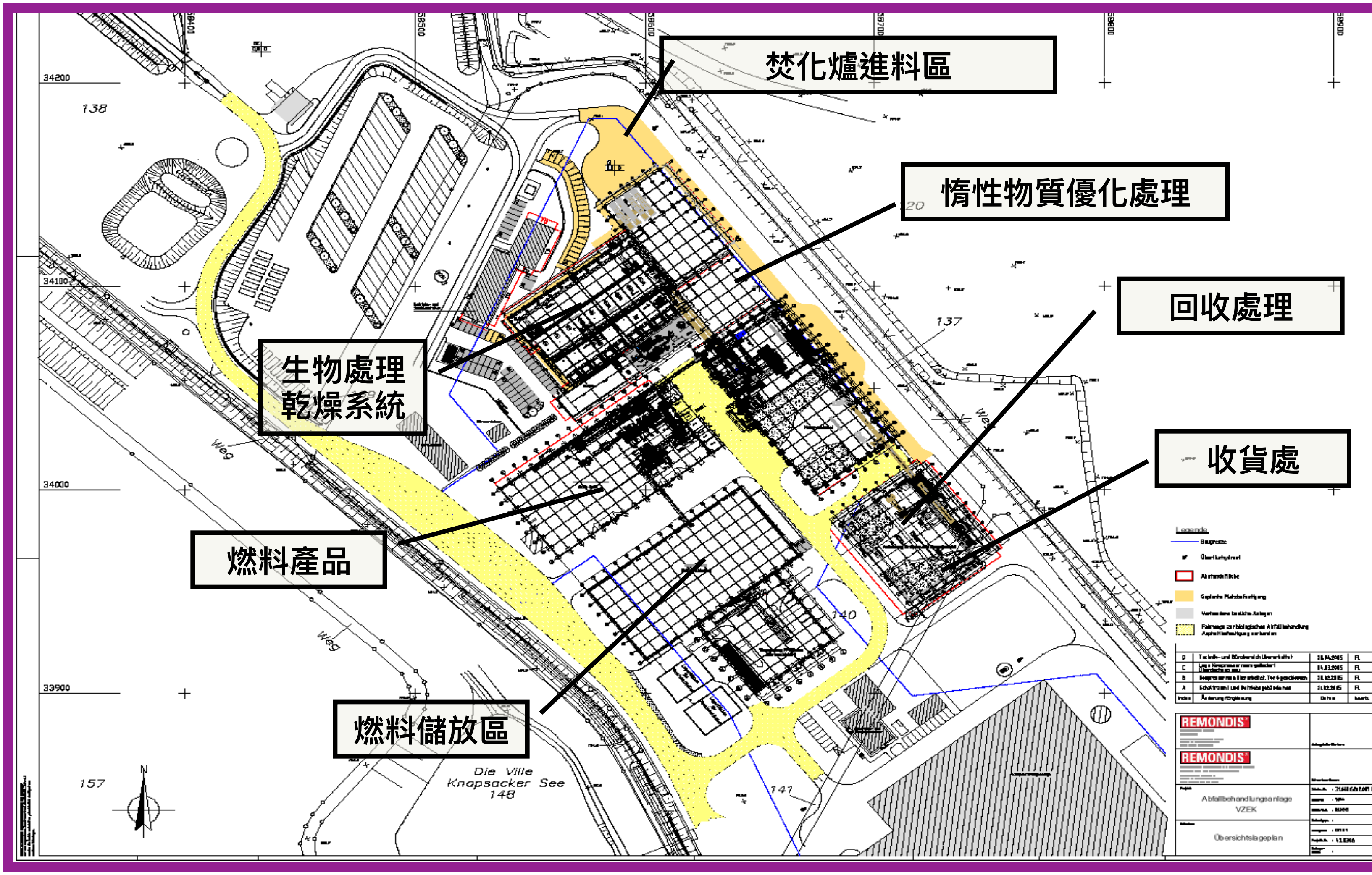
REMONDIS GmbH Rheinland **Plant Erftstadt**



處理綱要

objectives

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分選出較適合作為燃料的廢棄物

將廢棄物進行分類

考量燃料品質的基本條件

熱值高

中性

惰性

提供穩定的熱值燃料給當地焚化爐，或需要用燃料的產業

以生物系統乾燥處理降低廢棄物回收總量

分離含惰性物質廢棄物(如沙子、玻璃)

投入產出分析

Mass balance

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投入

城市垃圾	約 93.000 噸/年
大型廢棄物	約 22.000 噸/年
商業廢棄物	約 15.000 噸/年
工業廢棄物	約 15.000 噸/年
Total :	**約 145.000 噸/年**

- 船運產出的垃圾 約 12.000 **噸/年** (DSD/PPK)

產出

焚化用碎片	約 39 %
燃料	約 36,5 %
含惰性成份的物質	約 5 %
可回收物質	約 3,5 %
非鐵金屬	約 0,5 %
雜質	約 0,5 %
腐植流失	約 15 %

(處理過程中流失的生物物質)

處理流程

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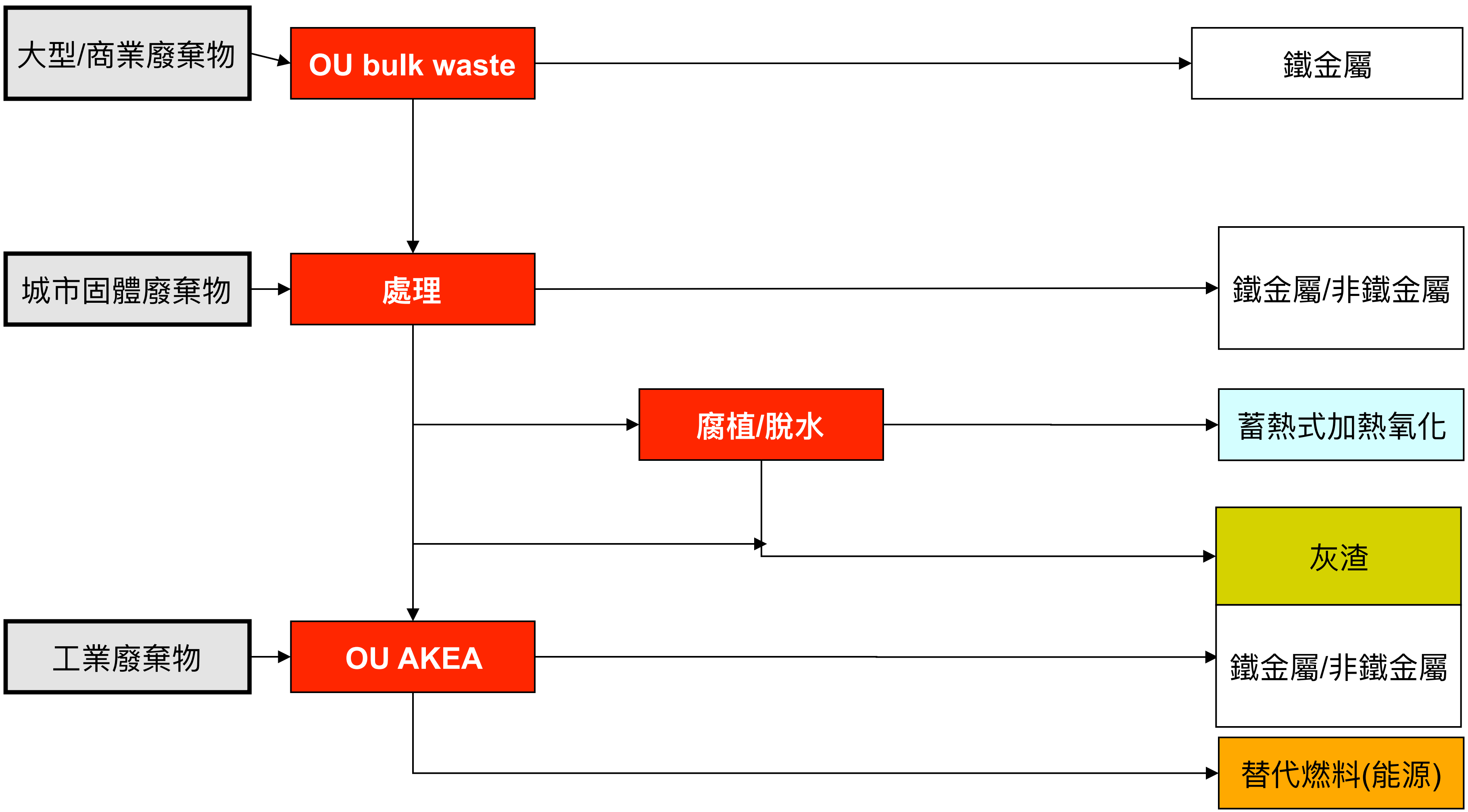
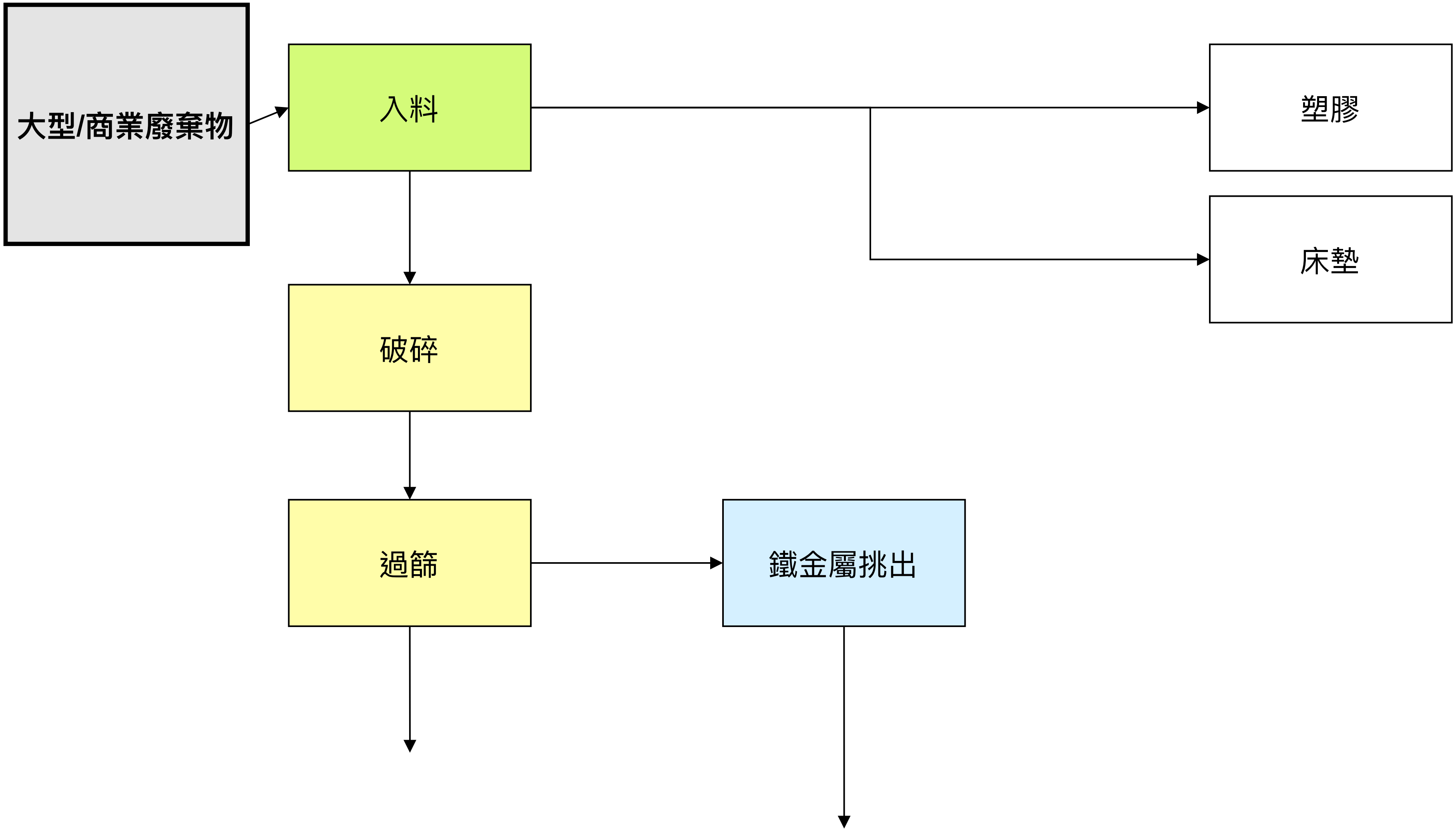


大型廢棄物
處理流程



(大型)廢棄物倉儲

Photos

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城市固體廢棄物
處理流程

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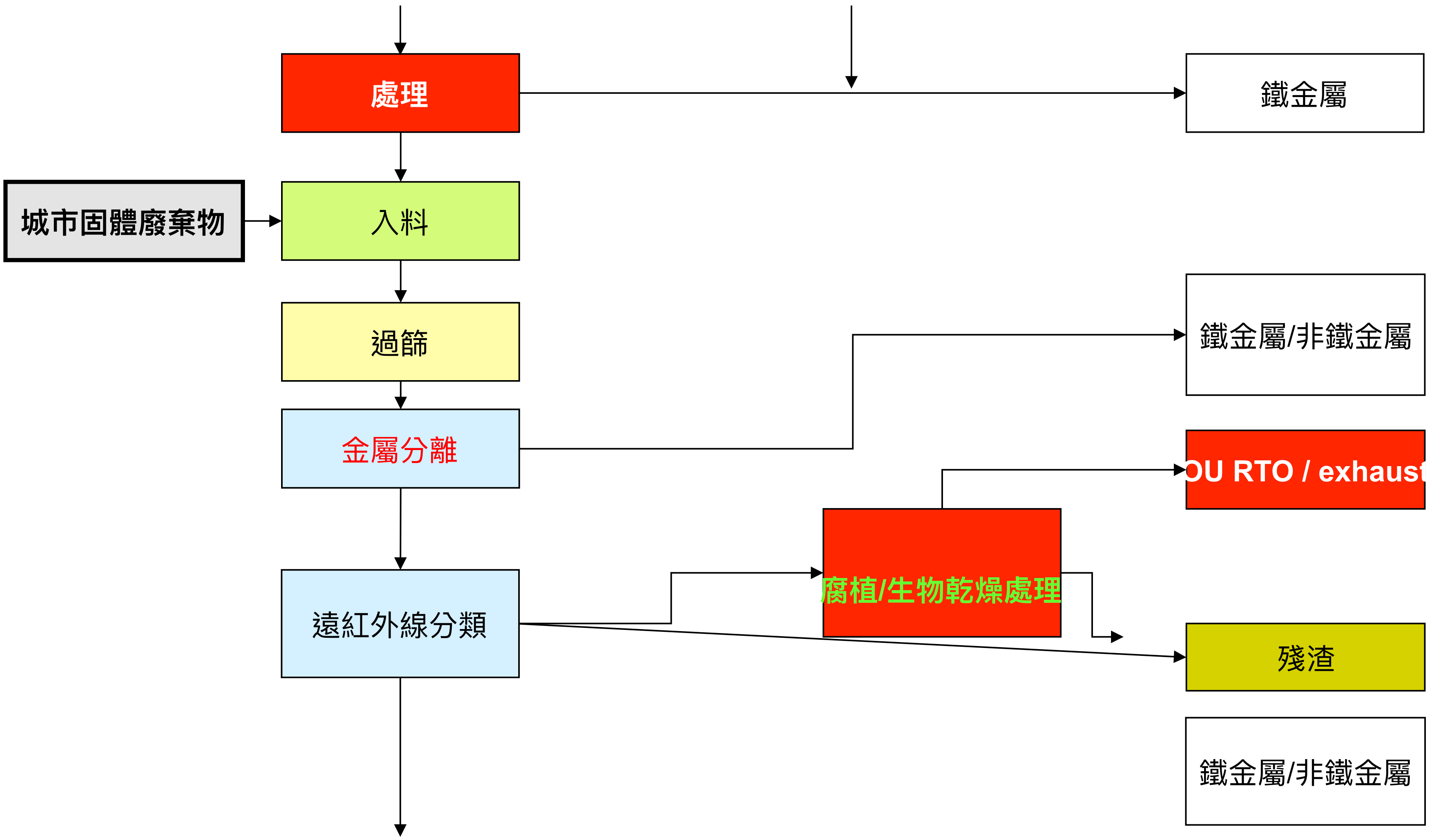
REMONDIS GmbH Rheinland Plant Erftstadt



紅外線分類

Near-infrared separation of high heat value fractions

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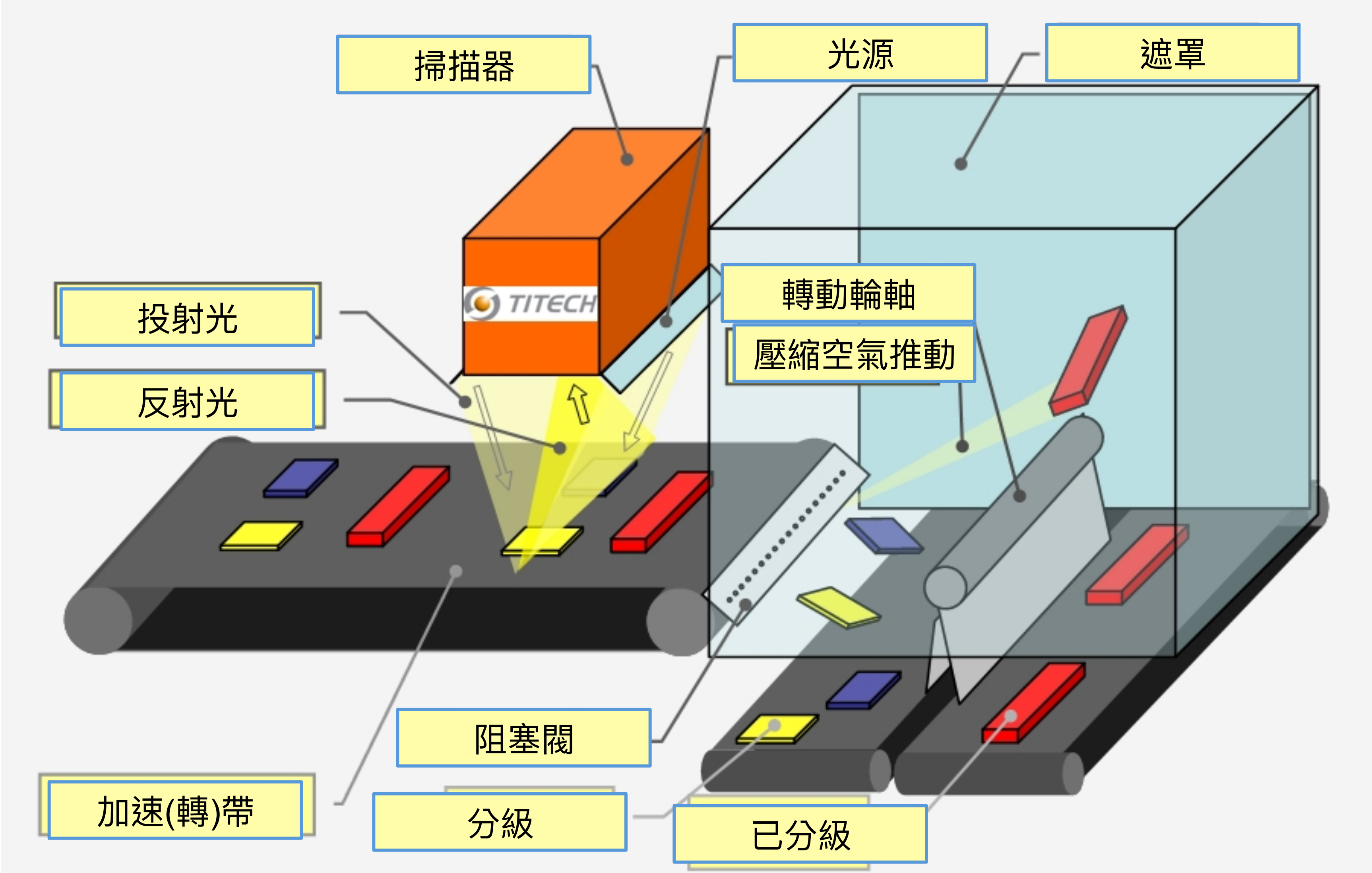

城市固體廢棄物

Photos

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工業廢棄物
處理流程

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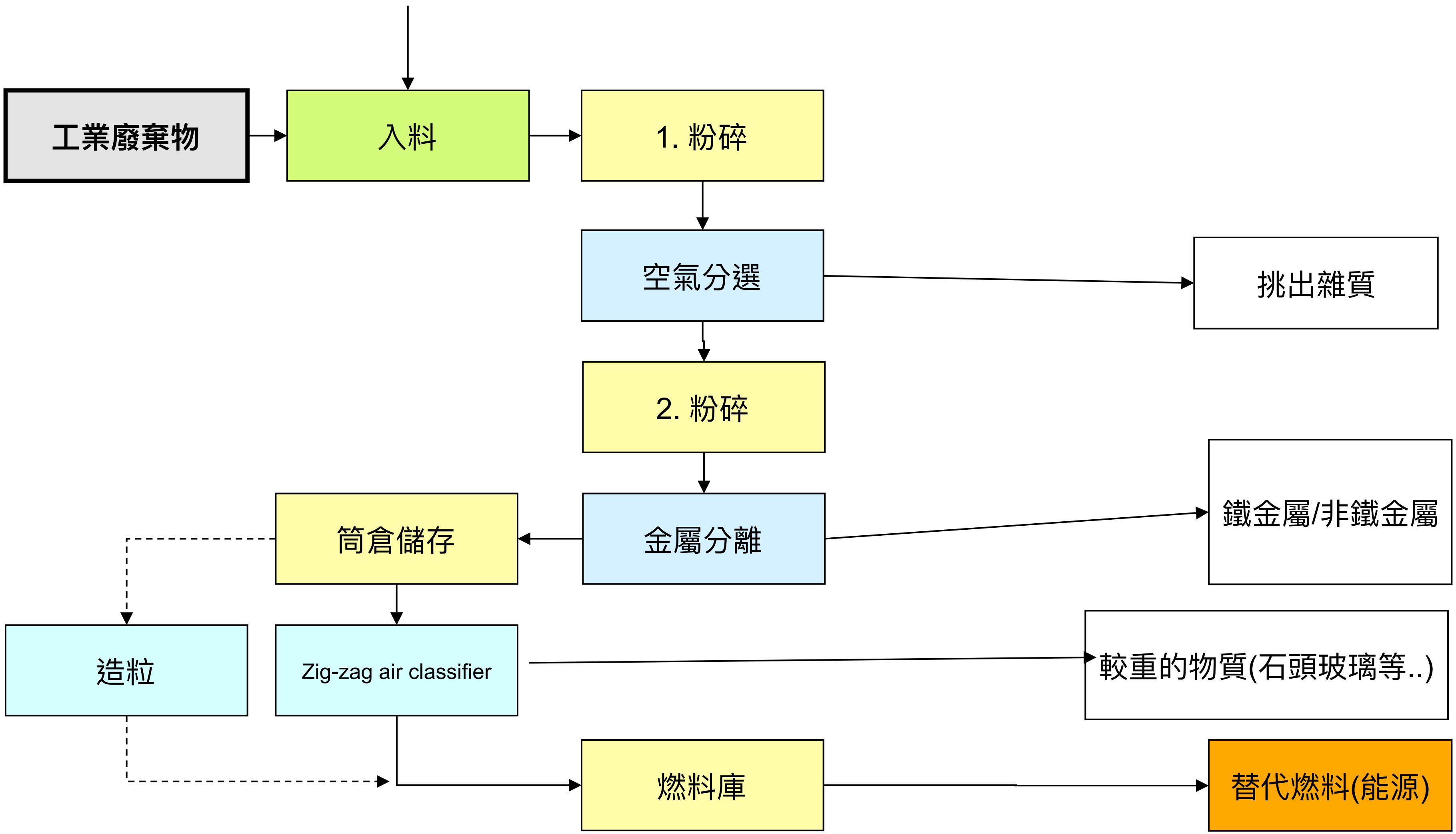

工業廢棄物

Photos

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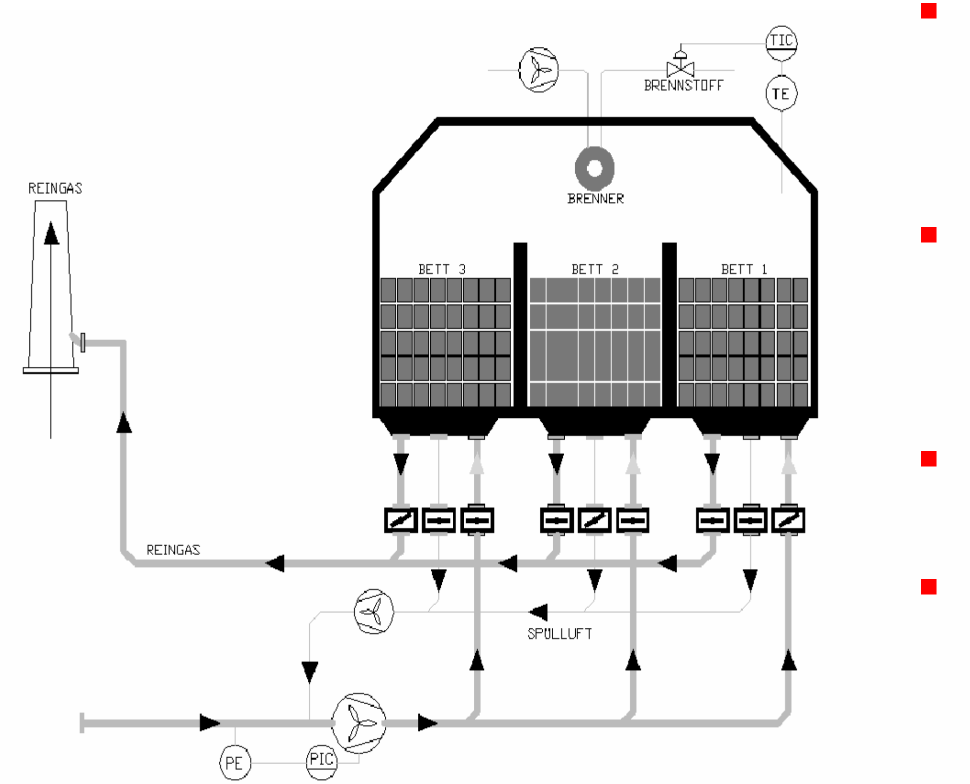
尾氣的循環再生熱氧化處理流程圖

RTO - Regenerative Thermal Oxidation



- 尾氣進入燃燒室高溫燃燒以確保碳氫化合物完全消滅
- 多效熱交換器進行廢熱回收以節省熱能
- 廢氣排放低於30. BImSchV
- 廢氣排放須連續且定期檢測

尾氣的循環再生熱氧化處理設備外觀圖

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WORKING FOR THE FUTURE

REMONDIS GmbH Rheinland Plant Erftstadt

脫水處理/惰性物質處理 (堆肥)

產品

REMONDIS®
WORKING FOR THE FUTURE

REMONDIS GmbH Rheinland Plant Erftstadt

SBS®：

- 替代燃料
- 供給發電站使用
- 熱值約 3100-4300千卡/kg (依客戶規格提供)
- 氯含量控制在0.5-0.7%

BioBS®：

- 替代燃料
- 供給發電站使用
- 熱值約
- 2600-3100千卡/kg (依客戶規格提供)
- 氯含量控制在0.4%

BPG®：

- 事業廢棄物產出燃料
- 供水泥廠使用
- 熱值約
- 4800-5700千卡/kg (依客戶規格提供)
- 氯含量控制在1.0%以下

- 可以接受客製化訂單
- 產物流動性佳可氣輸

產品圖

Photos

REMONDIS GmbH Rheinland **Plant Erftstadt**

SBS品質管理

生產程序

收貨
↓
風選高熱值碎片
↓
SBS®替代能源產出
↓
SBS®替代燃料儲存

品質管理程序

進貨控管

製程控管

製程控管

由內外部稽查進行產品控管

ISO 9001, EFB,
RAL-Gütezeichen
GZ 724

Gütezeichen Sekundärbrennstoffe
RAL

OPPORTUNITIES FOR A CIRCULAR ECONOMY IN THE NETHERLANDS

Ton Bastein | Elsbeth Roelofs | Elmer Rietveld | Alwin Hoogendoorn

OPPORTUNITIES FOR A CIRCULAR ECONOMY IN THE NETHERLANDS

The Netherlands Organisation for Applied Scientific Research (TNO)

TNO is a not-for-profit research and technology organisation that was founded in 1932 by an act of the Dutch parliament to make scientific research accessible and applicable for businesses and government. By law, TNO is required to operate in an independent and objective way. TNO's trademark is the application of rigorous scientific principles to a wide variety of disciplines. At the start of 2013 TNO employed around 4,000 highly qualified professionals. TNO is active in seven main themes: industrial innovation, healthy living, energy, mobility, the built environment, the information society, and defence, safety and security.

TNO is one of the most internationally oriented research and technology organisations in Europe. Maintaining and improving an excellent knowledge base is a major focus of TNO as it continues to increase its presence in the international knowledge arena. In 2009 TNO's internationally generated revenue was €153 million, which represents approximately 39% of the total revenue from the market.

TNO Strategy & Policy is one of Europe's leading centres of expertise in the areas of innovation, sustainability and (interactive) policy making, with a staff of about 55 multidisciplinary policy advisors. The group also provides support for complex decision-making processes ranging from learning trajectories, spatial-economic analyses and cost–benefit analysis (CBA), monitoring and evaluation, foresight and scenario development, actor and system analyses aimed at, for instance, urban renewal, industrial innovation, innovation trajectories, sustainability issues and environmental risks. International clients include the European Commission (e.g. DG Environment, DG Regio, DG Research, DG Enterprise & Industry). More information is available on www.tno.nl

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TNO innovation for life

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We are grateful to the many societal stakeholders (their names and affiliations are presented in Appendices 2 and 3) who devoted their time and effort by participating in interviews and workshops that have resulted in a clear view on the circular economy and how stakeholders can stimulate such an economy.

The results presented here would not have been possible without the support of TNO colleagues Arnold Tukker, Walter Manshanden, Sophie Emmert, Thijmen van Bree, Jinxu Hu and others for their contributions and critical comments.

Finally, the authors wish to thank the staff of Contactivity for their accurate, flexible and high-quality translation, editing and production of this report.

About the authors

Ton (A.G.T.M.) Bastein has a PhD in chemistry (heterogeneous catalysis). He joined TNO in 1993, and has been active as research, project and programme manager in the field of contamination control, nanotechnology, nano-instrumentation and the semiconductor industry. He is currently programme manager and coordinator of TNO's activities in the field of resource efficiency (ranging from technology, the biobased economy, to transition-related activities). He is co-founder of the Material Scarcity Platform, an initiative in which government, industry and academia collaborate in exploring and monitoring resource efficiency activities. He is involved in creating and developing national and European projects and programmes to identify ways to address the emerging resource scarcity problems.

Elmer Rietveld has a bachelor's degree in civil engineering from Delft University of Technology, and a master's degree in transport and planning. He joined Tauw BV, an engineering company, where he gained hands-on experience in major civil engineering projects. Since November 2006, he has worked at TNO in the area of spatial economics, spatial planning and cost–benefit analysis. In recent years he has focused on resource efficiency, material flow analysis, the circular economy and national accounts analysis, as a participant in several large EU projects such as CREEA, RHOMELO, COMPLEX and DESIRE. He is also involved in various first- and second-opinion societal cost–benefit analyses.

Elsbeth Roelofs joined TNO in 2000 after having worked with Tebodin Consultants & Engineers. She is now a senior business consultant on sustainable innovation. Elsbeth has a master's degree in chemical technology and the philosophy of science, technology and society. Since 2009 she has focused on research and consultancy in the area of the biobased economy and resource efficiency. She was closely involved in the development of two European programmes, BRIDGE and BIO-TIC, both in the area of developing the biobased economy. The BIO-TIC programme is developing a roadmap for the development of industrial biotechnology in Europe in the coming decades. Her fields of expertise include transition processes, systems innovation and value chain innovation (with an emphasis on construction and energy).

Alwin Hoogendoorn has a master's degree in mechanical engineering from Delft University of Technology and has worked as a consultant for Dutch engineering companies for almost 20 years. He is an expert in the fields of power production, renewable energy, biomass, bioenergy, biofuels and biobased products. He has been involved in due diligence work for investors and banks. As a result of a long-term R&D effort into innovative biofuel production pathways, Alwin was lead author of *Transportation Biofuels: Novel Pathways for the Production of Ethanol, Biogas and Biodiesel*, published by the UK's Royal Society of Chemistry (2010).

Contents

Summary

This report analyses the opportunities and obstacles that will present themselves as the Netherlands moves towards a more circular economy. It proposes a number of actions that can be taken, particularly by the government, to accelerate this process. The concept of a 'circular economy' refers to an economic and industrial system that is based on the reusability of products and raw materials, and the restorative capacity of natural resources. It also attempts to minimize value destruction in the overall system and to maximize value creation in each link in the system.

This report quantifies these economic and other opportunities to the greatest degree possible and examines their potential impact on employment and the environment. This analysis focuses primarily on the overall Dutch economy, but begins by examining two cases – the circular economy for products from the metal and electrical sectors, and the use of waste streams from biomass. The first case focuses on 'abiotic' materials, and the second on 'biotic' materials, both of which present their own specific challenges and opportunities. This report aims to answer the following questions:

- What opportunities would present themselves if the Netherlands were to accelerate the transition to a circular economy?
- How can these opportunities be used, how can obstacles be removed, and what shape should this transition take?
- What part can the government play in this process?

An expansion of the circular economy for technical products in the Netherlands initially means advocating more maintenance and repair work, intensive reuse and increased recycling. Of course, these activities are already happening. So we can already speak, to a certain extent, of a circular economy. By looking at 17 product categories from the metal and electrical sectors, we estimate that the current value of the circular economy for these products is €3.3 billion and that an additional market value of €573 million per year could be achieved by responding to a broad range of opportunities identified by stakeholders and experts.

With respect to value creation with biotic waste streams, the Netherlands has the advantage of being a densely populated country with an active agricultural sector and a large agro-food industry. As a result, significant biotic waste streams are available. The 34 most important waste streams have been identified: the use of these waste streams already represents a value of €3.5 billion. An estimated investment of €4 billion to €8 billion per year in new technologies could create added value of €1 billion per year for the circular economy in the areas of biorefining, biogas extraction and more comprehensive systems for sorting household waste.

The detailed analyses of an expanding circular economy of products from the metal and electrical sector and the use of biotic waste streams enables us to estimate the impact of an expanding circular economy on the Netherlands as a whole: we estimate the overall impact to be €7.3 billion, involving the creation of approximately 54,000 jobs. In addition there are a number of spin-off opportunities for the Dutch economy in terms of strengthening the country's knowledge position.

In order to develop an initial outline of useful and realistic actions that can be taken, we have examined the opportunities and obstacles from different angles based on a review of the literature, interviews and a workshop with selected stakeholders from the biotic and abiotic case studies. In doing so, we looked at the following: knowledge development and dissemination, entrepreneurial activities, market forces and mobilizing resources, policy and rules and regulations, and lobbying activities.

If the Netherlands is to take full advantage of the opportunities identified in this report, the government needs to develop a consistent, multidisciplinary and well-founded long-term strategy intended to lead to a circular economy. The following actions (and supporting studies) are needed now in order to identify areas of research, regulations, financial and fiscal incentives and strategies that will encourage frontrunners, promote the role of the government as a 'launching customer' and enhance international relations:

- create a clear, cross-departmental, consistent strategy for the circular economy;
- develop a coherent education and research plan for the circular economy;
- make a comprehensive assessment of the pros and cons of existing rules and regulations regarding waste;
- increase knowledge and awareness of raw materials in each value chain;
- ensure that leaders and others who stick their necks out receive a permanent and true advantage, for example through value chain management;
- review the effectiveness of a broad set of fiscal and financial incentives to promote circular behaviour;
- determine the impact of incineration plants on the viability of circular business cases and take appropriate action;
- develop the role of the government as active and expert 'launching customer'; and
- use the international playing field to help the circular economy move forward.

The current state of recycling, repair and reuse of a wide range of products in the Netherlands gives good reason to assume that there is further potential to make the transition to a more circular economy. However, clear and consistent communications across government departments are crucial to success. Dutch society seems very willing to join in, but is undoubtedly sensitive to conflicting information and incentives. In any case, citizens will be further encouraged if they are kept well informed about what has already been achieved, and if well-chosen transition experiments are launched. That the action plan for the government proposed here is by nature very exploratory and investigative is related to this. Measures to do with fiscal policy and rules and regulations are complex, and there must be some confidence that they will have the intended effects.

Throughout this study, the inputs from stakeholders have been extremely important in identifying in which direction the transition should go, and the obstacles that are likely to emerge. The views of these stakeholders do not by definition represent balanced judgements, which is why an expert and analytical government can contribute to what is in all respects a sustainable shift to a circular economy.

Raw material efficiency and rolling out the circular economy are goals that are clearly embraced at the European level. Nonetheless, the measures proposed here show that in many areas the Netherlands does not need to wait for approval at the European level.

More than once, this report stresses that a transition to a circular economy will benefit from initiatives that improve (sometimes drastically) circularity, as well as more radical measures that, in a more restricted sense, aspire to an ideal circular economic model in which circularity is already incorporated in the design phase. Based on the methods used here it is difficult to assess what the economic contribution of these more radical innovations and transitions would be. Still, the government can certainly support radical design innovations by identifying the leaders and removing obstacles for them or by acting as a launching customer to help these risky and radical initiatives get off to a good start.

Introduction

1 Introduction

This report analyses the opportunities and obstacles that will present themselves as the Netherlands moves towards a more circular economy. It proposes a number of actions that could be taken, particularly by the government, to accelerate this process. This report quantifies these economic and other opportunities to the greatest degree possible, and examines their potential impact on employment and the environment. The analysis focuses on the overall Dutch economy, but it begins by examining two cases – the circular economy for products from the metal and electrical sectors, and the use of waste streams from biomass. The first case focuses on the recycling of 'abiotic' materials, and the second 'biotic' materials, both of which present their own specific challenges and opportunities.

This report aims to answer the following questions:
- What opportunities would present themselves if the Netherlands were to accelerate the transition to a circular economy?
- How can these opportunities be used, how can obstacles be overcome, and what shape should this transition take?
- What part should the government play in this process?

1.1 Population, resources and the environment

During the 20th century, population growth led to an increase in the extraction of construction materials by a factor of 34, ores and minerals by a factor of 27, fossil fuels by a factor of 12 and biomass by a factor of 3.6.[1] As the demand for natural resources such as water, energy, raw materials and fertile land continues to rise, they are becoming scarce and more expensive. Moreover, rising consumption is putting a strain on the environment, leading to the depletion of large areas of forest and fish stocks, and to the extinction of many animals and plants.

The most important 'engines' of this increased consumption are the continued population growth and the simultaneous increase in prosperity in many parts of the world. The global population is expected to reach 9 billion by 2050 and 10.1 billion by 2100.[2] Despite the recent economic crisis, the global economy is expected to continue to grow at an average rate of 3.6% per year, especially in emerging and non-western economies, where growth rates of 6.3% per year are predicted.[3] As a result, in the coming decades the demand for natural resources will continue to rise.[4] A realistic prediction is that the global consumption of materials will triple by 2050.[5]

The fact that economic growth requires an extra input of natural resources is mainly attributable to increased urbanization and changing consumption patterns.

Urbanization results in the use of raw materials for building urban infrastructures, such as water supply systems, sewage systems, road and building construction, and other facilities to meet the need for transport to and from cities, and to deal with the rising volumes of waste. The growing middle class means changing consumption patterns and rising demand for luxury goods and food products. [6] The production of these goods requires the input of many natural resources.[7]

The growing world population and the desire for more prosperity are irreversible facts. In order to avoid overstepping our boundaries we will have to improve significantly the way we manage our resources. Major steps have been taken in recent decades in that respect. The world economy used approximately 30% fewer resources in 2005 to produce one unit of GDP than it did in 1980, for example. Nevertheless, in absolute terms the use of natural resources is still increasing. A 'normal' increase in the efficiency with which we manage resources is insufficient. We will have to find ways that lead to even greater prosperity for more people and that put less pressure on the environment in absolute terms – what is referred to as 'absolute decoupling'. The challenge we face is to make the transition to a society and an economic system that is tailored to this absolute decoupling. This transition is already underway, and one of its central tenets is the concept of a circular economy.

1.2 Circular economy

A circular economy is an economic and industrial system based on the reuse of products and raw materials, and the restorative capacity of natural resources. It attempts to minimize value destruction in the overall system and to maximize value creation in each link in the system.[8] The goals of the system are to counteract the depletion of natural resources; phase out waste, greenhouse gas emissions and the use of hazardous substances; and make a complete transition to renewable and sustainable energy supplies. We can only change our mindset once we prevent mankind from 'passing on' waste streams to nature and make waste prevention a primary focus of the design phase of products and systems. This would not only further improve current process optimization measures, but it requires a truly different and systematic way of thinking. However, it is conceivable that process optimization could prevent more radical changes from occurring in the transition to a circular economy. The increasing miniaturization of products and components, for example, may mean that repairs become much more complicated, or that recycling no longer pays.

Ideally, in a circular economy, waste streams and emissions would be used to create value, providing secure and affordable supplies of raw materials and reducing the pressure on the environment. This is an essential condition for a resilient industrial system that facilitates new kinds of economic activity, strengthens competitiveness and generates employment. In the transition to a circular economy the focus is no longer solely on decoupling environmental pressures from economic growth, but also on the opportunities created if these things remain coupled.

While an ideal circular economy resembles an inspiring 'point on the horizon', our present economy is often described as a linear economy, in which we are continually extracting new raw materials and creating – and then destroying – something with them ('*take, make, waste*'). Perhaps this is a somewhat gloomy picture of today's consumer society. In a transition to a circular economy, cost considerations and rules and regulations mean that energy and raw materials are managed more consciously, not necessarily because products, processes or systems have new, revolutionary designs. The existence of a recycling infrastructure, an active market for repairs and maintenance, and a lively second-hand market (the success of sites such as eBay and Marktplaats.nl in the Netherlands being prime examples) show that society is capable of moving towards a more circular economy. Increasingly, businesses in various industrial supply chains are cooperating in order to generate industrial symbiosis – by reusing waste, energy, water and material streams, for example – in an economically responsible way. This report highlights the benefits of continued optimization.

It is difficult to determine at what stage we are in the transition to an ideal circular economy. In the Netherlands we already recycle 78% of our waste, incinerate 19% and dump only 3%.[9] Within Europe, the Netherlands is one of the leaders when it comes to processing waste; as an example, figure 1.1 compares the different ways that the 27 EU countries[10] dispose of household waste. The statistics also illustrate that part of the economic potential and the potential to save materials have already been achieved. The potential of a transition to a more circular economy will probably be lower for the Netherlands compared to the average EU country (which is the case in the study by the Ellen MacArthur Foundation; see box and the discussion in section 1.2.1).

The Netherlands has made excellent progress in its endeavour to move towards circularity, but at the same time it is necessary to explore other opportunities. We are a long way from our target if our only goal is a high rate of recycling!

The move towards a circular economy represents an additional transitional step that requires chain optimization at the source. There are notably few examples of this optimization, which is in part attributable to the complex value chains that characterize our global economy. The products in these value chains are not only redesigned elsewhere in the world, but it is difficult to calculate accurately their production costs.

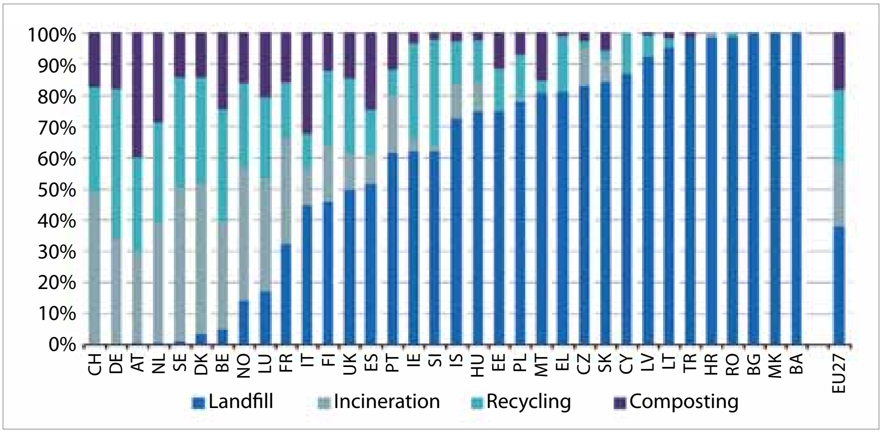

Figure 1.1. Processing of household waste in Europe (EU-27), 2009.
Source: Eurostat, 2009.

Putting all one's money on the creation of an ideal circular economy runs the risk of undermining the positive contributions of existing developments. These developments have tangibly helped to reduce pressure on the environment and create value, and this contribution is likely to increase considerably. In that sense a two-track policy, in which existing developments (as mentioned above) are driven by the 'pack', while the 'frontrunners' who embrace the principle of a circular economy deserve specific attention and support.

1.2.1 The concept of the circular economy

The Ellen MacArthur Foundation has presented an inspiring and appealing picture of a circular economy in its report, *Towards the Circular Economy*. The central notion is to take full advantage of the reusability of products and raw materials and the restorative capacity of natural resources, and to minimize value destruction. The report distinguishes between biotic and technical nutrients (green and blue loops, respectively, in figure 1.2), which find their way into the circular economy in different ways. Ideally, products made from technical nutrients are designed at the outset for advanced forms of reuse. In a circular economy, biotic nutrients, in any case, are non-toxic and so can be returned to the biosphere, preferably in a cascade of uses that tap as much value from them as possible.

In terms of economics, the report concludes that at the EU-27 level, cost savings could amount to US$380 billion (€286 billion) per year in a transition scenario, and US$630 billion (€474 billion) in a more advanced scenario.

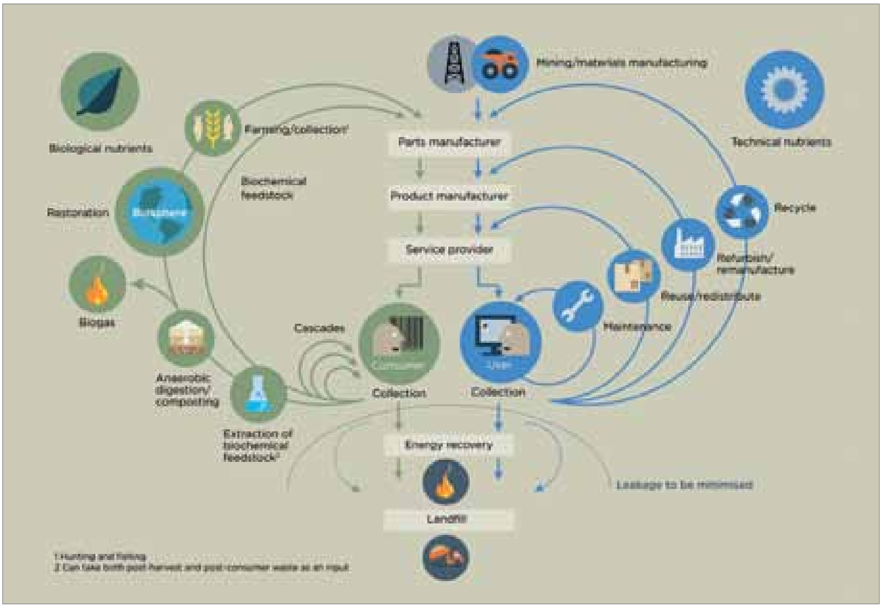

Figure 1.2. The circular economy – an industrial system that is restorative by design.
Source: Ellen MacArthur Foundation (2012) *Towards the Circular Economy*.

The report uses several key principles that lead to circular value (see box).

The various steps or feedback loops for manufactured products and materials ('technical nutrients' in figure 1.2) include the following:

– Maintaining and repairing products to keep them in circulation for as long as possible, and at as high a value as possible.

– Reusing and redistributing goods, which includes the second-hand market, lead to only a slight loss of the product's function, and therefore they make a positive contribution to a circular economy.

– Refurbishing and remanufacturing goods involve repairing or replacing failed parts or components, but the resulting product will have a shorter lifetime than the original product when new. When a product is remanufactured, the components are removed and used in new products. These processes generally include quality control to ensure high-quality products (with a guarantee).

– Recycling involves recovering materials that can be put back into one or more production processes. While the value of the raw materials is preserved, the added value of the original product (in the form of energy, labour and capital goods) will be lost (see section 1.2.3).

Obviously biotic nutrients cannot be kept in circulation in the same way as technical nutrients. It is assumed that biomass and biotic waste streams ('biological nutrients' in figure 1.2) will eventually be returned to the soil as nutrients, after they have been given as much value as possible through a cascade of processes:

- The extraction of high-quality raw materials ('extraction of biochemical feedstock'): processes known as biorefining can extract fuels, power, materials and high-quality chemicals from biomass, but often in small volumes.

- During anaerobic digestion micro-organisms break down organic material in the absence of oxygen. The result, among other things, is biogas (methane), which can be used as an energy carrier, thereby contributing to energy supplies ('biogases').

- Eventually it should be possible to use all biotic nutrients as non-toxic ingredients in agricultural fertilizers (for example 'restoration', 'farming/collection').

Value creation in a circular economy

As described in the report of Ellen MacArthur Foundation, the circular economy is based on several key principles, which drive four sources of value creation:
- 'The power of the inner circle': the more that hidden costs (such as materials, labour, energy and capital) are retained in a product, the greater will be the savings (or potential benefits). Repairs and maintenance retain much more of a product's value than recycling its individual component.
- 'The power of circling longer': the more often a product re-enters a cycle, or the longer it is used, the higher will be the value created.
- 'The power of cascaded use': if materials (as opposed to products) are to be reused (as a result of wear, for example), they can create added value if people look for other, more complex uses for them instead of breaking them down to the level of raw materials.
- 'The power of pure cycles', i.e. it is easier to separate inputs and designs: reuse, repair and recycling all benefit if the final phase of the life of a product has been taken into consideration when it is designed, by ensuring, for example, the use of non-toxic components and combinations of materials that are easy to separate.

Source: Ellen MacArthur Foundation (2012) *Towards the Circular Economy*.

1.2.2 A closer look at recycling

Recycling involves retrieving the materials contained in a product at the end of its life that can be used in other production processes. During recycling, in contrast with 'reuse', components and materials lose their function.

As an industrial practice, recycling has been around for a long time and is driven by solid business cases (in which scarcity and the rising prices of raw materials play a role) and environmental regulations, either national or European. Significant progress was made in the 1980s and 1990s in response to mounting environmental concerns regarding the wholesale dumping of waste. Recycling has regained attention in recent years, but for different reasons, including the rising prices of raw materials (making recycling processes profitable again) and concerns about supply security (recycled materials contribute to 'local' resources). On the other hand, future market developments are highly uncertain due to shifting geopolitical alignments, the complexity of markets and the volatility of raw material prices, as well as the rapid changes in technologies and products. Investing in large-scale recycling is therefore perceived as very risky.

Over the last decade consumer products have become considerably more complex, so that effective and efficient recovery is a massive challenge. There are as yet no effective processes for separating some combinations of materials, and in some cases such processes are even fundamentally impossible. The development of printed circuit boards, a familiar component of electrical and electronic products, is a good example. Process optimization has led to huge performance improvements and also to sharp reductions in the use of some materials.

Although at first glance these may appear to be positive developments, in the case of some products economically viable recycling is no longer possible. So what initially seemed to be a good first step – using fewer raw materials – has led to the sub-optimimal reuse of materials. Redesigning products could be a huge step in the right direction if it meant that manufacturers could avoid using combinations of materials likely to lead to recycling problems, and if components could be chosen in such a way that they would be easy to separate at the end of the economic life of a product. In light of the low concentrations of materials in many consumer products, it is important that the recycling collection rate is high: this is the only way of achieving sufficient scale, and thus also a potentially solid business case for the recycling of many materials.

Recycling is undoubtedly an important strategy for a society that wishes to increase material efficiency. Primary extraction will remain important (the most recycling can do is to keep what already exists in circulation) in societies experiencing strong economic growth. And in light of the problems mentioned above it would be naive to suppose that in the future, with the right science, regulations and attitudes, we would be able to recycle everything that has not yet been recycled and achieve an ideal and theoretically complete recycling stream.

1.2.3 Reuse, redesign, innovation and substitution

In order to move towards a circular economy we need to be innovative in the area of design – not only of technology and production processes, but also in terms of the social and economic processes that are necessary to change existing habits.

Intensifying the use of products is an important goal, but to achieve this it is necessary for both businesses and consumers to change their behaviour, and a solid and profitable business case needs to be made. We need to encourage the use of second-hand products and innovative rental and leasing arrangements. We also need to set up services that promote the sharing of consumer products, and encourage repair and maintenance services that extend their technical lifespan. In particular, we need to redesign products so that they and their components are easier to reuse.

Although such activities and concepts already exist, many of them have not yet been implemented on a large scale. The further introduction of leasing arrangements, for example, may be stifled by economic motives (suppliers will have to make higher initial investments), vested interests (that stand in the way of the introduction of new ideas) and behavioural factors (of both businesses and consumers). Although initiatives such as setting up a car-sharing scheme could greatly reduce the use of raw materials, people's desire for individuality, status or freedom often stand in their way.

This type of product sharing is a more obvious way to go for more expensive products that are not used on a daily basis and do not generate particular feelings of status or freedom, and is already in use in the form of tools and equipment rental services at DIY stores, for example.

One example of an innovative concept is that consumers 'buy' the service provided by a product rather than the product itself. In the case of professional copy shops, for example, customers pay for the copying service and for the materials (paper and ink), while the supplier remains the owner of the copying machines. The copiers are designed with the reuse of components in mind. Because the printers have continued ownership, this kind of design makes sense.

Another example is Turntoo, a model developed by Amsterdam-based architect Thomas Rau. An early application of this model is the 'Pay-per-lux' lighting concept introduced by Philips, where the customer pays for an agreed amount of light, while Philips is responsible for maintaining the lamps and lighting system. Because the manufacturer, Philips, remains the owner of the materials and system, it is encouraged not only to take production costs into account in the design of its products, but also the costs related to their use. Concepts such as this can lead to more efficient product designs and more intensive recycling, as well as save energy.

In order to take full advantage of concepts such as this it is important that manufacturers acknowledge that products and components can be given a second or longer life during the design process (‘*design for disassembly, for repair, for reuse, for remanufacturing, for recycling*’). This is true when the producer remains owner of the product, and is therefore responsible for extending its life, as well as when the manufacturer has lost track of the product and more generic service providers become involved. Therefore, materials should be used that are easy to recycle (even in complex products), and whose fragile and frequently replaced parts are easy to incorporate. This is more easily said than done. For generations, designers were required to take into account criteria such as effectiveness, efficiency, cost and function, but they now have to consider requirements that may even push up costs. However, if the potential costs of a new design and different materials, and the benefits resulting from the more intensive use of parts and materials occur in different parts of the value chain, there will be no incentive to redesign a product.
More radical changes can be brought about by looking for alternative (for example, circular) solutions or substitutes.

Substitution implies replacing a material, product or service with another while retaining or even improving the same function. In recent years, when many Dutch high-tech companies experienced supply shortfalls, their first response was to try to make their supply chains more robust by stockpiling components or by looking for alternative suppliers.[11] Only later did they decide to look for substitutes. But these substitutes were not regarded as ideal alternatives and so were abandoned as soon as the supply interruptions were resolved. This leads to the question of to what extent substitution can play a role within existing patterns of production and consumption, or whether it will only be accepted if and when consumption patterns shift and new demands emerge.

With many ‘examples’ of substitution the purpose has not been to improve raw material efficiency. More often products have been radically redesigned so that they provide completely different or better services, and are marketed on that basis. Examples include the digital cameras that have largely displaced film cameras, or the wireless networks that are replacing fixed telecommunication systems. Pioneering or innovative products often fulfil a need that previously did not exist, as entrepreneurs such as Henry Ford and Steve Jobs have so convincingly demonstrated in the past.

It is not a foregone conclusion that a substituted product necessarily helps to reduce pressure on the environment. Many kinds of modern entertainment equipment, such as plasma display panels, have led to substantial increases in energy consumption. Another example is biofuels and the question whether they are circular. Analyzing the impacts of substitution requires a broad systems approach, which will inevitably give rise to tensions between the desire for innovation and prosperity on the one hand, and pressure on the environment on the other.

Using waste streams from biomass

The Netherlands imports large quantities of biotic materials for its intensive dairy and food processing industries. The products of the food industry are partly exported and partly consumed in the Netherlands. Ultimately, the waste products (such as sewage sludge from treatment plants) can enter the circular economy, and so will not replace the original raw materials. In order to make a quantitative estimate of the opportunities that a biotic circular economy could generate, this study looks at ways of using all biotic waste streams with an eye to maximizing the potential added value. Of course, the food chain, which is broader than the food industry, gives rise to many significant biotic waste streams, including from agriculture, the retail trade (discarded food products) and society (organic waste and sewage sludge). This study attempts to quantify and analyze these streams and the opportunities to use them.

Although the circular economy is still in its infancy, many actors within the government, academia and industry are already actively supporting the transition. One example is the Nutrient Platform NL, a consortium of businesses, knowledge institutes, NGOs and the government that are working together to implement the phosphate chain agreement (see section 5.3).

1.3 Sustainable use of resources and closing cycles

The various strategies outlined above are undoubtedly important for achieving a circular economy. Primary extraction, however, remains important in societies experiencing rapid growth: after all, the most we can keep in circulation is what is already in circulation, and even that is a very ambitious objective. It would be unrealistic to expect complete recycling in the foreseeable future. Some material streams, such as food and energy, cannot be recycled or reused, and have to be continually renewed so that we can be sure of constant supplies.

A number of organizations have agreed on a definition of the circular economy as ‘the regional production of goods, using an optimized cascade of nutrients and energy, assuming there is optimization in both the region's own chain and between different businesses and industry'.[12] This study does not consider efforts to promote regional production (glocalization), important though they may be. For example, a more circular perspective can lead to new ideas in terms of environmental planning and the problem of whether to condense, reduce and separate or, rather, combine functions such as living and working. The study also does not examine the function of logistics in connecting the various links in a circular economy.

Opting for products from the metal and electrical sectors

The authors of *Towards the Circular Economy* advocate the use of products with a medium life expectancy (mobile phones, washing machines, etc.) that can be expected to retain their value once introduced into the circular economy. This study takes a slightly broader view and looks at the products that are manufactured and traded by the metal and electrical sectors, including base metals, metal products, electrical engineering and electrical appliances. These sectors contribute about €10 billion (1.9%) to the Dutch economy and about 9% to the total value added, and have made a significant contribution to the country's position as an exporting nation. In 2010, the two sectors produced and exported goods worth more than €20 billion, offsetting by more than €5 billion the costs of the goods and services they imported in that year.

The analysis uses both sector data and detailed information about specific products (see chapter 3). The goods produced by the metal and electrical sectors are all, to a significant extent, recycled, repaired, rented or leased, or traded on the second-hand market. Data from the Central Bureau of Statistics indicate that the sectors are so closely interwoven with other service sectors that it seems that the circular economy is already happening. They therefore provide interesting insights into the degree to which the circular economy has already taken root in the Netherlands.

Many companies in these sectors are willing to comply with the demands of a transition to a circular economy. They are accustomed to dealing with change and innovation, involving both manufacturers and waste processors in the Netherlands. They are also aware of the sense of urgency at the European level, in view of the extensive attention to the raw materials used in their products in settings such as the European Innovation Partnership on Raw Materials.

1.4 The methodological approach

This report analyses the opportunities and obstacles that will present themselves as the Netherlands moves towards a more circular economy. In doing so, it quantifies the economic and other opportunities as accurately as possible and examines their potential impacts on employment and the environment. While the focus of the analysis is on the overall Dutch economy, it begins by examining two cases – the circular economy for metal and electrical products and the use of waste streams from biomass (see box).

Determining the potential of a circular economy

To assess the potential of increasing circularity for abiotic waste streams, and the Dutch economy as a whole, we used the following methodology.

Regarding the circular economy for products from the metal and electrical sectors:
- The metal and electrical sectors are described by means of 17 discrete product groups.
- The starting point of the analysis was that making estimates for each product category will generate a characteristic picture of the Netherlands. For example, simple or inexpensive household appliances are unlikely to be repaired, but some of them will find their way into recycling streams, while more complicated and expensive appliances (washing machines, etc.) are already being repaired. In order to estimate their circular potential, a realistic scenario is developed for each category of products and its potential in terms of maintenance, rental services, etc. These estimates are initially based on figures for 'urban mining' in the Netherlands, i.e. final consumption and investments in fixed assets.
- For each of the 17 product groups, we then estimate the degree to which an expansion of the circular economy could occur. These estimates are based on insights from the literature, interviews and the workshop organized for this study.
- This expansion is described in terms of the number of products, their value and the consequences in terms of the land use, water use, CO_2 emissions and use of raw materials avoided.

Regarding the circular use of biotic waste streams:
- Based on data from the literature and information from interviews, we outline the nature and scale of the most important biotic waste streams and the ways in which they are already being used (or not) in the economy.
- For each waste stream, we then identify the technological or other initiatives and opportunities for creating greater added value (for example, by using improved biorefining processes for valuable chemicals).
- This added value represents the potential for the expansion of the circular economy.

Regarding the overall Dutch economy:
- By extrapolating the findings from the abiotic and biotic cases, we estimate the impact on the Dutch economy and the associated impact on the environment.

We analyze these streams in the current system and assess what would be possible now, based on technological and social trends. In doing so, we draw on the work of the Ellen MacArthur Foundation, which outlines the potential savings in terms of materials, labour, energy and emissions. This approach therefore does not have as its ultimate goal an ideal circular economy, but rather outlines the prospects for the coming years. We must not forget that radical social and economic changes could accelerate the transition to a circular economy, but these changes are difficult to quantify.

This report aims to answer the following questions:
- What opportunities would present themselves if the Netherlands were to accelerate the transition to a circular economy?
- How can these opportunities be used, how can obstacles be removed, and what shape should this transition take?
- What part should the various societal actors, including the government, play in this process?

In answering these questions, the report attempts to complete another step in the exploration of the concept of the circular economy for the Netherlands. It is a SMART (specific, measurable, attainable, relevant and time-bound) interpretation of the notion of circularity that is intended to raise the awareness of stakeholders of the opportunities in that area in the Netherlands.

1.5 Reader's guide

This report is structured as follows:
- chapter 2 presents a quantitative analysis of the opportunities that could emerge by incorporating more intensively products from the metal and electrical sectors into the circular economy;
- chapter 3 presents a quantitative analysis of the opportunities for the circular economy using biotic waste streams;
- chapter 4 extrapolates the analyses in chapters 2 and 3 to identify the potential economic and other opportunities for the overall economy;
- chapter 5 discusses the drivers and operational obstacles to a circular economy identified in the literature, interviews and workshop; and
- chapter 6 discusses the role that the government could play in accelerating the transition to a more circular economy.

Details of the analyses will be published separately in a background document (in Dutch only).

The abiotic circular economy: products from the metal and electrical sectors


Power
Time
Start / Stop

2 The abiotic circular economy: products from the metal and electrical sectors

Expanding the circular economy for technical products in the Netherlands will mean more maintenance and repairs, more intensive reuse and increased recycling. Of course these activities are already taking place, so one can say that the circular economy already exists to some extent. For 17 product groups in the metal and electrical sectors, the current value of the circular economy is €3.3 billion, and an additional €573 million per year could be achieved by responding to a broad range of opportunities identified by stakeholders and experts.

2.1 Metal and electrical products and the circular economy

The more circular an economy becomes, the more products will be maintained and repaired, reused (entire products or some or all of their components), refurbished and recycled. The degree to which that is already happening, and could increase in the future, will largely depend on the nature and characteristics of each product. For this analysis, we defined 17 groups of products from the metal and electrical sectors that demonstrate some similarities, such as price, expected lifespan, the number of links in the value chain, their complexity and sensitivity to changing fashions. These product groups are listed in table 2.1.

In this analysis of the potential of a more circular economy, the starting point is the current flows of goods in Dutch society. In economic terms, this refers to the combination of final consumption by households and businesses in the Netherlands (approximately €7.5 billion in 2010, or 1.7% of final consumption) and the investment in fixed assets and capital goods (approximately €9 billion in 2010, or 8.6% of all investments in fixed assets).[1]

Table 2.1. Products from the metal and electrical sectors divided into 17 user-defined product groups

Product group	Examples of products
1 Base metals	Beams, cylinders, plates, wire, pipes, metal briquettes, railings, reinforcement, grating, etc.
2 Metal products	Construction parts, girders, doors, window frames, containers, gates, radiators, tools, DIY materials, faucets, food packaging, kitchen tools, engine parts, pistons, vehicle parts, gauges, coils, magnets, springs, weapons, coatings, blades
3 Electronic components	Semiconductors, printed circuit boards (chips), integrated circuits
4 Home computers	Printers, laptops , desktops, scanners, fax machines, PC parts
5 Mobile appliances	Mobile telephones, smartphones
6 Televisions	Televisions
7 Video and DVD players	Video recorders, DVD players, video cameras, accessories
8 Other consumer electronics	Transmitters, audio equipment, fixed telephones, alarm systems, etc.
9 Measuring equipment	Measuring and monitoring instruments, other cameras, sensors, radiation equipment, appliances using magnetism
10 Electrical capacity	Electrical engines, transformers, batteries, etc.
11 Electrical parts	Batteries, capacitors, switches, cables, disconnectors, wires, etc.
12 Bulbs	Incandescent light bulbs, cold-cathode fluorescent lamps (CCFLs), light-emitting diode (LED) lamps, fluorescent lamps, etc.
13 Washing machines	Washing machines, driers, dishwashers
14 Air conditioners	Air conditioners
15 Microwave ovens	Microwave ovens
16 Refrigeration	Refrigerators and freezers
17 Other household appliances	Ovens, electric heaters, radiators, cosmetic appliances, etc.

2.2 Current status of the circular economy

For each of the product groups listed in table 2.1, a quantitative analysis was made of the number of items (and their prices) that enter circulation each year and the number of products that are offered for maintenance and repair, reused (second-hand), refurbished (products and components) and/or recycled. These are the various steps that were identified in the report *Towards the Circular Economy* (see section 1.2.1).

The value of new products from the metal and electrical sectors that are sold on the Dutch market amounts to approximately €16.5 billion every year. This figure is based on information obtained from the National Accounts and supplementary data from professional trade organizations. Information on repair cycles was obtained from certified statistical agencies[2] on maintenance, and the depreciation of capital goods (for both businesses and households). This information was used to estimate how many products have been offered for repair. The size of the economic sectors associated with repairs was also used as a control in the estimates. The estimated value of a product in need of repair in the feedback loop was compared with its value in the eyes of the owner before it needed repairing.

The reuse of products, through second-hand markets, is an important part of the circular economy. An impression of the second-hand market for products from the metal and electrical sectors was obtained from empirical research on sales outlets, especially online selling points such as Marktplaats.nl and Speurders.nl. Data from the Central Bureau of Statistics (CBS) on used capital goods were used as controls. The estimated value of a product destined for reuse is the price of the second-hand product, including an estimate of the price that consumers would be willing to pay.

The reuse of product components (parts such as engines, wheels or microchips) is strongly linked to the estimated number of products on the second-hand market. The data for this feedback loop were obtained from core figures from the literature[3] describing the relationship between the reuse of complete products and of components. It is interesting to note that in the literature, a part is considered to be more valuable if it has been removed from the original product. For example, a computer disc drive is worth more if it has been removed, cleaned and is ready for reuse. Here too the estimated value of products in the 'reuse of components' feedback loop tallies with the sales value of the components destined for reuse.

Finally, we determined the value of the recycling feedback loop, based primarily on a recent study by the United Nations University.[4] In addition to providing useful estimates of the various waste streams, in particular of waste electrical and electronic equipment (WEEE), the UNU study makes assumptions about the relationship between recycled products and new products entering the market, which creates an additional control option. The value of a recycled good is estimated based on the total costs of recycling – including the costs of collection and disassembly/processessing – and the revenues from the sale of the secondary raw materials.

Table 2.2 summarizes the extent to which elements of the circular economy are already being applied in relation to products from the metal and electrical sectors.

Table 2.2. Status of the current circular economy for metal and electrical products (numbers of items, 2010)					
Products	New products ('000s)	Repairs ('000s)	Reuse of products ('000s)	Reuse of components ('000s)	Recycling ('000s)
Light bulbs	52,540	0	4	89	44,444
Base metals	2,226	0	4	2	2,020
Air conditioners	1,273	153	512	238	952
Mobile telephones	9,627	1,444	105	2,250	9,000
Electronic components	809	0	400	375	750
Metal products	16,510	330	2,740	81	8,080
Microwave ovens	730	15	525	30	595
Televisions	3,806	457	2,052	180	3,600
Electrical parts	775	39	682	6	565
Other consumer electronics	3,150	378	4	340	2,267
Home computers	18,611	2,792	639	1,667	16,667
Video and DVD players	4,548	364	106	200	4,000
Refrigerators/freezers	922	46	53	38	750
Washing machines	1,183	177	1,025	300	857
Other domestic appliances	1,193	143	733	143	950
Electrical capacity	693	14	77	75	500
Measuring equipment	4,234	423	3,209	375	3,750
Total	122,828	6,774	12,873	6,387	99,747

The distribution by product category across the various feedback loops obviously fluctuates depending on the nature of the product. Almost all light bulbs, for example, will end up in the recycling loop since they cannot be repaired when they are broken. Appliances such as home computers represent so much value in terms of use that a significant number of defective computers are repaired.

The annual stream of products from the two sectors that are repaired and reused represents about 16% of the number of new products that enter the Dutch market each year. About 81% of products from these sectors are offered for recycling. These numbers suggests that, in these two sectors at least, a certain degree of circularity has already gained acceptance in the Netherlands.

Of course, what is even more interesting is the analysis of the value of the current level of circularity. Table 2.3 shows the value of repairs, reuse (of products and components) and recycling by product category. The total value of these feedback loops for the six most valuable product categories is depicted in figure 2.1, while figure 2.2 shows the distribution of this value across the various feedback loops.

Table 2.3. Value of the current circular economy for metal and electrical products (2010)

Products	Value of new products (€ million)	Repair, reuse of products and components (€ million)	Recycling value (€ million)	'Circular' value (€ million)
Light bulbs	482.8	0	−33.3	−33.3
Base metals	113.5	0	−5.1	−5.1
Air conditioners	73.9	16.9	9.9	26.7
Mobile telephones	898.3	165.6	−74.9	90.6
Electrical components	80.6	25.4	18.6	43.9
Metal products	2212.4	150.1	−33.4	116.7
Microwave ovens	122.0	9.2	34.7	43.9
Televisions	679.9	255.5	26.3	281.8
Electrical parts	135.8	61.0	35.3	96.3
Other consumer electronics	576.9	42.2	27.0	69.2
Home computers	4202.3	379.8	−114.2	265.6
Video and DVD players	1137.4	54.6	30.9	85.4
Refrigerators/freezers	248.1	13.3	54.8	68.1
Washing machines	384.9	147.5	66.9	214.5
Other domestic appliances	370.2	201.6	69.4	271.0
Electrical capacity	441.8	32.8	56.0	88.8
Measuring equipment	4324.1	1,391.8	206.6	1,598.4
Total	16,484.9	2,947.2	375.5	3,322.7

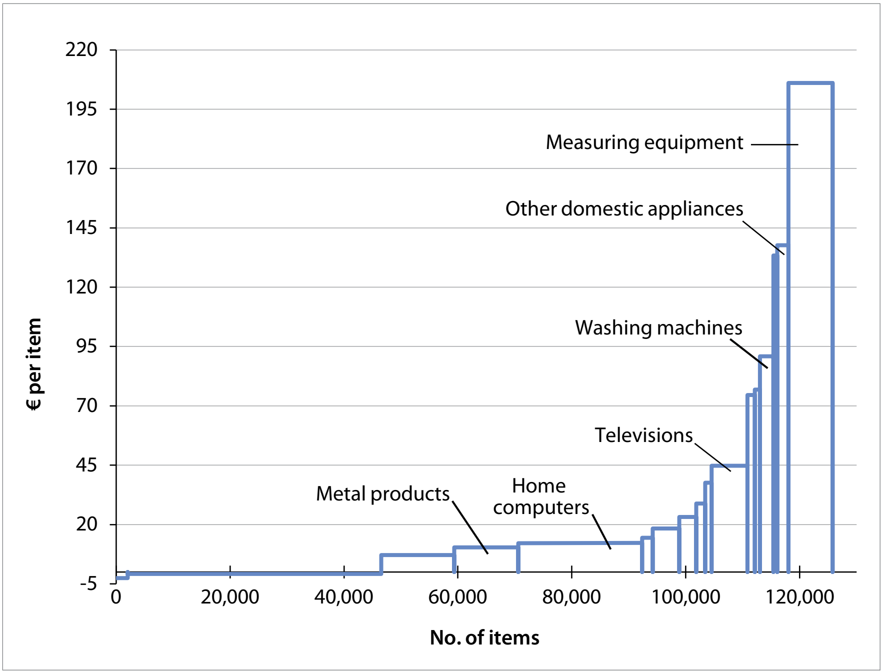

Figure 2.1. Current value of circularity for the six highest-value products from the metal and electrical sectors.

Based on these estimates, the value of the current circular economy for the metal and electrical sectors is approximately €3.3 billion. The most important contributions come from the repair and reuse of measuring equipment, followed by a broad group that includes computers, televisions and other household appliances. Recycling contributes only slightly more than 11% of the total, despite the large share of recycling in terms of the number of items. The largest contribution comes from the reuse of products, at approximately 54% (see figure 2.2).

The metal and electrical sectors represent almost €16.5 billion in terms of new value. The total value of the circular feedback loops (€3.3 billion) is therefore only 20% of the new value.

This is understandable in view of the depreciation in value that occurs, for example, when goods are reused (second-hand goods) or recycled. Take the example of recycling. Although the share of recycling (measured in terms of the number of items) is large, the intrinsic value of the materials and raw materials contained in a recycled product (especially in metal and electrical goods) is generally only a fraction of the value of that product when new. According to a recent report by the United

Nations Environment Programme, for example,[5] the total commodity value of a PC (which is worth €1,100 when new) is only €8.60. The 'lost' value includes the costs of labour, energy and capital goods (the operating costs of machines, write-down on the machines) during production. This value is a relatively large write-down that naturally disappears when products are recycled. It explains the relatively low value of the share of recycling, which is also under pressure because of the additional costs of collection and processing.

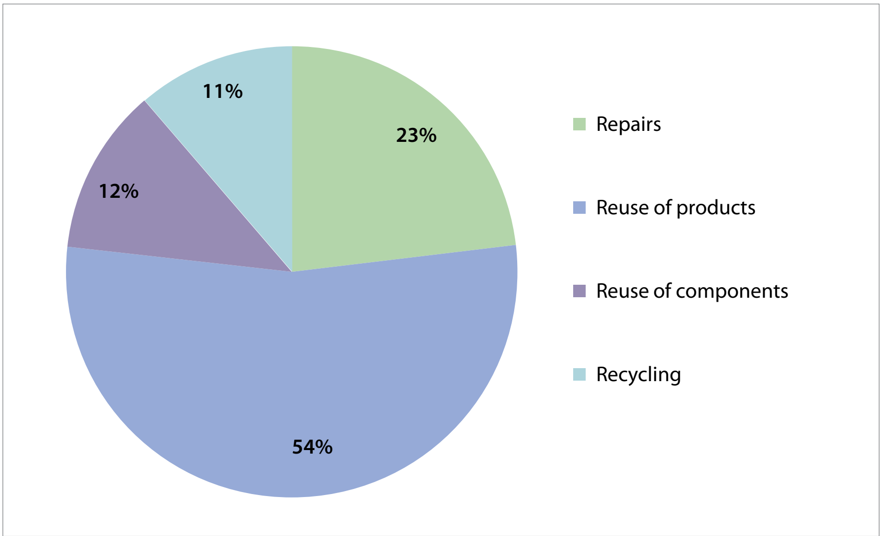

Figure 2.2. Contributions of repairs, reuse and recycling to the value of the current circular economy for metal and electrical products (2010).

2.3 The value of increasing circularity

Increasing the circularity of products in the metal and electrical sectors will require strengthening commercial activities that will enable the reuse of product components, the shared use of products and a higher rate of recycling. There are many social changes that will affect shifts of this kind, although of course the extent of such changes is impossible to predict. In order provide a rationale for the type and degree of change, we have relied on information about the driving forces and the likely obstacles on the road to a circular economy obtained from the literature, interviews with experts and other interested parties, and the workshop held in the context of this study (see chapter 5). We then assessed the possible consequences for the circular economy of a number of these driving forces in order to generate an overall picture of the potential shifts. It should be noted that our assessments of shifts rely heavily on 'expert judgement' (in this case that of the authors, based on information from the field) and have a major impact on the results of the assessment. The current values are conservative, and so too is the outcome; it is certainly not a 'point on the horizon'.

Table 2.4 summarizes the most important opportunities and the degree to which the volumes (number of items) and value (euro per product) could change. The increased value is determined by increases in both the number of items that enter the circular economy (for example, more electrical appliances collected), and/or the value of this shift in activities (for example, more appliances are repaired than recycled). Simply projecting these changes in terms of the percentage of items and/or value per item onto the current situation gives us an idea of what the consequences would be if these changes took place. For example, if previous studies indicate that 177,000 washing machines are being repaired at the moment, then an increase of 5% would mean that the value of an additional 8,850 washing machines being offered for repair can be deemed positive.

In determining the value of these washing machines offered for repair we took their material value as the starting point. What is a washing machine worth if it is broken but can be repaired? The repair service was not included in this value because the value to a repairman is the same as the cost to the customer. We will not forget the increase in the demand for repair services, which will be included when we determine the increase for the overall Dutch economy (in chapter 4).

As circularity increases, there will be losers at first. In any economy, as more goods are reused and repaired, fewer new goods will be bought, which in turn means a loss of income for manufacturers, transporters and dealers. In this case we assume that an increase in the number of products reused and repaired has a reciprocal effect on purchases of new products, that the reuse of components leads to a gradual decline in purchases (we assume by 75%) and that an increase in recycling does not affect purchases of new products. These corrections are included in table 2.4 under 'new value', for which a negative contribution was estimated in all cases.

Some of the pain caused by declining sales will not be felt in the Dutch economy, since many metal and electrical products are manufactured abroad. For example, if the avoided value of new products is €200,000, but it is known that only 13% of the final consumption of televisions involves value that is not imported, then this means that only 13% of the €200,000 is calculated to be negative for the Dutch economy.

It is worth noting something about the nature of the shifts suggested here. In chapter 1, the concept of a circular economy was introduced as one based on the radical redesign of products and services that takes as its starting point the reusability of products and raw materials and the restorative capacity of natural resources, and which aims to minimize value destruction in the overall system. It has been noted that many Dutch businesses are actively trying to use raw materials, existing products, processes and systems more efficiently, both as individual companies but also in the context of entire value chains.

With regard to the reasons for the shifts listed in table 2.4, it is striking that most measures are applicable to existing products, processes and systems, as well as (obviously) products, processes and systems that have been designed or redesigned according to the principles of the circular economy. Using subsidy schemes such as the Random Depreciation of Environmental Investments (VAMIL[6]) or reduced rates of VAT can act as incentives for both circular products and services, and products and services in a transitional phase.

Other shifts may also lead to more circularity without products having to be radically redesigned. These include innovative leasing and rental contracts, different attitudes to possession, the introduction of lending and sharing schemes such as 'Neemby', and the introduction of collective insurance schemes that offer cover for repaired goods and products containing used parts.

These are examples of an approach that will bring us a step closer to a circular economy. Various efforts are already being made to consider different kinds of reuse during the design process, such as the development of recyclable plastics and the introduction of 'assembly for disassembly' PCs. Such examples are most often found in business services: for example, including reusable parts in the design of professional copying machines is now accepted practice.

Table 2.4. Estimated shifts in the circular economy of metal and electrical products in the coming years. The reasons for these shifts are discussed in chapter 5

Product group*	Feedback loop	Reason for shift	No. of items	Value (€/item)
13	Repairs	Lease and rental contracts for washing machines; see section 5.3	+10%	+1%
13	New value		−1,5%	0
1–17	Reuse	Different attitudes towards possession, see section 5.5	+3%	0
1–17	New value		−1%	0
1–17	New value	Subsidies such as the Environment Investment Allowance (MIA) or Random Depreciation of Environmental Investments (VAMIL), to encourage longer product lifetimes; see section 5.4	−1%	2%
1–17	Recycling	Changing location of waste incinerators; see section 5.3	+1%	−1%
4–8, 13–17	Reuse	Sharing systems such as Neemby, Floow2; see section 5.3	+2%	0
4–8, 13–17	New value		−1%	0
12	Recycling	Increased recycling due to the high value of LEDs; see section 5.3	+1%	0
3–17	Recycling	Development of plastics designed for recycling; see section 5.3	+1%	0
4	Recycling	'Assembly for disassembly' PCs; see section 5.3	+1%	+2%
3–17	Recycling	Reassessment of the EU's Waste from Electrical and Electronic Equipment (WEEE) directive; see section 5.4	+2%	0
2, 4, 5, 9, 10	Reuse (components)	Divestment of 'stranded assets' strategies; see section 5.2	+2%	−1%
2, 4, 5, 9, 10	New value		−1%	−1%
1–17	Recycling	Use logistical knowledge about main ports; see section 5.2	+1%	0
1, 2–17	Recycling	Introduction of raw materials passports; see section 5.3	+1%	+2%
2–17	Reuse (components), repairs	Collective insurance covering repaired goods/products with used parts; see section 5.4	+2%	+5%
2–17	New value		−1%	0

Table 2.4. (Continued)

Product group*	Feedback loop	Reason for shift	No. of items	Value (€/item)
1–17	Recycling	Lifting the ban on stockpiling; see section 5.5	+1%	1%
1–17	Reuse (components), repairs, recycling	Rising prices of raw materials; see section 5.3	+12% +1%	0 0
1–17	New value		−6%	2%
3–17	Components, repairs	Conditions for the supply of parts incorporated in B2B contracts; see section 5.3	+3%	0
3–17	New value		−1%	0
3–17	Recycling	Use reserve from collection contributions; see section 5.4	+1%	2%
4–10, 13–17	Reuse, (components), repairs, recycling	Reduced rate of VAT on circular services; see section 5.4	+5% 1%	+1% +1%
4–10, 13–17	New value		−3%	0
4, 8–10, 13, 17	Reuse, (components), repairs	Development of product service systems (PSS) for the most expensive metal and electrical products; see section 5.3	+3%	0
4, 8–10, 13, 17	New value		−1%	0

* Product groups: 1 Base metals; 2 Metal products; 3 Electrical components; 4 Home computers; 5 Mobile telephones; 6 Televisions; 7 Video and DVD players; 8 Other consumer electronics; 9 Observation equipment; 10 Electrical capacitors; 11 Electrical parts; 12 Light bulbs; 13 Washing machines; 14 Air conditioners; 15 Microwave ovens; 16 Refrigerators; 17 Other household appliances.

Table 2.5 shows our estimates of the changes in the value of all product categories following the introduction of these measures and actions, while figure 2.3 highlights those changes for six products that are likely to benefit most from such measures.

Table 2.5. Changes in the value of products following the introduction of measures to promote a circular economy

Products	Change in value after introduction of measures (€ million)	Total value after introduction of measures (€ million)
Light bulbs	−4.3	−37.6
Base metals	−0.4	−5.5
Air conditioners	4.8	31.5
Mobile telephones	25.7	116.4
Electrical components	6.4	50.3
Metal products	17.6	134.3
Microwave ovens	−1.3	42.6
Televisions	64.3	346.2
Electrical parts	15.2	111.4
Other consumer electronics	13.0	82.3
Home computers	54.0	319.6
Video and DVD players	15.2	100.6
Refrigerators and freezers	11.0	79.1
Washing machines	40.7	255.2
Other domestic appliances	64.5	335.5
Electrical capacity	14.8	103.6
Measuring equipment	231.7	1,830.1
Total	572.9	3,895.6

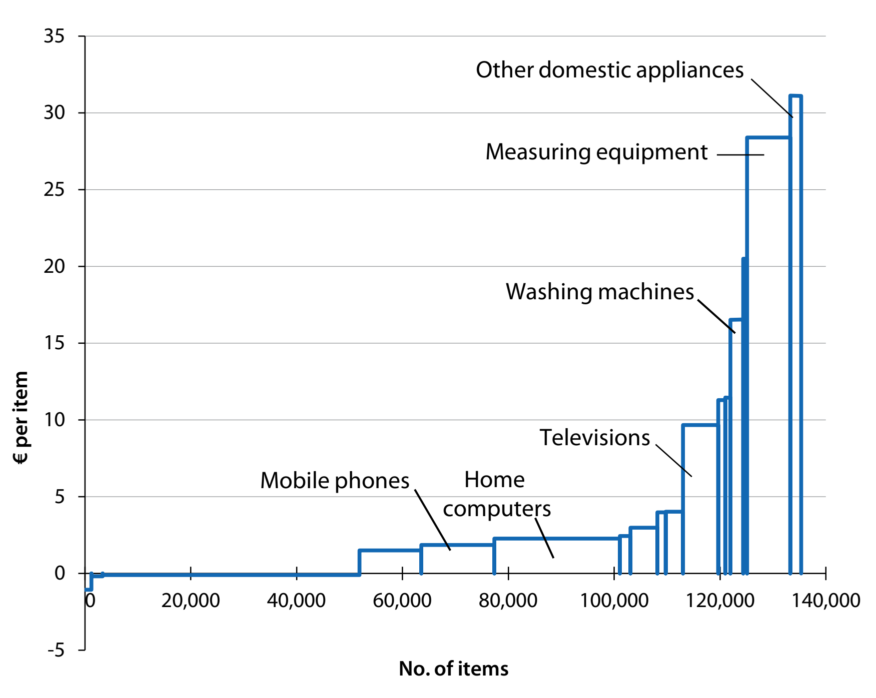

Figure 2.3. Changes in the value of six products likely to benefit most from measures to promote a circular economy.

The total increase in the market value of the circular economy for products from the metal and electrical sectors amounts to €573 million per year. If this figure is adjusted to take into account the decline in purchases of new products, which we estimate will amount to approximately €387 million, then the total value of the four feedback loops – repairs, reuse of products and components, and recycling – increases to €960 million. This increase is derived from the repairs and reuse of products and components feedback loops (about 30% each), and from recycling (10%). Figure 2.4 shows the increase in the value of the four feedback loops in a circular economy compared with the current situation.

This increase – based on conservative estimates – is significant if we consider that the total added value in the metal and electrical sectors is €9,983 million. Few developments in recent history, whether technical, institutional or social have generated this kind of a rise in prosperity in real terms (corrected for inflation) in so short a time.

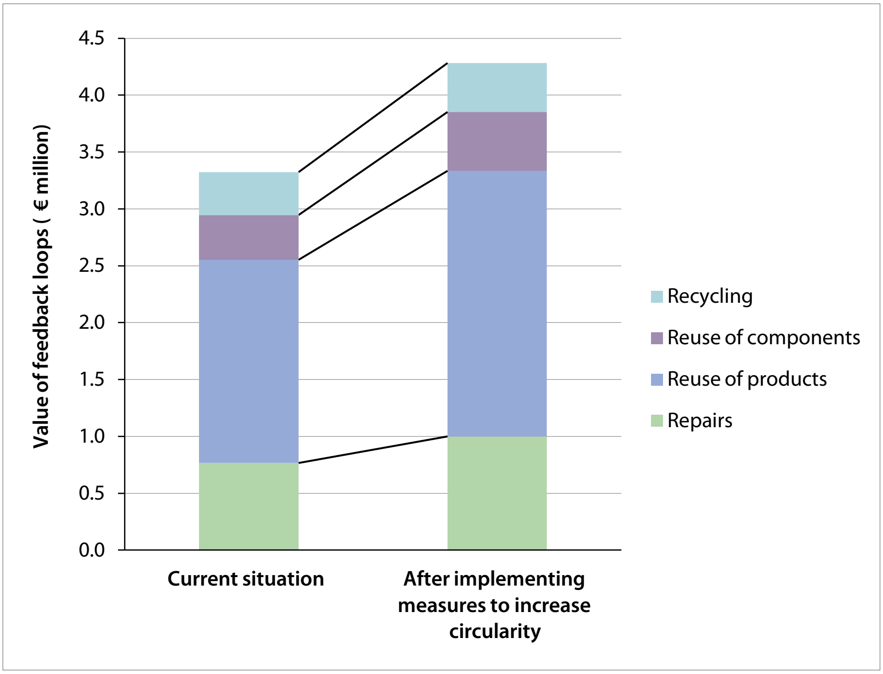

Figure 2.4. Increase in the value of the four feedback loops in the circular economy.

Since we know the shares of labour in the various sectors, we can determine quite precisely that this increased market value of €573 million would lead to the creation of 10,583 new jobs in the metal and electrical sectors (see table 2.6).

Table 2.6. Changes in employment in the metal and electrical sectors due to an expanded circular economy

	Change in market value (€ '000)	Share of labour costs in value added	No. of new jobs created
Base metal industry	−390	0.54	4
Metal product industry	17,628	0.55	198
Electronics industry	236,758	1.15[7]	4,449
Electrical appliance industry	318,954	0.66	5,933
Total	572,950		10,583

2.4 Environmental impacts of increased circularity in the metal and electrical sectors

In addition to the increase in monetary value (part of which can be translated into permanent employment growth), moving towards a circular economy would lead to a decline in what are referred to as negative external effects on the environment in the Netherlands and beyond its borders, but have no use or offer no compensation.

In this study, these negative external effects are examined using four indicators:[8]

- CO_2 emissions;
- use of freshwater;[9]
- land use (ecological footprint); and
- the Raw Material Equivalent (RME), which represents the 'package' of all the raw materials used to manufacture a product that is consumed in the Netherlands.

For the Netherlands as a whole, we estimate that a more circular economy could help to avoid CO_2 emissions amounting to 747 kt per year, which is just 9.7% of the current annual CO_2 emissions produced by the metal and electrical sectors. Note, however, that this figure does not include the CO_2 emissions avoided in other countries due to the use of fewer raw materials (RME; see box).

Raw Material Equivalent

The Raw Material Equivalent (RME) is a measure that takes into account the complexity of today's economy and its value chains. It indicates the quantities of all the raw materials a sector uses to manufacture its products, both domestically and abroad. The raw materials are divided into 52 groups, including grain, wood, natural gas, rubber and iron ore. In 2009, the metal and electrical sectors in the 27 EU countries used almost 1 billion tonnes of raw materials. Of this, Dutch industries accounted for approximately 81.9 million tonnes, even after deducting the RME used in products that were subsequently exported

The water use avoided for the metal and electrical sectors could amount to approximately 37 million m^3, with a total use of 280 million m^3 presently throughout the Netherlands. The base metal industry in particular could take measures to reduce this volume.

The avoided land use resulting from more circularity in the metal and electrical sectors would amount to only 20 km^2. This rather modest improvement is attributable to the fact that the impacts of the extraction of minerals and raw materials used in these sectors on land use are not expressed in existing indicators.10 If land use figures were included in these indicators, the ecological footprint due to increased circularity could be reduced by more than 20 km^2.

The RME avoided could amount to 5.2 billion tonnes of raw materials (for a breakdown, see the background document), which amounts to 6.3% of the RME currently used in the metal and electrical sectors. This figure has been calculated by looking at specific product groups.

2.5 There's no such thing as a free lunch: the cost of transition

The previous section calculated the benefits of using the opportunities presented by a circular economy. The cost of a transition to a circular economy will to a large extent depend on its estimated potential. This is true, for example, of the costs related to collecting and processing materials, and the investments repair businesses would have to make, etc. These costs have been included to the greatest extent possible in the concept of value and therefore in the calculations. We cannot give detailed estimates of these costs, just as we cannot specify who will have to pay them, or when.

The biotic circular economy: waste streams as raw materials

3 The biotic circular economy: waste streams as raw materials

The Netherlands is a densely populated country with an intensive agricultural sector and large agro-food industry, both of which generate significant waste streams. This chapter identifies the 34 most important biotic waste streams and their current uses, which already represent a value of €3.5 billion. The application of new technologies, such as biorefining, biogas extraction and improved means of sorting household waste could add another €1 billion to the Dutch economy.

3.1 Waste streams from the agro-food sector

The Dutch circular economy would benefit from adding as much value as possible to biotic waste streams. We would not be starting from scratch: many processes that add value to biotic waste streams are already in place. But to gain insight into the potential of a more circular economy, we have to look carefully at all the data on the nature and size of existing biotic waste streams, and at the ways in which they are already being (and could be) converted into valuable product streams.

A distinction can be made between three waste streams:[1]

- *primary waste streams* are generated during harvesting, storage and transport prior to primary processing;
- *secondary waste streams* are generated during primary processing within the agro-food industry; and
- *tertiary waste streams* are generated during production or consumption by end users.

These waste streams are significant because agricultural sector and the food, drink and beverages (e.g. beer) industry are extremely important to the Dutch economy. In 2010, for example, agriculture accounted for 5.3% of Dutch exports, and employed 240,000 people. The food industry contributed as much as 12.9% of exports (total value €32.9 billion) and provided work for approximately 120,000 people.

Approximately 2.66 million ha, or 64% of the area of the Netherlands, has been earmarked for agricultural uses, such as horticulture, arable farming and cattle farming.[2] Figure 3.1 shows the yields of arable crops grown in the Netherlands, which together amounted to approximately 28 Mt in 2011 on 711,000 ha of land.[3] The predominant crops include maize for animal fodder (complete plants, 46 t/ha per year), sugar beet (80 t/ha per year) and potatoes (approximately 50 t/ha per year).

The Netherlands is also a net importer of grain (6.7 Mt per year of wheat, barley and maize), oilseeds such as soybean, sunflower seed and rapeseed (about 5 Mt per year),[4] and meat and vegetables (CBS). The Netherlands produces approximately 3.1 Mt (slaughter weight) of beef, pork and poultry, and 11.3 Mt of milk per year.[5]

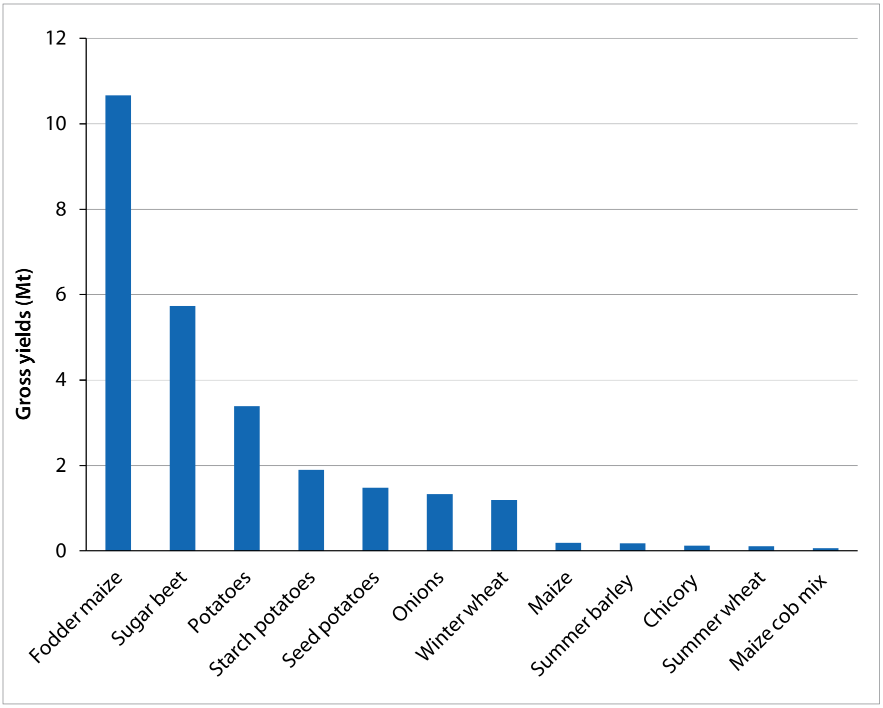

Figure 3.1. Yields of arable crops grown in the Netherlands, 2011.
Source: CBS.

As well as the waste streams from the agriculture and food sectors, this study has also examined a number of human waste streams, such as organic waste, household waste and sewage sludge.

Table 3.1 provides an overview of 34 waste streams generated by the agro-food sector, and how they are currently used. Although these waste streams together represent a volume of 42.9 Mt (wet weight) per year, this analysis considered only those streams larger than 50 kt per year. The table also provides indicative prices, although it should be noted that prices fluctuate significantly depending on factors such as location, season, quality and, in the case of a market notable for its lack of transparency, the intended purpose of the product. Primary waste streams are indicated in green, secondary in blue and tertiary in black.

Figure 3.2 shows the most important current uses of the primary, secondary and tertiary waste streams. The secondary streams are the largest in terms of volume due to the large amount of transported fertilizer (17.4 Mt, wet weight). Figure 3.3 plots the current values of the 34 waste streams, which amount to approximately €3.5 billion, while figure 3.4 shows the waste streams that represent the most value in absolute terms.

The uses of these waste streams can be roughly divided into five categories: incineration (substantial negative price), composting (negative price), waste that remains or is spread on the land, wet and dry cattle feed, and biodiesel production. The total value of dry and wet cattle feed is €2.1 billion, making it by far the largest area of use. The use of soybean meal as cattle feed accounts for 35% of the current market value of biotic waste streams.

The prices of a number of waste products have risen in recent years (or are less negative), partly because of rising energy and agricultural commodity prices, the surplus waste incineration capacity in the Netherlands26 and fierce competition regarding the procurement of organic and biodegradable waste for composting.

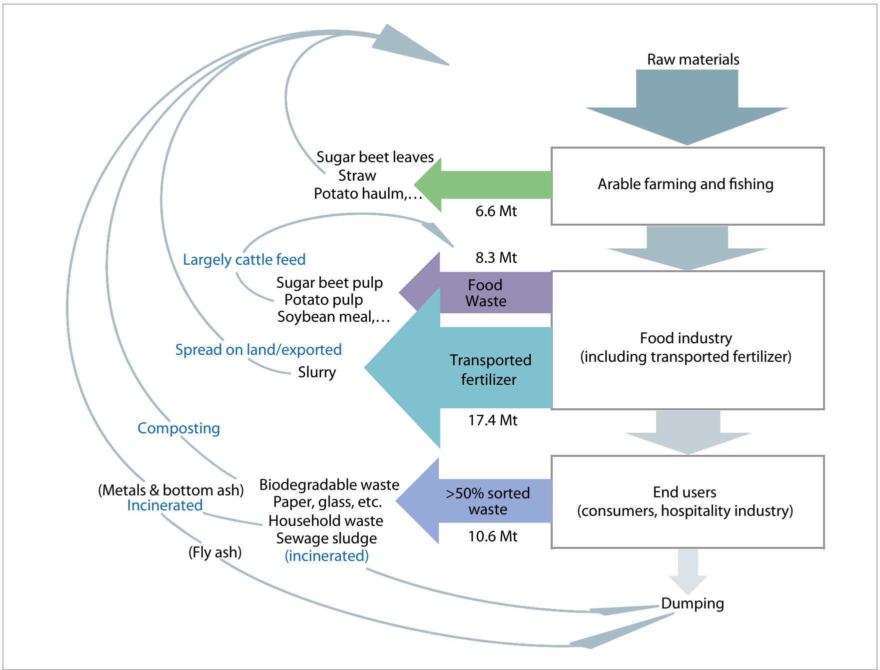

Figure 3.2. Waste streams from the agro–food sector and their circular applications.

Table 3.1. Summary of the 34 waste streams from the agro-food sector (ranked in order of indicative prices)

Biotic waste stream	Current uses	Indicative price (€/tonne)	Generated in NL (t/yr a.r.)[6]	Water content (%)
Mixed kitchen & supermarket waste[7]		−90	100,000	30%
Meat & bone meal (Cat. 1 & 2)[8]	Processed (to avoid risk of prion transmission)	−90	90,000	10%
Household waste (excl. biodegradable waste)[9,10]	4.4 Mt incinerated; metal extraction; road building; heating networks[11]	−80	7,600,000	30%
Sewage sludge[9]	Biogas, heat	−50	1,500,000	78%
Feather meal[7]	Heat	−50	37,000	5%
Flower auction waste[12]	Composting	−30	125,000	60%
Horticultural crop residues[13]	Composting	−30	220,000	60%
Biodegradable waste[14]	Composting, biogas[15]	−30	1,297,000	55%
Onion crop waste[11]	Biogas	−15	60,000	86%
Poultry manure & other[16]	Fertilizer	−15	1,160,000	30%
Cattle slurry[15]	Biogas, soil additive in phosphate- and nitrogen-deficient areas	−15	7,400,000	90%
Pig slurry[15]	Biogas, soil additive in phosphate- and nitrogen-deficient areas	−15	8,800,000	90%
Spent mushroom compost[12]		−10	780,000	30%
Sugar beet leaves[17]	–	0	3,000,000	87%
Fish waste[11]	Mink feed, biogas	0	76,000	75%
Potato haulm[18]	–	0	1,756,700	75%
Yeast extract (wet)[19]	Cattle feed	18	67,500	89%
Potato peel[20]	Cattle feed	20	450,000	80%
Maize grain, stalks and cobs[21]	Cattle feed	30	512,000	65%
Potato pulp[18]	Cattle feed	36	395,000	84%
Wet sugar beet pulp[19, 22]	Cattle feed, biogas	50	445,000	76%
Cocoa shells[18]		50	66,000	15%
Draff[18]	Cattle feed, biogas	50	500,000	78%
Straw (wheat, barley)[18, 21]	Stall bedding, second-generation biodiesel	150	1,100,000[23]	15%

Table 3.1. (continued)				
Biotic waste stream	Current uses	Indicative price (€/tonne)	Generated in NL (t/yr a.r.)[6]	Water content (%)
Grain byproducts[24]	Cattle feed, wheat semolina	210	250,000	13%
Dry sugar beet pulp[19, 21]	Cattle feed	240	310,000	10%
Rapeseed meal[23]	Cattle feed	300	1,105,000	13%
Sunflower meal[23]	Cattle feed	300	555,000	11%
Meat & bone meal (Cat.3 food)[7, 25]	Pet food	300	300,000	5%
Frying oil[19, 21]	Cattle feed, second-generation biodiesel	450	120,000	5%
Animal fat (Cat.1)[7]	Cattle feed, pet food, second-generation biodiesel	450	40,000	5%
Whey powder[23]	Cattle feed	500	93,000	5%
Soybean meal[23]	Cattle feed	505	2,390,000	5%
Animal fat (Cat.3 food)[7]	Cattle feed, pet food	550	200,000	6%
TOTAL (tonnes/yr)			42,900,200	

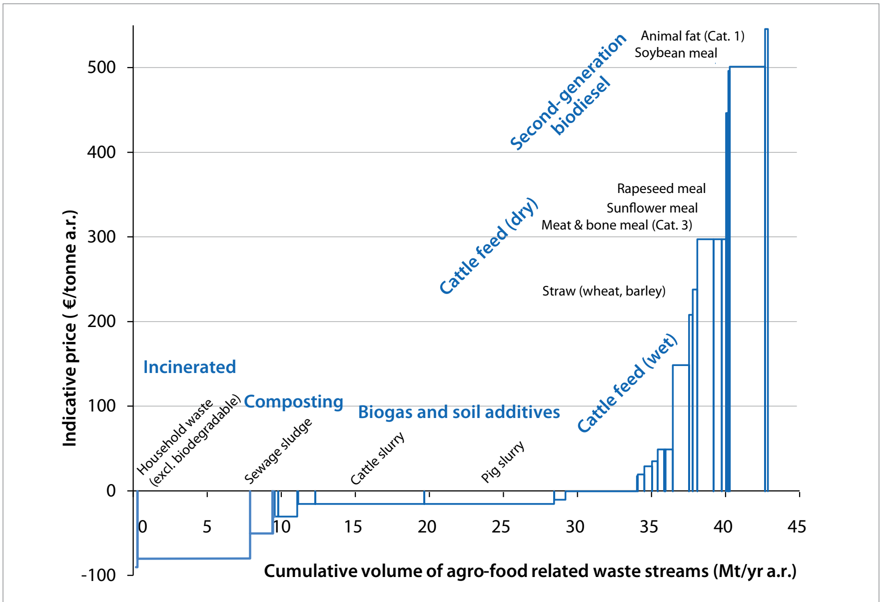

Figure 3.3. Cumulative current value of the 34 biotic waste streams.

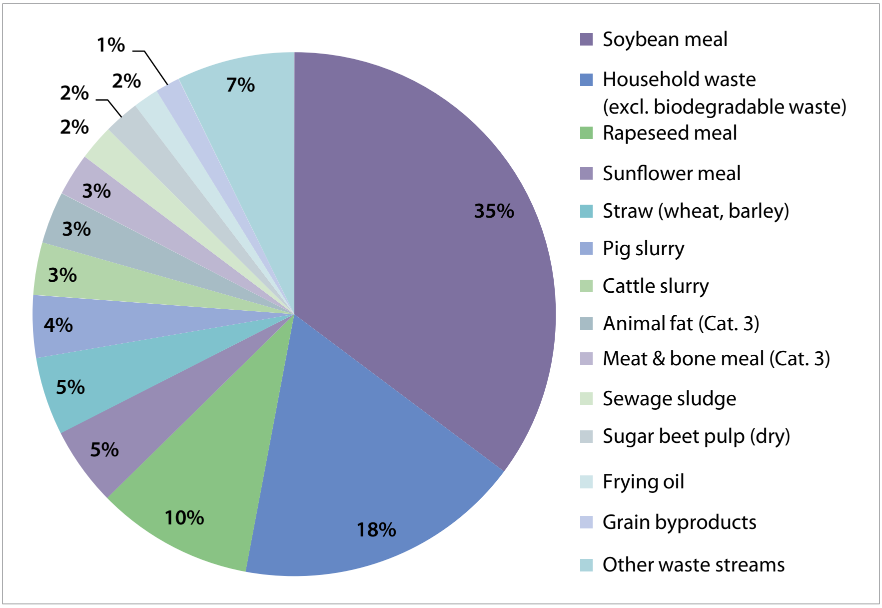

Figure 3.4. Breakdown of the current market value of the 34 biotic waste streams (total value €3.5 billion in 2012).

3.2 Getting more out of biotic waste streams

The previous section has demonstrated that a large proportion of biotic waste streams are already being used as cattle feed or raw materials for biogas or second-generation biodiesel. Researchers are working to develop novel applications and processes that could potentially generate a higher added value than existing uses, such as biorefining, insect breeding, the production of C_5 and C_6 sugars,[27] solid state fermentation, and more efficient biogas production processes. A summary of the technological options for creating added value from biotic waste streams can be found in appendix 4. The technical and commercial feasibility of many of these applications still have to be demonstrated.

In the most optimistic scenario, in which these 34 biotic waste streams are indeed used more efficiently and effectively than they are now, they could generate a net added value of €1 billion per year for the Dutch economy. Approximately 50% of this added value will be created by increasing biogas production, 42% by applying novel biorefining techniques and the remaining 8% by increasing the volume of household waste being sorted.[28] These values can be regarded as 'points on the horizon'. Figure 3.5 shows the added value for each biotic waste stream (where this can be compared with the current value). The sources of this added value are shown graphically in figure 3.6, and the underlying assumptions are explained in table 3.2.

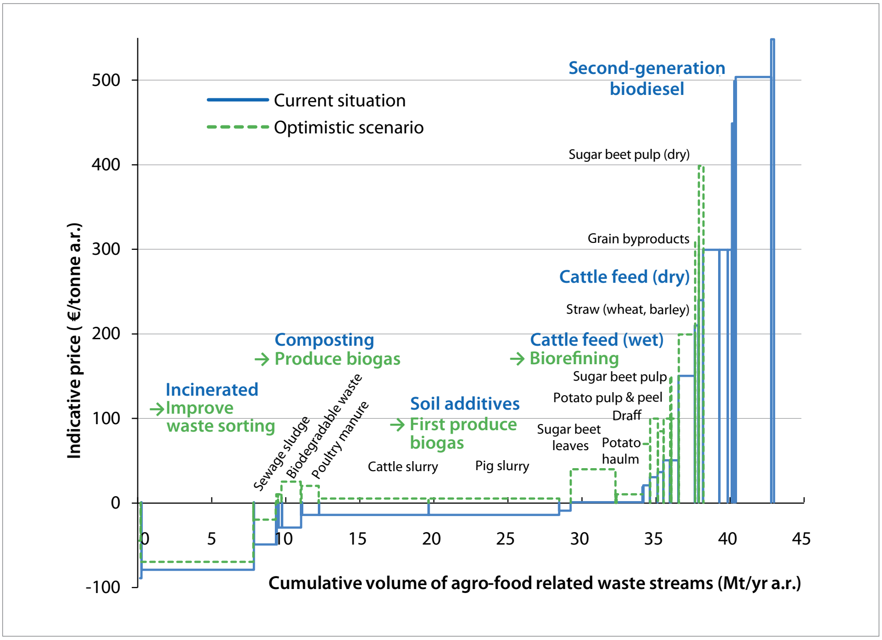

Figure 3.5. Indicative price–volume curves for the 34 biotic waste streams: current situation (blue) and the optimistic circular scenario (green).

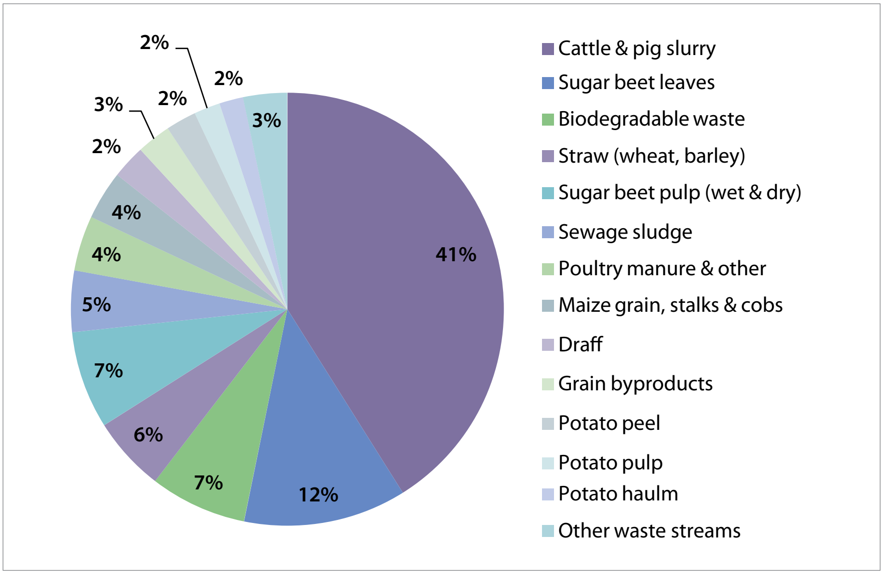

Figure 3.6. Sources of added value – approximately €1 billion per year – for the Dutch economy.

Table 3.2. Starting points and assumptions made in calculating the added value of biotic waste streams				
Waste stream	Assumption regarding new circular application	New products	Indicative new 'value' (€/tonne)	Comment
Mixed kitchen & supermarket waste	Biogas production	Biogas	−45	Contains a large amount of cardboard and packaging
Household waste (excl. biodegradable waste)	Improved waste sorting	Paper, glass, textiles, biodegradable waste	−70	Savings of €250 million if the volume of waste being sorted were to be increased by one third
Biodegradable waste	Biogas production	80 m^3 biogas/t	+25	
Slurry	Biogas production	30 m^3 biogas/t[29]	+5	Value as fertilizer approximately +€8/t
Sugar beet leaves	Extraction of 1 wt% RuBisCO[30]	RuBisCO protein (€4/kg)	+40	7 Mt/yr
Sugar beet pulp	Biorefining	Diet products, cosmetics, fibre	+100	According to Benschop (2012)[31] and Elbersen (2010)[32]
Draff	Biorefining	Protein, fibre (sugars)	+100	Path according to Elbersen (2010)
Potato pulp	Biorefining	Starch, pectin, fibre	+85	Path according to Elbersen (2010)
Maize residue	Biorefining	$C_5 + C_6$ sugars	+100	Use of sugars for ethanol production
Straw	Biorefining	$C_5 + C_6$ sugars	+200	Use of sugars for ethanol production
Waste streams costing >€200/t	No change	–	–	High-quality applications already exist

In the following we look at some of these waste streams in the Netherlands, and the prospects for getting more out of them.

Biodegradable waste

Each year Dutch households produce approximately 1.3 Mt of biodegradable waste, most of which is sorted and processed into compost in 22 waste plants for use in arable farming, for example. These composting companies are facing increasing competition in public tender processes and, as a result, sharply declining margins.

A growing number of waste management companies, such as VAR, HVC and Shanks Orgaworld, are converting biodegradable waste into biogas (approximately 40–100 m^3 per tonne of waste) so that a compost fraction can be produced after all. There are currently seven biogas plants in the Netherlands, which in 2011 processed a total of approximately 220,000 tonnes of biodegradable waste. In 2010 these companies signed a 'sustainability declaration', in which they agreed on a target of processing 1 million tonnes of biodegradable waste by mid-2015.[33]

Fertilizer

Approximately 67 Mt of slurry (wet weight) is collected from Dutch farms every year, of which about 7.4 Mt is cattle slurry and 8.8 Mt pig slurry, which are transported to other locations to be used to produce biogas or spread on agricultural land deficient in organic nutrients such as nitrogen and phosphate in the provinces of Zeeland or Groningen. The use of fertilizers is subject to strict government regulations, as well as the EU Nitrates Directive (2006), which sets limits on the use of phosphate fertilizers in order to protect groundwater quality. A bill recently presented to the Dutch parliament aims to promote the responsible use of fertilizers by specifying the obligations of manufacturers regarding processing (for example, its conversion into granules). Companies such as Ferm O Feed are already producing organic granular fertilizer from poultry manure, much of which is exported to China.

Sugar beet

Approximately 3 Mt (wet weight) of sugar beet leaves are currently left on the land, and so seldom appear in statistics. The leaves contain small quantities of RuBisCO, a high-quality protein that could be used as a food supplement. Studies are currently under way to identify ways to extract it.

Approximately 1.1 Mt (wet weight)[34] of sugar beet pulp is sold as cattle feed, and a small proportion ends up in biogas plants. Some of the pulp is dried into pellets and some is sold wet. Cosun, the owner of the only two remaining sugar factories left in the Netherlands, in Dinteloord and Groningen, is considering opening a biorefinery at one of these sites to generate a range of products that could cause the value of sugar beet pulp to increase from approximately €200–240 to €400 per tonne (dry weight).[35]

Draff

Draff is the residue of malt and grains used in the production of beer that is used as cattle feed because of its high protein content (approximately 25% dry weight). Some companies are considering biorefining the draff in a process that would separate the protein (for use as cattle feed) and the fibres (for starch, for example[36]).

Potatoes

Potato pulp and peel waste streams, which amount to 395,000 tonnes and 450,000 tonnes (wet weight) respectively, are currently used as cattle feed, but their starch, fibre and pectin fractions make them potentially attractive for refining for use as food, cattle feed and for applications such as starch or paper production.

Maize stalks and cobs

Maize production generates approximately 30 tonnes/ha of stalks and cobs. As mentioned above, these residues could be biorefined to produce sugars.

Straw

Each year the Netherlands produces about 1.1 Mt of barley and wheat straw,[37] about 75% of which is already put to good use as bedding in animal stalls, for example, and 25% is left on the land to improve the organic content of the soil and soil structure. Straw and maize stalks are now being used as raw materials in the new second-generation bioethanol plants being built in the United States (e.g. POET-DSM in South Dakota and Abengoa in Kansas) and Italy (Chemtex in Crescentino near Turin).

Potato haulm

Potato plants are sprayed with pesticides or mechanically 'folded' several weeks before the harvest, after which the haulm – the leaves and stems – is left on the land. The 1.7 Mt of potato haulm produced in the Netherlands has an interesting potential for biorefining because the potato plant contains two natural toxins (alkaloids chaconine and solanine) that protect the plant against fungi, insects and other parasites.

The authors of this report estimate that a one-off investment of about €4–8 billion would be needed to achieve the required biodigestion and biorefining capacity, which could have an annual market value of €1 billion.[38] In the end, the exact amount will depend on factors such as scale, steel prices, biogas revenues, the number of annual operating hours and the selected process concepts. Producing biogas through fermentation and improving the sorting of household waste are technologies with a proven track record. Biorefining has been shown to be feasible in the laboratory, but not yet commercially.

In some cases, the new value of a waste stream that could be used more effectively in a circular economy would represent an immediate saving if that product is normally imported. Examples include RuBisCo protein extracted from sugar beet leaves (reducing imports of high-quality proteins), the production of biogas from animal slurry (eliminating imports of natural gas) or the production of ethanol from maize cobs (reducing imports of ethanol). In other cases, such as the biorefining of protein-rich draff, the potential benefits are not so clear. Indeed, draff is already used as cattle feed and so has helped to reduce imports of soya.

3.3 Environmental impacts of increased circularity in the use of biotic waste streams

Extending or intensifying the uses of biotic waste streams could help to avoid many negative environmental impacts, expressed in terms of indicators such as CO_2 emissions, the use of freshwater, land use and the Raw Material Equivalent (RME).

CO_2 emissions can be avoided by burning less fossil fuel. In the Netherlands increasing the share of biogas in the energy mix could help to reduce CO_2 emissions by an estimated 150 kt (based on an average energy value of biogas of 15 MJ/m^3), which is 1.2% of the emissions currently produced by the Dutch agriculture and fisheries sectors. If the CO_2 emissions avoided are the result of biogas (or ethanol) production, that would also contribute to the government's target of meeting 16% of the energy demand from renewable sources by 2020.

The RME avoided is the result of a slight reduction in exports of raw materials due to the use of biorefining techniques and burning less fossil fuel. The potential is estimated at 0.4 million kt of raw materials.

In this study the use of fresh ('blue') water avoided was not calculated because no clear relation between water use and biotic waste streams could be determined.

However, following from this study of biotic waste streams, it is possible to calculate the land use avoided due to the use of biowaste. This is the result of a reduction in imports of some inputs used in the Dutch agricultural sector. Even using conservative estimates, the ecological footprint would be reduced by no less than 2,000 km^2, considerably more than in the case of abiotic waste streams discussed in chapter 2, because of the predominance of agriculture in the calculation of ecological footprints.

The impacts of increased circularity on the Dutch economy

4 The impacts of increased circularity on the Dutch economy

After analyzing the uses of biotic waste streams and the effects of an expanded circular economy on products from the metal and electrical sectors, we can estimate the impacts of moving towards a circular economy on the Netherlands as a whole. We estimate that the added value could amount to €7.3 billion per year, involving 54,000 jobs. It would also provide a number of spin-off benefits for the Netherlands, including strengthening the country's knowledge position.

4.1 Scaling up: the potential value of the circular economy

In chapters 2 and 3 we estimated the economic opportunities presented by an expansion of the circular economy for two cases: the more intensive use of and greater efforts to keep in circulation products from the metal and electrical sectors and biotic waste streams. But of course these areas of activity represent only part of the Dutch economy.

To estimate the influence of increased circularity on the entire Dutch economy (and the environmental effects) we considered various other sectors that are linked in some way to those examined in chapters 2 and 3. In other words, we looked at the opportunities for increased circularity in the food, textile and clothing, and wood and paper industries the same way as we did for biotic waste streams. For other industrial sectors (such as the automotive, printing and graphics, and construction industries) we assume that the opportunities for increased circularity are comparable with those for products from the metal and electrical sectors. The growth in value in the base metal, metal, electronic and electrical appliance sectors are 0%, 0.3%, 12.1% and 35.5%, respectively (see table 2.4).

We assume a fixed increase in value of 0.1% for the various service sectors, while the activities in the service sectors involved in repairs, rental, maintenance and recycling will increase proportionately to the estimates for these activities in chapter 2.

Based on this extrapolation, we estimate the total market value of the opportunities presented by the circular economy for the Dutch economy could amount to €7.3 billion a year, or 1.4% of today's GDP. This corresponds, given the market value of salaries in all sectors, to approximately 54,000 jobs (including those created from the biotic and abiotic cases).

This €7.3 billion can be accounted for as follows: slightly more than €1 billion by an expanding services sector, €0.93 billion in agriculture and €5.3 billion in the industrial sectors.

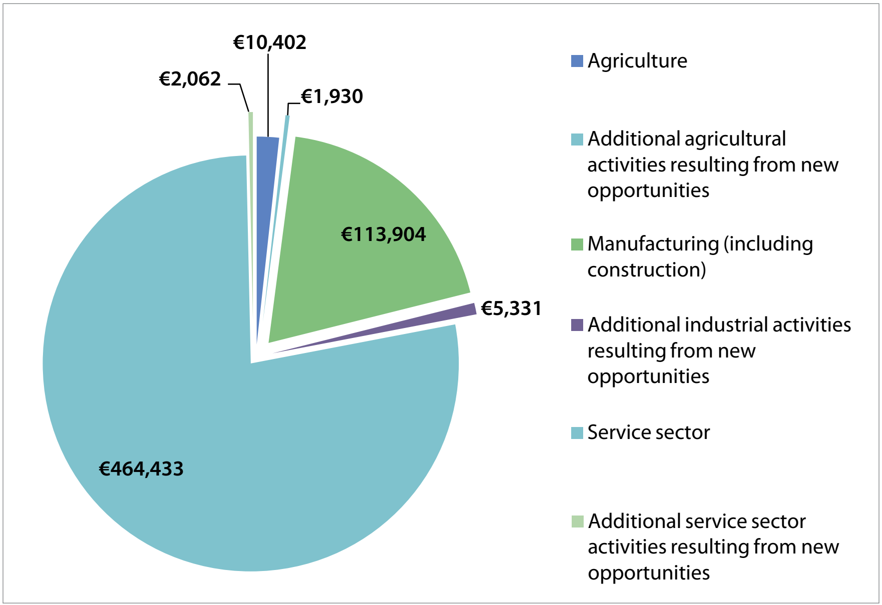

Figure 4.1 Breakdown of Dutch economy in 2010 expressed in gross domestic product (GDP) and the shares of potential GDP growth (in euros) as a result of circular economy.

Obviously this €7.3 billion will not find its way into the Dutch economy immediately. A number of steps will need to be taken, some of which will require long-term research, drastic changes in behaviour or amendments to laws and regulations, while others could be implemented relatively quickly. We have assessed the various steps and the time it would take for them to help develop a circular economy, and identify three phases:

Phase 1: short term (0–3 years)

- leasing and rental contracts for washing machines;
- subsidies such as the Environment Investment Allowance (MIA) or Random Depreciation of Environmental Investments (VAMIL), to lengthen product lifetimes;
- loan schemes such as Neemby, Floow2[1];
- increased recycling of LEDs due to their high value;
- reassessment of the WEEE directive;
- use of logistical knowledge of major ports;
- collective insurance to cover repaired goods/products with used parts;

- lift ban on stockpiling;
- rising prices of raw materials;
- use of reserve from collection contributions; and
- reduced rate of VAT on circular services.

Phase 2: medium term — the period of Horizon 2020, the EU's Framework Programme for Research and Innovation (3–7 years)
- changing the location of incineration plants;
- 'assembly for disassembly' computers;
- changes in attitude towards possession;
- rising prices of raw materials (continuing incentive);
- conditions for the supply of parts incorporated into B2B contracts; and
- new technologies to intensify the use of biotic waste streams.

Phase 3: long term – point on the horizon (>7 years)
- development of plastics that are designed for recycling;
- divestment of 'stranded assets' strategies;
- introduction of raw materials passports;
- rising prices of raw materials (continuing incentive);
- development of product service systems (PSS) for the most expensive metal and electrical product groups; and
- introduction of new technologies to intensify the use of biotic waste streams.

In each of these three phases, the opportunities provided by an expanding circular economy could generate an estimated value of €3.3 billion in the short term, €1.7 billion in the medium term (3–7 years) and €2.3 billion in the long term (after 2020, see figure 4.2).

Clearly, in order for the Netherlands to benefit from the long-term opportunities, action needs to be taken now.

In its report, Towards the Circular Economy, the Ellen MacArthur Foundation (EMF, 2012/2013) estimates that the circular economy could add US$380 billion (€287 billion) to the European economy during the transition stage, increasing to US$630 billion (€476 billion) in a more advanced stage. These estimates are based on a more restricted group of industrial sectors than the one we used to derive our estimate of €7.3 billion for the Dutch economy. The question now is how our assessment compares with that of the EMF report.

For the sectors examined in the EMF report, the Dutch contribution to the European economy (EU 27) is 2.9%.[2] If we restrict our analysis to this set of industrial sectors, then according to our calculations the contribution to the Dutch circular economy could be worth €2.7 billion (rather than the indicated €7.3 billion). This is approximately 1% of the €287 billion that the EMF estimates for the EU-27. The potential that we estimate is rather lower than the EMF's estimate, for three reasons:

- The estimates of the shifts that were introduced in chapter 2 (and used for the extrapolation in this chapter) were conservative; the potential effects of more radical changes and business models that could help the move towards a circular economy are particularly difficult to calculate.

- The negative economic effects of a transition have been taken into account to the greatest extent possible. For example, a shift towards more recycling can result in higher costs in some cases, and a circular economy would also lead to fewer new products being bought.

- The Netherlands is already affected by the 'frontrunner's handicap' (i.e. an initial headstart that can turn into a disadvantage in the long term) when it comes to the amounts of materials being saved through recycling, etc. Figure 1.1 showed that within the EU the Netherlands is a leader in terms of the volumes of materials being recovered from household waste. The net savings in terms of materials in the Netherlands could therefore be higher than what is assumed to be the European average (note, however, that the costs associated with more intensive recycling have not been included here).

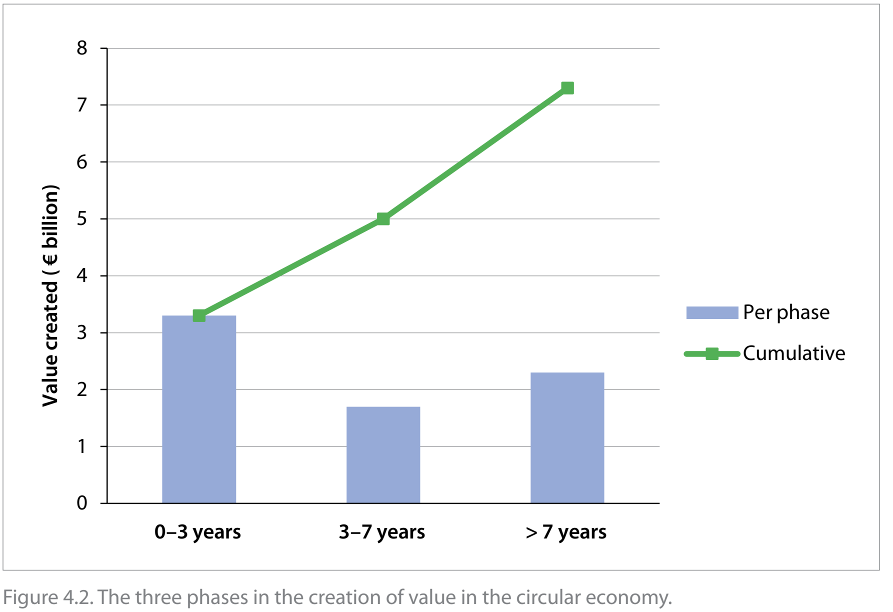

Figure 4.2. The three phases in the creation of value in the circular economy.

4.2 External effects of the circular economy for the Netherlands

A simple extrapolation of the reduction in CO_2 emissions from the two cases to the national level reveals a potential reduction of 17,150 kt, almost double the CO_2 emissions that are being saved now by using renewable energy. By comparison, national CO_2 emissions in the Netherlands in the base year 2010 were 214,000 kt, some 172,000 kt of which was produced by economic activity.

A reduction in land use would come to 2,180 km^2, whereby the contribution from the abiotic waste streams would be marginal compared with the biotic case. Given that at present the ecological footprint of the Netherlands is three times larger than its land area (41,500 km^2), an expanded circular economy would reduce this footprint by approximately 2.5%.

The avoided use of fresh water due to expanded circularity would amount roughly to 0.7 billion m^3. The Netherlands currently uses approximately 16 billion m^3 of water per year, which industry uses about 3.5 billion m^3.

The avoided use of raw materials (represented by the Raw Material Equivalent, RME) is 100,400 kt, which is more than 25% of the total imports of goods by weight in the Netherlands each year.

4.3 Indirect benefits of the circular economy

The move towards circularity in the Dutch economy is likely to generate a number of direct benefits, including increased GDP, and therefore jobs, as well as indirect benefits (the value of which has not been analyzed in detail here), such as:

Development of knowledge for export

There is a clear opportunity in terms of developing and spreading knowledge about the development of a circular economy in the Netherlands. Such knowledge and expertise can be used within and outside the country, as is the case with Dutch water expertise. The location of the Netherlands on a delta with high rates of production and consumption means that circularity will require a number of breakthroughs. The knowledge that will be needed to make these breakthroughs can be used subsequently in other densely populated areas, which are expected to increase worldwide.

More secure supply of raw materials

Ensuring the security of raw material supplies has become an important strategic imperative for companies, national governments and the European Union. The literature and interviews held for this study reveal that many companies are already experiencing supply interruptions. A circular economy will make companies less dependent on imports of raw materials and therefore less vulnerable to trade restrictions and price fluctuations.

New incentives for the manufacturing sector

In addition to trade, the manufacturing sector plays an important part in the Dutch economy. Manufacturing industries are important innovators (in production processes, as well as products themselves). However, the share of manufacturing in total GDP in the Netherlands is shrinking. The circular economy will provide a number of opportunities for the further development of manufacturing industry, including in areas such as product design and related production techniques, as well as the repair and reuse of products and components. Regenersis, a UK company, is an example of a company that is already putting this idea into action.[3]

New incentives for the recycling industry

BRBS Recycling, a Dutch trade association, believes that recycling is still in its infancy,[4] and has recently conducted a survey to gauge how much further recycling can be developed in the Netherlands. Preliminary results suggest that one condition for creating an ideal recycling scenario would be to weaken the dominance of incineration plants in the processing of biotic and abiotic waste streams. Recycling companies are introducing increasingly accurate technologies for sorting waste streams. Examples include Van Baetsen Recycling, which is using robots for hand-sorting waste, and HKS Metals, which uses X-ray analysis to separate metals from waste streams.

In another development, several major producers are examining ways of reusing plastics from old appliances in new ones, although this is still more expensive than 'downcycling'. Plastics from waste electronic and electrical equipment (WEEE) contain a mix of acrylonitrile butadiene styrene, polyethylene/polypropylene, polystyrene and polyvinyl chloride, and are not suitable for disassembly or recycling.

Innovation in the logistics sector

A circular economy will have a significant impact on the Dutch logistics sector. Logistics operations will change, and in some areas increase, as the collection of products, components and waste streams become everyday practice. On the other hand, a circular economy would ideally mean reducing the use of primary raw materials and semi-manufactured goods, and increasing the lifespan of products, thus reducing the demand for logistics. What the balance would be in terms of volume and value needs to be examined in more detail. In mid-2013, the Council for the Environment and Infrastructure was expected to present its outlook for the logistics sector between now and 2040, and role of the circular economy.[5]

Development of new economic activity

The circular economy will also encourage the development of new economic activity. These could include, for example, businesses that focus on repairing and reusing electronic products and reusing components, such as Regenersis, or introduce different kinds of product services, such as Turntoo, Neemby and Floow2. Other kinds of economic activity might also emerge that we cannot yet anticipate. All of these activities will reduce the transaction costs of circular services, both as a result of economies of scale and the closer proximity (and visibility) of these services to consumers.

Drivers and obstacles on the way to a circular economy

5 Drivers and obstacles on the way to a circular economy

Chapter 4 presented a picture, based on an economic analysis, of the potential of a circular economy in the Netherlands. This chapter examines those aspects that could either impede or encourage this potential, and chapter 6 focuses on the role of the government can play in that respect.

5.1 Introduction

In order to create a circular economy that has the potential as described in chapter 4, a number of preconditions have to be met and various hurdles have to be cleared. This chapter presents a summary of these hurdles, based on the literature, interviews and a workshop that was held in the context of this study. They give an idea of the preconditions, obstacles and incentives in the eyes of the stakeholders we consulted. The summary also provides guidelines for an action plan for various stakeholders, including the government (see chapter 6). The driving forces and obstacles identified by the stakeholders are discussed in light of each of the key processes in the innovation system in the Netherlands (see box).

5.2 Developing and disseminating knowledge

One precondition for the transition to a circular economy is the capacity to innovate. What is the general state of the Netherlands' innovative capacity? Compared with other EU countries, the Netherlands is above average, an 'innovation follower', but certainly not a leader. Dutch companies are innovative –almost 40% of industrial companies and 21% of businesses in the services sector have produced at least one technological innovation – but the number of innovative companies is not rising. Both public and private investments in R&D are under pressure. The Netherlands is a global frontrunner in the area of patents, but the absorption and transfer of technology could be better. The Netherlands scores well in the sciences, but future employment opportunities in the sciences and engineering are not developing adequately.[1] In short, when it comes to developing and disseminating knowledge and entrepreneurial activities, the picture is mixed.

Categorizing obstacles and creating opportunities

In order to draft a useful and realistic initial action plan, it is important to explore the opportunities and obstacles from different perspectives. In this chapter, we examine the results of a qualitative analysis of the incentives and obstacles regarding a transition to a circular economy using the concept of an innovation systems analysis (for further details, see the background document and Appendix 1).

In any innovation system a number of specific functions or key processes must work well together in order for the system to succeed in generating innovations. These system functions can grouped into four categories:
– knowledge: developing and disseminating knowledge;
– business: entrepreneurial activities, market mechanisms and mobilizing resources;
– policy and rules and regulations (government-related framework activities); and
– lobbying and framework activities (non-government-related).

This classification will be used to identify the opportunities and obstacles to developing a circular economy, is based on a review of the literature, interviews and a workshop with stakeholders selected from the biotic and abiotic cases and TNO experts. We conducted interviews with 14 representatives of three research and education institutes, five businesses, a government agency, two trade associations and three other intermediary organizations. The workshop participants included 16 representatives of nine businesses, two research institutes, one government agency, two trade associations and one other intermediary organization (see appendices 2 and 3).We have included the sources (literature, interviews) in the analysis whenever possible; if the source is not mentioned, it means the analysis was based on TNO expertise.

The standard of knowledge on transitions and transition management in the Netherlands is up to par

In the last two decades, adequate knowledge has been developed in the Netherlands in the area of transitions. Various programmes have been launched to develop and disseminate knowledge and implement innovations, such as Sustainable Technological Development (DTO), the National Initiative for Sustainable Development (NIDO) and the Knowledge Network for Systems Innovations and Transitions (KSI).[2] This knowledge has also been used in the various transition platforms set up by the government between 2004 and 2010 and in CSR Netherlands (MVO Nederland) and the Sustainable Trade initiative (IDH). Agency NL, a division of the Ministry of Economic Affairs, Agriculture and Innovation (EL&I) hosted the Competence Centre for Transitions from 2005 to

2009, where knowledge about transitions, the required competences and learning experiences from actual transitions was collected, developed and disseminated.[3] Various knowledge institutes, universities, intermediary organizations and research bureaus are developing knowledge that could be used to explore an action plan for the government, set up experiments and monitor the development of a circular economy. There has to be a guarantee, however, that this knowledge dovetails with technological competences.

If we are to make full use of the opportunities for biotic waste streams, then in addition to the large-scale introduction of biogas plants, biorefining technologies need to be further researched and developed. Biorefining entails a series of technologies that aim to use as effectively as possible all of the valuable components of biomass, one of the most promising options for making the most efficient uses of biotic waste streams. It involves 'whole crop' biorefining (using maize and grain as raw materials), lignocellulose biorefining (using dry ligneous biomass) and organic biorefining (using wet biomass). All over the world, including in the Netherlands, many research and pilot projects have been set up related to biorefining. A number of commercial operations are under way, especially in the United States, based on maize, sugarcane, grain and sugar beet as raw materials, but as yet the focus is not on the production of industrial products from biotic waste streams.[4] Research is being carried out in the Netherlands on various biotic waste streams, including ways to extract the valuable RuBisCo protein from sugar beet leaves and tomatine from the leaves of tomato plants.[5]

In addition to the required technological developments, another precondition for the successful application of biorefining is the creation of integrated bioconversion chains. These chains should cut across the agricultural, energy, chemical, pharmaceutical and agro-food sectors so that they all work together to generate high-quality products, while the waste streams can be used to produce materials, bulk chemicals and energy. These achievements, together with the development of biorefining technology, will contribute to the circular economy in the long term.[5]

Closing the phosphate cycle is a priority for the Netherlands and has been supported by the Nutrient Platform NL since 2011. Nutrient Platform NL is a network of stakeholders from various sectors that focuses on creating operational conditions for the more sustainable use of nutrients throughout the entire value chain. The platform has launched a number of pilot projects[6] and is developing and disseminating knowledge on ways to close the phosphate cycle, and to strengthen the platform's position.

Knowledge that will contribute to the circular economy should be integrated into the creative industries and design schools

In order to close material cycles, knowledge is needed that can be used to 'design for disassembly, refurbish and recycle'. This notion is not included in most design school curricula.[7] The circular economy most likely will have to go hand in hand with far-reaching standardization to facilitate the reuse of product parts. Knowledge development for the design process will therefore have to focus on the art of combining constantly evolving standardization with designs that still allow manufacturers to distinguish themselves from their competitors. Perhaps the internationally acknowledged 'Dutch design' of the future will be instantly associated with circularity. This design knowledge can also grow as a result of skills acquired during the repair and disassembly phases of products. Businesses already learning to do this are clearly developing knowledge on the (dys)functioning of parts and how to discover manufacturing or design errors.[8]

But several major obstacles are impeding the development and dissemination of this knowledge:

Knowledge management is fragmented and rarely cuts across sectors

An important obstacle impeding knowledge development in the Netherlands is linked to how it is currently organized. The government's 'top sector' policy identifies nine priority sectors and envisages a multitude of innovation contracts. This kind of knowledge policy could be an effective way of improving efficiency within individual sectors. But if the aim is to take more concrete steps towards a circular economy, then the government will have to forge strong links with a variety of sectors and be particularly strongly rooted in a biobased economy. There is already a 'top consortium' for knowledge and innovation in the biobased economy in the Netherlands, but that is no guarantee of targeted and ongoing cooperation between businesses, knowledge institutes and government agencies.[5] The question is how to develop knowledge for a circular economy in an effective and focused way and, just as important, how to introduce this knowledge to the market. Indeed, focusing on reducing pressures on the environment, increasing energy efficiency and the use of raw materials in particular sectors could result in suboptimization, which could prevent the next step on the path to a circular economy. The top sector policy should be assessed for these kinds of negative effects.

The lack of a coherent approach to training and the development of skills and competences[9]

In general, a circular economy means restructuring society. Every business will have to adopt new business models, and the nature of many jobs will change to some degree. As a new point of departure for society in many disciplines, the concept of a circular economy will also have to be introduced into education. A coherent plan for a circular economy should ensure that these topics are clearly identified on the research agendas of the top sectors (and of the Top Consortium for knowledge and innovation), and in the curricula at all levels of higher education, from intermediate vocational colleges to universities. In addition to focusing on detailed knowledge of the concept of a circular economy in education, more thought could be devoted to developing the 'circular' skills and competences of graduates, including:

– their knowledge and skills in applying the principles of systems thinking;

– their ability to work together in multidisciplinary settings, and, for that matter, to work together in general. Circular working practices within and between businesses requires thinking in terms of chains and thinking outside the box. To do this, people must be able to work together with professionals from other fields; and

– their acceptance of 'not knowing'. A 'process-driven' approach to education involves and engages students in issues that affect them and others, but does not rely on getting answers from students based on current knowledge and desired behaviour (expert-driven education). Indeed, the circular economy means new ways of working and thinking that people will have had little or no experience with.[10]

The lack of knowledge within businesses and poor dissemination of knowledge

Many businesses are unaware of the exact origin or the composition of the raw materials they use. Moreover, the dissemination of knowledge about the development of new materials is often poor. There is little understanding of which materials are 'good' in terms of environmental impact, and it is often difficult for businesses to access such information. Finally, many businesses are not aware of the fact that they could reduce their waste streams or put them to use by working together with other businesses in the chain.[11]

5.3 Business: entrepreneurs, markets and resources

As described in the previous section, the Dutch business sector offers a mixed a picture in terms of innovative capacity. Dutch companies are just as innovative as those in other countries, but on the whole their numbers are not increasing.

5.3.1 Entrepreneurs

A good way to assess the innovative power and vitality of the Dutch economy is to look at whether the numbers of rapidly growing companies and young startup businesses are increasing. In that respect, the Netherlands lags behind other European countries. Many of the fastest-growing young businesses are in fields such as IT services, software, apps, webshops and gaming, but are all but absent from the heavy industry sector, which is extremely important for the development of a circular economy. Investments in R&D are about the same as in previous years. The range of major investors is becoming broader. R&D spending by small and medium enterprises (SMEs) is decreasing, while for major companies R&D expenditure overseas is becoming an increasingly high priority. Most of them are already spending more than half of their R&D budgets outside the Netherlands. At the same time, the interest of foreign companies in the Dutch knowledge economy has risen steadily over the past 10 years.[12]

Nonetheless, if we look at entrepreneurial activities related to the circular economy in the Netherlands, it is evident that there are a considerable number of frontrunners. They range from companies that emphasize corporate social responsibility (CSR) and are implementing the 'cradle to cradle' concept in their business practices and in the use of their waste streams, to companies that are developing and implementing new business models by using different product service systems.[13] These frontrunners are becoming increasingly well organized thanks to organizations such as CSR Netherlands, De Groene Zaak (entrepreneurs for a sustainable economy) and the Circle Economy, as well as government initiatives such as the 'Green Deals' to promote sustainable energy or energy-saving projects.

An inspiring example of how the business sector, knowledge institutes, NGOs and the government can work together to create a value-enhancing chain approach, is the Nutrient Platform and its efforts to implement the *phosphate chain agreement*. Their ambition is to create a sustainable market where as many phosphate streams as possible will either be returned to the environmental system or be exported as products. In doing so, a more 'energetic' society will take the lead in solving social problems (based on solid business cases), with the government as an equal partner. The platform brings together various market players, removes obstacles if necessary and desirable, establishes operating conditions, explains the advantages and drawbacks of national and European rules and regulations, and is helping to generate support for a European market in Europe and beyond.[14]

A growing number of businesses are viewing *corporate social responsibility* as the inevitable way of doing business in the future. Some aspects of CSR would support a move towards a circular economy, including more sustainable business operations, products and services, the value chain development approach and stakeholder dialogue.

The development of *biorefining* is necessary for a transition to a biotic circular economy. The biorefining activities related to biotic waste streams are generally conducted by companies that use specific plant or animal ingredients in their products. In many cases, the market prospects for such applications are still unclear, although in a technical sense many existing waste streams could be put to use. Experiments are under way in the Netherlands to set up new value chains across several sectors, involving SMEs and government agencies, although they are often poorly organized. The opportunities to develop further the biorefining of waste streams will depend on a growing consumer demand for high-quality products that contain only natural, biologically degradable ingredients.[15]

The use of *biodigesters for treating biotic waste streams* will have to be expanded. Composting businesses are now building digesters that can produce biogas as well as compost.[16] The Netherlands has 113 digestion plants that can process a total of 1 Mt (wet weight) of manure, usually by means of co-digestion, in which approximately half of the stream of material is manure. The cost-effectiveness of these plants leaves a lot to be desired, however.

Newly planned digestion plants are often larger than their predecessors and are equipped with digestate drying units.[17] As a result, exporting organic digestate granules as fertilizer and soil improvers is an obvious path to explore. The market for digestate granules from biogas plants still needs to be developed. Biodigesters with drying units appear to be an interesting application for biotic waste streams that cannot be utilized in better ways. They would mean, for example, that the large volumes of poultry and pig manure produced in the Netherlands could be used to generate energy, and would also dovetail with a new regulation obliging farmers to make the necessary investments to build their capacity to process manure.

5.3.2 Markets and new business models

The transition to a circular economy should be accompanied by greater efforts to experiment and work with new business models that encourage consumers to 'buy' the service provided by a product rather than the product itself. Examples include results-driven product service systems (PSS) such as Turntoo, or marketplaces such as Floow2,[18] where businesses can share equipment and services. Various studies have shown that results-driven PSS are the most interesting option in terms of sustainability,[19] and in theory could correct the uneven distribution of environmental costs and benefits of the production and consumption of products.[20] Indeed, it is in the interests of both producers and consumers to reduce the lifecycle costs and the use of raw materials during the use of a product. Furthermore, if it is true that producers really want to meet consumer demands, then they will have far greater freedom to design more sustainable product service systems.

The challenges of results-driven PSS lie in drawing up agreements that are sufficiently clear about what functional result will be, and limiting the risks for producers when it comes to delivering on their promises. The starting point of this is to 'replace' a product with a suitable results-driven PSS – one that will not clash with the desire for status, convenience or freedom. Based on a number of experiments with product service systems, the following lessons have been learned:

– Being customer-driven and eco-efficient is an extremely strong incentive for producers. It creates customer intimacy, because of the contact producers have with customers during the use phase. However, there is also the drawback that users can become dependent on the producers, either because of long-term contracts or other conditions included by the producers in the PSS.

– The transition to a results-driven PSS represents a huge change for companies whose core business is selling new products. Initially, they will experience the transition as undermining their business sector. Sales of new products are likely to decline because consumers will no longer focus on products but on the functions they perform. But manufacturers stand to gain from selling products with a long lifespan and meet consumers' needs.

– The transaction costs of switching from current business practices to PSS should not be too high.

– The risks of PSS should not be too high for producers, and should be reasonably easy to predict. This is more the case in the business-to-business (B2B) market than in the business-to-consumer (B2C) market, and also if the use phase is closer to the company's core business. Consider a company that is responsible for maintaining a swimming pool, for example, that is also asked to prevent teenagers from vandalizing it. Since security was never the company's core business, this gives rise to unanticipated problems and financial risks. On the other hand, one could view this situation as providing an extra incentive for the company to think about the use phase of its product.

The introduction of *new kinds of warranties* could act as an incentive to repair and reuse parts of appliances. For example, collective insurance could be developed to guarantee repaired goods and products with used parts. Regenersis, a company in the UK, is a good example of a company that focuses on this element of the circular economy. Regenersis profiles itself as a repairer of electronic appliances and their parts, and offers a warranty extension as one of its products.

5.3.3 Resources from waste

The system for collecting electronic and household appliances is well developed in the Netherlands, but there are many opportunities for improvement in the following areas:

- Lowering the threshold for recycling by citizens. For example, councils could develop mobile phone apps to inform citizens about waste collection points,[21] although such efforts would require the cooperation of all parties involved in waste collection.

- Financial incentives could encourage citizens and businesses to separate their waste for collection. One example is DIFTAR, a system of differentiated tariffs (*gedifferentieerd tarieven*), where citizens are charged according to the amount and type of waste they generate. Studies have shown that in municipalities where DIFTAR regulations have been introduced, the amount of waste electrical and electronic equipment (WEEE) ending up in household waste has halved. This may be because the financial incentive makes people less lazy, or the authorities have provided information to raise awareness about the need to separate waste.[22] The introduction of DIFTAR has also led to lower waste collection fees, probably because waste is sorted more comprehensively before being offered for collection, which produces less residual waste.

- The EU's WEEE directive should be reassessed to provide better incentives for recycling electrical and electronic waste streams. The directive requires EU member states to collect 45 tonnes of e-waste for every 100 tonnes of electronic goods put on sale during the previous three years, with a target of 65 tonnes by 2019. In practical terms, this will mean that more e-waste will have to be collected than is now the case. The extra effort that producers will need to make will vary according to the product.[23]

- Manufacturers' associations estimate that they lose track of about two-thirds of used electrical and electronic equipment when it is resold to scrap dealers via municipalities, the retail trade and installation companies. Introducing legislation obliging individuals and businesses to hand in this kind of equipment for disposal could help fill the gap. Opinions in the field are divided about the need for such legislation, however.[24]

For businesses involved in waste collection and recycling, the obstacles on the road to circularity lie include:

– *Entrepreneurs tend to focus on themselves, while trade associations focus on traditional chains.* Most entrepreneurs focus on themselves, on their own company.[25] This is evident in the practice of collective sustainable development of industrial estates, for example, and closed-loop recycling projects in the construction sector.[26] As a result, many entrepreneurs ignore opportunities for innovation in the chain and fail to cash in on the value of waste streams. Many are also unaware of where their raw materials come from or what they are composed of. It is not a given that trade associations will offer their support during the development of a circular economy, since they often focus on traditional chains and much less, if at all, on cross-sector cooperation and international cooperation. Moreover, the priorities of company initiatives related to raw material efficiency and the circular economy often conflict, and there is little internal capacity to consider new business models or to change a company's culture.[27]

This is not the case with frontrunners in the circular economy, such as businesses that acknowledge their corporate social responsibility, develop closed-loop recycling initiatives for their raw materials, use cradle-to-cradle principles or introduce product service systems. Various studies have shown that frontrunners do recognize the opportunities of chain innovation. Yet these frontrunners also face a number of obstacles:[28]

– *Uneven distribution of costs and benefits.* The costs and benefits of innovations at the chain level are often unevenly distributed across the links in the chain. This may happen if a business designs its products differently in order to reduce waste, for example, or it collects and reprocesses waste materials so that they have a secondary use. While the entire chain – and society as a whole – saves costs through these kinds of initiatives, the initiator faces additional costs. In such cases, it is extremely difficult for a business to make a viable business case if agreements have not been made within the chain to spread the costs. This has to do with the uneven distribution of power and resources in the chain. The government can play an important role in controlling the chain, as the implementation of the phosphate chain agreement has shown.

– *Uneven distribution of power and resources.* The actors in material and product chains are unequal in size and financial strength. While medium-sized and large companies generally have the staff and resources to develop new solutions, approach partners in business and ask the government for support, this is barely the case, if at all, with small companies. Many frontrunner businesses are relatively small companies that try to secure a position for themselves in the sector as newcomers. They do not have the time to build networks and find partners, nor do they occupy positions of power in the chain to 'command' certain changes. Long-standing market conditions can therefore cause economically promising initiatives to run aground.

– *There is no leeway for innovation.* A general obstacle often cited by frontrunners is that there is no leeway for innovation, or 'space to experiment'. The government, for example, not only determines policy objectives in some domains, but also specifies which resources market players must use to achieve these objectives. This is common practice with building regulations. The ways in which existing rules are interpreted are equally important. For example, a government information service for entrepreneurs was obstructed because the competent authority clung to a risk-averse interpretation of the rules, or perhaps was not capable of dealing with the uncertainty that is inherent in innovative solutions. As result, it may take so long for an entrepreneur to obtain a necessary license or to issue a practical test that sponsors are forced to withdraw. Unintentionally, a government bent on risk aversion is more likely to discourage than encourage innovative frontrunners to develop and bring to market their new, sustainable technologies.

Frontrunners involved in biotic waste streams face a number of specific obstacles:[29]

– *Investing in biorefining entails significant risk*. The effective use of biotic waste streams requires substantial investment in a financially difficult time in the context of strongly volatile agro-commodity prices. Many of the biorefining technologies that are needed to utilize biotic waste streams as effectively as possible are still being developed and their feasibility has not yet been proven. Investing in these technologies therefore entails significant risk.

– *Writing off existing biorefining investments*. In order to take advantage of the opportunities offered by biorefining, significant changes will have to be made in existing product chains. Established players will have to be quicker in writing off existing investments.

– *Considerable investments need to be made in biodigesters for treating manure*. Biodigesters, used in combination with digestate drying units, provide clear benefits in terms of the transport and processing of manure. But they also require investments in new forms of animal stalls, and in the plants themselves.

– *The risks related to biobased products based on biotic waste streams*. Biobased products have different properties (for example, composition, colour and smell) and many have not yet been approved in terms of regulations such as the EU directive on the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). Because of these different properties entrepreneurs are uncertain whether consumers will accept biobased products.

– *Suppliers*. Suppliers of cheaper and better-known primary raw materials have an advantage over suppliers of secondary raw materials.

- *The overcapacity of waste incineration plants* since 2008 is not encouraging the effective use of biotic waste streams. As a result, their rates have fallen, encouraging companies to incinerate their biotic waste rather than exploring opportunities to use them more effectively.

5.3.4 Product components

There are several factors obstructing the use of used product parts and components:

- Used components are often more expensive than the resale margin and so are less attractive options for producers or second-hand dealers.[30]

- Businesses need to work together on repairing and reusing components. This requires close communication and trust, and takes time. One problem is that the availability of products components for repair by independent operators is often blocked by businesses that have a monopoly on supplies of components or products.

- Consumers tend to look more at the price of a product and less, if at all, at the entire lifecycle costs. In the construction sector, for example, there is huge potential for the use of better materials and modular systems that are easily replaced, but in practice buyers focus on price rather than on entire lifecycle costs.[31]

These obstacles highlight the importance of changing the culture within companies in order to bring about a transition to a circular economy. Internal barriers have to be removed and company purchasing departments have to become part of integrated business strategies.

5.4 Policy and rules and regulations

The disposal of waste was one of the first pillars of Dutch environmental policy. Several of the most serious waste problems have now been solved, and the government is turning its attention to other policy areas, such as climate change and raw materials. These are important for the transition to a circular economy. Innovation policy will also play an important part. The current policy for the business sector involves the redistribution of resources across nine broadly defined 'top sectors', but without increased funding for public sector R&D and innovation. The government's intention to use taxation as part of the R&D policy as a way of encouraging R&D and moving away from specific innovation subsidies is a risky endeavour, especially during the current economic crisis when for many businesses turnover and profits are under increasing pressure.[32]

The government could introduce a number of tax initiatives that would promote a more circular economy. It could, for example, tax lost value instead of added value, and reduce the rate of VAT on circular services such as repairs and reuse of components.[33] Chapter 6 addresses this and other government plans.

A recent study of the obstacles to a biobased economy conducted for the Ministry of Economic Affairs has shown that several of the obstacles faced by entrepreneurs have now been removed.[34] These efforts have included, for example, the interdepartmental catalyst team of Green Gas, a foundation that collects information on green gas and biogas to accelerate market developments; a programme of the Ministry of Economic Affairs to reduce administrative burdens; previously implemented changes and evaluations of regulations by ministerial departments (such as changes to the Ministry of Infrastructure and the Environment's waste regulations); and the government's top sector policy.

One example of the obstacles that have been removed concerned the appeal and review procedures that delayed plans to build a co-digestion plant (the simultaneous fermentation of manure and other biotic waste streams). The lack of knowledge about co-digestion among local-level civil servants, and their fear of the risks, led them to object to the plans. As a result of this risk-averse behaviour, it look longer than necessary for them to process the permits and to issue unnecessarily strict requirements that would affect the plant's profitability. The solution involved providing them with information: InfoMil, a knowledge centre within the Ministry of Infrastructure and the Environment, has launched a new initiative, 'Assistance in co-digestion of manure', so that these issues receive consistent attention, and is organizing information sessions for businesses and for civil servants.

The removal of a number of regulatory obstacles to the use of biotic waste streams has made it easier to use them as biobased raw materials.[35] An amendment to Dutch waste regulations (Dutch Environmental Management Act, chapter 10), which came into effect in March 2011, has meant that some agricultural and forestry waste streams are no longer regarded as waste products, so that the waste regulations no longer apply. The amendment originates from the European Waste Framework Directive and has removed many obstacles, although there are conditions. Materials such as crop residues and wood shavings must be used for agricultural or forestry purposes, or to generate energy, and they must not be harmful to humans or the environment. Stakeholders involved in organic waste streams are now discussing whether they should also be exempt from the waste regulations.

According to the experts consulted during interviews and the workshop for this study, government policies and rules and regulations create a number of obstacles to a circular economy:

– *Risk-averse behaviour by local governments regarding innovation*. The interviewees felt that the government's responses to business and citizen initiatives is inadequate. The long wait for licences for technologies unfamiliar to new or low-level local government officials is a sign of risk aversion – as in the case of co-digestion plants – which creates business continuity problems particularly for small, innovative companies.[36]

– *Government inconsistency with regard to potentially encouraging measures*. Governments are often uncertain and need to respond to constantly changing political conditions. One recent example has been the changing policy on subsidies for green energy (feed-in tariffs for solar and wind power).

– *The thinking behind waste rules and regulations is that 'we have to get rid of waste' rather than regarding it as a raw material*. It would be interesting to view the waste rules and regulations, but also other regulations, from the perspective of a circular economy to see whether they provide insights into when they act as incentives and when they create obstacles. The study of conflicting interests in a biobased economy, referred to above, is an excellent example of what can be accomplished by looking at matters from a different perspective.[37]

– *It takes too long to implement new rules and regulations*. It often takes less time to bring products to market then it does to draft new rules and regulations. As a result, licencing procedures can take a long time or are accompanied by strict requirements, and this has a negative impact on profitability. According to the interviewees, these procedures take longer in the Netherlands than in other countries. This observation merits examination and could potentially lead to a benchmark process.

Efforts to make more effective use of biotic waste streams are obstructed by various policy and regulatory factors:[38]

– *The lack of a level playing field for fossil and biotic raw materials, for the use of biotic raw materials for energy and for the use of industrial materials*. This comes at the expense of developing potential business cases for the effective use of biotic waste streams. The causes are import levies, excise duties at national and European levels, and the incentives for biofuels through the EU's Renewable Energy Directive and the Emissions Trading System. An energy tax is only levied on fossil fuels, but not on products based on fossil raw materials. Fossil-based products and fuels are not subject to import levies within the EU, but biobased products and biofuels such as bioethanol are. All in all, biobased products are at a disadvantage.

– *The overcapacity of incineration plants in the Netherlands*. Waste incineration has its place in waste stream processing, even if it is a low-value process. From the point of view of climate and energy policies (the Renewable Energy Directive) the co-incineration of biomass in large incineration plants is a good alternative to the production of heat and electricity from fossil fuels. But the reality is different: the low rates charged by incineration plants for treating biomass and biotic waste are standing in the way of more effective and high-grade uses of biomass. The use of biomass for energy is becoming more efficient, but the development of truly effective uses of biomass is at a standstill. The low rates currently charged by waste incineration plants, incidentally, have also had a negative impact on the economic feasibility of comprehensive recycling of abiotic waste streams.[39]

– *The rules and regulations regarding food security are obstructing the effective use of raw materials and energy from biotic waste streams*. For example, the use of swill as food for insects (a novel source of protein) is not permitted.[40]

– *The rules and regulations regarding minerals are obstructing the use of digestate from biodigestion plants as a substitute for artificial fertilizers*.[41] This digestate is regarded as a fertilizer and its sale costs entrepreneurs money. As a result, the profitability of plants producing biogas from fertilizer is limited.

The interviewees from industry also identified a number of restrictive policies and rules and regulations that are acting as obstacles to the expansion of the abiotic economy:

– *Complicated regulations regarding the export and import of waste streams*. For example, the rules and regulations for plastics vary for each type of plastic, complicating the recycling of plastics from electrical and electronic appliances.[42]

– *The EU's WEEE directive sets targets for waste collection based on weight and not on the value of raw materials*. This provides little incentive to recycle scarce materials because the amounts per product are so small.

– *Subsidy schemes such as MIA and VAMIL only encourage purchases of environmentally friendly and energy-efficient appliances*. It would be useful to explore the potential of these and other subsidy schemes to encourage circular behaviour, such as the shared use of appliances and other ways to reduce the use of raw materials.[42]

– *Imports of used products for recycling are regularly blocked*. The workshop participants revealed that imports into the Netherlands of used products after their first life cycle were not allowed because of the uncertainty about processing rules. It is unclear whether this is because the regulations are ambiguous, or whether the competent authorities lack relevant knowledge or have misinterpreted the rules.

5.5 Lobbying and framework activities (non-government-related)

This section highlights the impacts of initiatives launched by non-government-related interest groups, such as business lobby groups, NGOs, citizens and consumers.

MVO Nederland (CSR Netherlands) is a national network that promotes corporate social responsibility and is working to put the circular economy on the business agenda by supporting the Circle Economy, setting up communities of practice and organizing 'BOOSTcamps' where businessmen, scientists and politicians work together. CSR Netherlands encourages businesses to reflect on what the circular economy can mean for them.

Citizens' initiatives such as energy cooperatives could be encouraged to support local initiatives that could lead to a circular economy.

Citizens' attitudes to the circular economy. My 2030's is an extensive study, conducted by Tertium, of the desires and concerns of citizens regarding a biobased economy, using inputs from the BE-Basic Foundation, a public–private partnership based in Delft. Although the study focused on a biobased economy, the results are also applicable to the circular economy and the use of biotic waste streams:[43]

- Citizens appear to be easily influenced by the concept of 'biobased', even though it is not clearly defined. Its interpretation therefore relies on individual impressions. If the various aspects of a biobased economy (or circular economy) are not clearly communicated, there is a danger that the term could come to have negative connotations. It is not yet clear what citizens think of the 'circular economy', but the concept should be clearly and unambiguously defined by the government, businesses, knowledge institutes and NGOs so that it can be communicated to the largest possible audience as effectively as possible.

- The circular economy seems to dovetail well with citizens' views of a biobased economy. Many believe that they should 'be more conscious about raw materials, recycling and reducing waste' (*My 2030's*, p.24). But product service systems are a different story. 'That is not true yet for a significant variation of the circular economy: "the lease society", in which consumers' belongings are all pretty much on loan instead of owned. … This vision of the future evokes a fundamental discussion. A "lease society" is a desirable thing for some people, while for others it is an unrealistic and undesirable vision of the future'. This means that product service systems and what they have to offer citizens will have to be clearly explained before they are introduced.

– Citizens are unlikely to take a leading role in a biobased economy, according to *My 2030's*. However, they do expect the government and the business sector to take the lead. If that happens, then they would be willing to contribute as consumers and employees. It is unclear whether this attitude would apply to a circular economy as well, in view of the many citizens' initiatives that have been launched related to sustainable development. How citizens view and interpret their role in a circular economy is as yet unclear.

– Citizens see the government as important for achieving a biobased economy. 'The government has to inform people about the advantages and disadvantages and encourage or force businesses to work with biobased practices. For that purpose, a consistent policy needs to be put in place. The government can also encourage consumer demand for biobased products with tax incentives.' The citizens consulted think that 'only a combination of information and financial incentives can change consumer behaviour' (*My 2030's*, p.21). This is a clear sign of what the government's role should be in a biobased economy. Of course these statements in themselves are not surprising: financial incentives – as yet unquantified – should have an impact on behaviour. The degree to which they will act as incentives in a circular economy has often been mentioned, but has not been substantiated, and so deserves to be looked at more closely.

– Citizens want to see results close to home. 'Biobased inventions have to contribute to clear improvements in the environment or in people's own lives if they are to inspire individuals to actively start using them.' In a circular economy, these achievements could take the shape of lower production costs by wasting less energy and raw materials, or by offering new services at lower rates of VAT.

– Citizens are accustomed to sorting waste. The citizens interviewed for *My 2030's* expect that comprehensive waste sorting is possible, as long as there is something in it for them and it does not require too much extra effort.

The younger generation (generation Y) seems to be less preoccupied with possessions than their older counterparts, and more concerned with experience and fulfilment,[44] according to a survey conducted by MotivAction. This trend should be acted on by rolling out product service systems, for example, or innovative leasing concepts.

Some interest groups may resist wholesale change, and place several obstacles on the path to circularity.

For various parties with vested interests, the economic returns on their investments, and perhaps even their existence, will depend on how a more circular economy develops. Incineration and power plants, for example, still have substantial economic value because their core activities are dependent on the purchase and sale of consumer goods, or are related to the existing infrastructure for waste collection and recycling. These parties do not necessarily stand to benefit from a transition to a circular economy, and so cannot be expected to give their immediate support. The lobbying activities of these kinds of stakeholders could affect our picture and the development of a circular economy.

Obstacles resulting from the anticipated attitudes of citizens and consumers:[45]
– Many citizens feel that their individual contributions to sustainability are much smaller than those made by the business sector or the government.
– The extra effort required to contribute to a biobased economy should not be too great or cost too much. These preconditions probably apply to a circular economy as well.
– For most consumers, the price of a product is a more important consideration than whether it contains sustainable raw materials, for example.
– Consumer sensitivity to the latest fashions could be at odds with circular consumer behaviour. The rapid succession of new electronic appliances is a good example, where the sensitivity to fashion is based on continually improved functionality rather than on seasonal influences, as is the case with clothing. On the other hand, the desire for individuality, so as not to blend in with the masses, also could support circular behaviour (reusing products to make vintage clothing, for instance).[46]

5.6 Observations on the transition to a circular economy

Chapter 1 examined the transitional steps between a linear economy ('take, make, waste') at one extreme, a *transition on the road to a circular economy* (based on cost considerations and rules and regulations, the more conscious use of energy and raw materials, without radically redesigned products, processes and systems), and at the other extreme the *circular economy*, an economic and industrial system that takes as its starting point the reusability of products and raw materials and the restorative capacity of natural resources and minimizes value destruction in the overall system.

If we look at the obstacles, on the one hand, and the activities that a circular economy would promote, on the other, then we could argue that each of these aspects could make a tangible contribution to increased circularity. That was already clear in the discussion in chapter 2 (particularly about table 2.3), where various aspects were used to make an educated guess of the potential shifts towards increased circularity. Indeed, removing most of the obstacles and introducing incentives could gradually set events in motion before introducing more radical steps. Again, this is an argument in favour of a policy that is geared not only to the frontrunners who aspire to an 'ideal' circular economy, but also to keeping the 'followers' in motion.

In terms of *developing and disseminating knowledge*, it is the innovative capacity, the available knowledge and expertise of transition, the incentives for multidisciplinary and integrated education and the increasing awareness among businesses of the significant general value of a transition to more circularity.

Biorefining has an important place in the circular economy in terms of added value (see the discussion of the Ellen MacArthur Foundation report in chapter 1); chapter 3 showed that biorefining constitutes a significant part of the circular economy's potential. That is why consistent knowledge development in this area is extremely important. This is reinforced by the fact that the risks are still high, and many innovative entrepreneurs in this sector are still unwilling to take the risk. The creative industries and industrial design schools must be approached in a transition to a circular economy as well. Their competences will be essential for creating new product and service concepts that are indeed based on reusability and preventing value destruction.

In the area of *entrepreneurial activities and market mechanisms,* the innovative capacity and increasing awareness (in addition to long-standing regulations) in the Netherlands seem to have created a country that is experiencing the 'frontrunner's handicap'.

Various activities respond to *financial incentives* (different warranty systems, financial incentives for waste processing) or in improvements in infrastructure that will promote cooperation in value chains in general and in recycling in particular. These measures are again generally applicable to the majority of businesses that hope to use raw materials more efficiently and circularity.

The circular economy stands to benefit from *critical encouragement and support* from frontrunners in the business world who are taking risks (including, for example, cradle-to-cradle initiatives). Investing in product service systems belongs to the same category, although rolling out a successful product service system does not necessarily mean that the products would have to be adapted.

The observations on *rules and regulations* are primarily motivated by the wish to have a government that responds more quickly and develops consistent policies, and does not shy away from taking risks.

Observations such as these are applicable to all changes that lead to more circularity and not only to 'purely' circular initiatives.

Towards a circular economy:
an action plan for the Dutch government

6 Towards a circular economy: an action plan for the Dutch government

If the Netherlands is to take full advantage of the opportunities identified in this report, the government needs to develop a consistent, multidisciplinary and well-founded long-term strategy intended to lead to a circular economy. This chapter highlights the actions (and supporting studies) that are needed now in order to identify areas of research, regulations, financial and fiscal incentives and strategies that will encourage frontrunners, the role of the government as a 'launching customer' and international relations.

6.1 Creating and seizing the opportunities

A circular economy would present the Netherlands with excellent opportunities, not only to strengthen its own economy and reduce its ecological footprint, but also to develop a powerful proposition that is convincing internationally and provides Dutch businesses with international opportunities. The Netherlands already holds a strong knowledge position in areas such as water, chemicals, agro-food and life sciences, its strong logistics and recycling sectors, and its extensive experience in waste management puts it in a prime position to capture an internationally competitive position.

For the government, the most important condition for success in creating these opportunities is to roll out a consistent long-term strategy that is strong multidisciplinary and cross-departmental in character and based on firm foundations – one that can take a blow. Such a strategy requires joint and targeted efforts by the government, businesses, consumers and social organizations. Based on the discussions in previous chapters, this chapter presents an action plan for the government that gives shape to this joint strategy.

6.2 An action plan for the Dutch government

This section proposes an action plan with the following elements:
- create a clear, cross-departmental, consistent strategy for building a circular economy;
- develop a coherent education and research plan for the circular economy;
- make a comprehensive assessment of the pros and cons of existing rules and regulations regarding waste;
- increase knowledge and awareness of raw materials in each value chain;

- ensure that frontrunners and others who stick their necks out receive a permanent and true advantage, for example through value chain management;
- review the effectiveness of a broad set of fiscal and financial incentives to promote circular behaviour;
- determine the impact of incineration plants on the viability of circular business cases and take appropriate action;
- develop the role of the government as an active and expert 'launching customer'; and
- use the international playing field to help the circular economy move forward.

6.2.1 Create a clear, cross-departmental, consistent strategy for the circular economy

In order to launch a successful transition to a circular economy it is important that the Dutch government clearly communicates its ideas about the circular economy and the rationale behind it. For many actors in civil society, the circular economy is a new concept. What does it actually entail? Why should the Dutch government get involved, and is there a point on the horizon they should be working towards?

The rationale behind these recommendations is that a circular economy transcends sectors and requires investments in the long term from various civil society stakeholders. One of the long-term conditions for these investments is that the government's strategy and policy are transparent, cross-departmental and consistent. This has emerged from research on transitional processes and from the interviews conducted in the context of this project.

Subsequently, the consequences of this vision for all areas of policy, regulation and communications will have to be consistently and clearly explained. A call to consume more and a simultaneous call to promote services that could have a negative impact on consumption will create a disjointed impression and will not lead to the desired unity of direction. For example, how does this strategy relate to the government's top sector policy and green growth strategy, or the Netherlands' inputs to Horizon 2020, the EU's framework programme for research and innovation? If there is clarity about the long-term direction, then businesses, investors, education and research institutes will want to take appropriate action and organize themselves.

This strategy is explicitly cross-departmental. The steps that need to be taken on the path to a circular economy are pre-eminently systematic in character, as a result of which policy areas such as energy, sustainability and climate, agriculture, trade, waste, raw materials, foreign affairs and development cooperation, education and research funding, and fiscal tools have to join forces.

At the very least, a coherent vision and strategy must address the following:
- What are the dominant knowledge issues and what does the corresponding knowledge agenda look like?
- How to guarantee the development of much-needed knowledge of materials, products, raw materials, etc.?
- Which rules and regulations are potentially restrictive and which encourage a transition to a circular economy?
- What financial and fiscal tools can be used and what would their impact be?
- What role should the frontrunners have and how can they be encouraged?
- How can the stragglers be encouraged to draw inspiration from the activities of the frontrunners?
- What points should the Dutch government act on, and what points should it leave to others?
- Which international partnerships should the Netherlands seek in the framework of a circular economy?

Based on this study, several of these points can be more specifically addressed in formulating a future government agenda.

6.2.2 Develop a coherent education and research plan for the circular economy

The previous chapters identified several research questions in the following areas that need to be addressed in a transition to a circular economy:
- technology development for biorefining, biogas extraction and phosphate recycling;
- design for reuse and recycling;
- developments in the area of tracking and tracing of consumer products;
- promoting systems thinking (in terms of technology and economics); and
- the development of appropriate new business models for a circular economy.

A coherent plan for a circular economy would have to ensure that these issues are clearly included in the research agendas of the top sectors (and the corresponding 'top consortia' for knowledge and innovation), and in the curricula at all levels of education, from vocational colleges to universities (see section 5.3).

If the government manages to involve all these levels when explaining and rolling out the philosophy of the circular economy, it would create a strong driving force to seize opportunities as they emerge.

A powerful research agenda is a prerequisite for the Netherlands if it is to seize the opportunity to export knowledge.

6.2.3 Make a comprehensive assessment of the pros and cons of existing rules and regulations regarding waste

Stakeholders have repeatedly called for the rules and regulations to be amended during our talks with them, so that a solid business case can be developed based on the use of waste streams. Some regulations effectively prevent small-scale experiments using waste materials or erect barriers to the transport of waste materials. More generally, many regulations do not view waste as a potential raw material.

At the same time, the existing rules and regulations for waste materials are based on historical developments and are often created to prevent or fix environmental problems. That is why the government should thoroughly reassess the existing rules and regulations on how waste materials are handled, with an emphasis on the following:

- how to create leeway for experimentation with new value chains; concerns about food safety could negatively affect the freedom to experiment with the use of biotic waste streams, for example;
- the opportunities that could be created by amending the rules and regulations (will a significant new value chain actually emerge?); and
- the use of inspections to urge stragglers to improve their behaviour when it comes to waste materials.

There seems to be broad support for improving the percentage of waste that is collected, which would be preferably based on its value and not on its mass. The government can play an important role in the introduction of and the compliance with the EU's WEEE Directive, the introduction of differentiated tariffs (DIFTAR) for the collection of household waste, and the introduction of mandatory systems for disposing of household waste.

Practice shows that knowledge about rules and regulations – especially when they concern obstacles that have been removed – does not always reach stakeholders. Clear and effective communication about amendments to rules and regulations is also a prerequisite for removing obstacles on the path to a circular economy.

6.2.4 Increase knowledge and awareness of raw materials in each value chain

Many companies seriously lack knowledge about their own products. Steps that will point the way to a more circular economy are difficult to make without this background knowledge. Improving this knowledge is primarily the responsibility of the business sector, which cannot assess the vulnerability of their own value chains and so are unable to respond to risks. The complexity and long-term character of the raw material problem is particularly an obstacle for smaller businesses. The government should actively encourage the foundation of an extensive raw materials information service.

To make it easier to develop circular business cases, the government should support research on the feasibility, desirability and character of a raw materials passport. The government could consider using these passports at a level that would still offer added value to processors of waste streams. The administrative burden and technological feasibility of such measures need to be carefully considered.

6.2.5 Ensure that frontrunners and others who stick their necks out receive a permanent and true advantage, for example through value chain management

We observed above that there are many players who could take the lead in creating opportunities for a circular economy. Examples include the members of the 'Frontrunners Counter' (Koplopersloket), a dedicated service for innovators, the Circle Economy, parties that have completed 'green deals', and the broad range of companies that take corporate social responsibility seriously. Moreover, the government can act as value chain manager in certain chains or ask parties to take on that responsibility themselves. An example of a successful approach is the Nutrient Platform that was set up to close the phosphate cycle and to appoint a government chain manager. The results have been impressive. The government's role is not just that of a value chain manager, but it also identifies and removes regulatory obstacles, brings together parties in the value chain, outlines the advantages and drawbacks of national and European rules and regulations, and generates support for a European market in Europe and beyond.[1]

To help these parties move forward, it is important to guarantee support at a strategic level with heavy and integrated involvement from the core ministries. Moreover, any potential incentives (financial ones, for example) should preferably be directed at these frontrunners. Belonging to the frontrunner group should be seen as a great advantage. Enthusiastic frontrunners would then become and remain active advocates of the circular economy.

The involvement of these pioneers in setting up and implementing transition experiments aimed at encouraging the development of a circular economy is also important. The hallmarks[2] of a transition experiment should be that it can make a significant contribution to the circular economy, make an important contribution in the Netherlands, set a positive example (from which lessons can be learnt) and clearly adds to already existing initiatives or joins them together.

6.2.6 Review the effectiveness of a broad set of fiscal and financial incentives to promote circular behaviour

Interviews conducted in the context of this study show that civil society actors have expectations regarding the promotion of circular behaviour by changing tax regimes (see section 5.4). Clearly it is in the government's hands to make these changes. Examples include:

- lowering the rate of VAT on services in the circular economy (maintenance, repairs, refurbishment, various product service systems);
- taxing extracted value instead of added value (a shift from taxing income to taxing materials);
- creating contributions meant to extend warranty periods on products;
- actively using financial resources from guarantee and disposal funds to further encourage business activity (although it is not up to the government to act on this); and
- actively using financial resources from existing fiscal subsidy instruments promoting environmentally benign investments (MIA or VAMIL) for a broader series of investments or activities that would help increase circularity.

These developments are not new: work is being done at the European level, for example, to use market-based instruments, as described in the *Roadmap to a Resource-efficient Europe*.[3] A quantitative study focused on this set of fiscal measures, and their impacts on different kinds of circular activities, is still lacking. Before the government can introduce clear measures in that respect, a study would need to be conducted to create support for them. Although this study estimated the impacts of a lower rate of VAT on maintenance and repairs services at the macro-level, the effectiveness of this measure could be studied based on targeted consumer research: what other kinds of behaviour could be encouraged by this kind of a fiscal shift? Would these measures result in more goods being repaired, as opposed to recycled or thrown away? Would a shift from taxing income to taxing the value of extracted raw materials have a significant impact on our behaviour towards products whose material or component costs are only a fraction of the purchase price?

A study of the financial incentives should also focus on 'perverse' incentives that could potentially have a negative impact on circular business cases. An example of this is the lack of a level playing field – in many respects – for the use of fossil raw materials and biobased raw materials. An energy tax is only levied on fossil *fuels*, but not on products based on fossil raw materials. Fossil-based products and fuels are not subject to import levies within the EU, but biobased products and biofuels are.

6.2.7 Determine the impact of incineration plants on the viability of circular business cases and take appropriate action

In order to promote the circular economy, it is recommended that the government critically examines the role of incineration plants and current regulations in creating obstacles to circular business cases. The argument that incineration creates obstacles to recycling is regularly put forward, but a thorough investigation would clarify whether the appeal of low processing tariffs at incineration plants actually makes it impossible to develop concrete and viable business cases for recycling.

6.2.8 Use the government as an active and expert 'launching customer'

The government can encourage circular business cases, especially in the initial phase, by demanding the use of circular products or services in government procurement tenders. This kind of behaviour sets a positive example and reinforces the picture of a government that is seriously embarking on this path at all levels. It goes without saying that these tenders have to be transparent and based on solid facts.

6.2.9 Use the international playing field to help the circular economy move forward

The Netherlands has a good starting position when it comes to the circular economy, but it is obviously not the only country working on this front. The government should (for example, via the TWA network, a network of attachés with engineering and science backgrounds) seek to work together or exchange information with countries that are frontrunners in certain fields. For example, Germany and Denmark are at an advanced stage of developing 'multiple value creation' through the combined use of natural resources for recreational purposes and to produce biomass. Japan has a more intensive recycling programme than the Netherlands. Germany has established a Raw Materials Agency (DERA) that is developing knowledge and recommendations on raw materials. Sweden has established a chair to take care of the management of knowledge about the recycling of electronic goods. Israel gives start-ups excellent support, which benefits the innovation climate. And the United States is developing knowledge, according to the interviewees, on good divestment strategies for large plants that are going to be shut down.

The EU is particularly active in several areas that would affect the transition to a circular economy, as the *Roadmap to a Resource-efficient Europe*, the 'Blue Growth' agenda, and the Common Agricultural Policy all show. Encouraging business activity in the Netherlands aimed at a transition to a circular economy requires the Dutch government not only to take into account European policy, but also to attempt to influence it in favour of a circular economy. In that respect, European waste regulations are extremely important. They reflect the policy on the dumping, incinerating, collecting and processing of end-of-life products (cars, electrical and electronic appliances, batteries and packaging), and the 'extended producer responsibility'. In the latter case, member states can even decide to hold producers responsible for processing waste generated by their products. The creation of solid business cases related to recycling requires sufficient critical mass: achieving critical mass could rely heavily on the international transport of waste materials. The EU Waste Shipment Regulation is a potential (practically or bureaucratically speaking) obstacle in that respect.

It should be clear that the importance of a level playing field is that the various member states can coordinate the implementation and enforcement of these measures, and that the Dutch government, in its efforts to move closer to a circular economy, will have to play an active role at the European policy level.

6.3 Dealing with uncertainty: a government that learns and networks

Because all this involves complex changes that will undoubtedly cause uncertainty, and because the government's resources are limited, the government will have to operate in a manner fitting the situation. *Networking* is one useful strategy. It prioritizes relationships with other parties, who are therefore equally motivated to achieve a circular economy. 'Networking is different from "ordinary" ways of working because the government cannot achieve its own objectives without the help of others, while the other parties have the option of withdrawing from the process and the objectives. So the other party can make an independent assessment, which is also crucial for achieving the policy. […] Networking therefore is about emphasizing the interaction between the government and the parties in the environment'.[4] Several authorities are experimenting with networking, including within the Dutch Ministry of Economic Affairs and the province of South Holland.[5]

A transition to a circular economy requires changes at many different levels and by many different stakeholders. This was mentioned in chapter 5 in the section on developing and disseminating knowledge. The nature of every job will change, because every business will have to adapt, to some degree or another. How exactly is something we will only discover once the process is under way. To deal with uncertainty and still provide direction when possible requires the government to assume a *learning attitude*. That means, for example, that the government will have to set up experiments together with other civil society stakeholders, without knowing whether they will succeed. And there will have to be leeway in these experiments to allow regular reflection on the kinds of activities the government is promoting.

6.4 Conclusion: opportunities for the circular economy in the Netherlands

The current state of recycling, repair and reuse of a wide range of products in the Netherlands gives good reason to assume that there is further potential to make the transition to a more circular economy. However, clear and consistent communications across government departments are crucial to success. Dutch society seems very willing to join in, but is undoubtedly sensitive to conflicting information and incentives. In any case, citizens will be further encouraged if they are kept well informed about what has already been achieved, and if well-chosen transition experiments are launched. That the action plan for the government proposed here is by nature very exploratory and investigative is related to this. Measures to do with fiscal arrangements and rules and regulations are complex, and there must be some confidence that they will have the intended effects. The highly exploratory and investigative nature of the proposed action plan for the government is related to this. Measures to do with fiscal policy and rules and regulations are complex, and it should be clear before they are implemented that they will have the intended effects.

Throughout this study, the inputs from stakeholders have been extremely important in identifying in which direction the transition should go, and the obstacles that are likely to emerge. The views of these stakeholders do not by definition represent balanced judgements, which is why an expert and analytical government can contribute to what is in all respects a sustainable shift to a circular economy.

Improving raw materials efficiency and rolling out the circular economy are goals that are clearly embraced at the European level. Nonetheless, the measures proposed here show that the Netherlands for the most part does not need to wait for approval at the European level. And of course that is less the case when it comes to rationalizing the rules and regulations for waste, implementing fiscal and financial incentives, and potential regulations for incineration plants. These are imbedded in European regulations and will affect whether or not a level playing field can be created for the parties involved.

More than once, this report has stressed that a transition to a circular economy will benefit both from initiatives that improve the circularity of current practices and from radical initiatives that aspire to an ideal circular economic model: an economy in which circularity is already incorporated in the design phase. Based on the methods used here it is difficult to assess what the economic contribution of these more radical innovations and transitions would be. Still, the government can certainly support radical design innovations by identifying the frontrunners and removing obstacles for them, or by acting as a launching customer to help these risky and radical initiatives get off to a good start.

Appendices

Appendix 1: Innovation systems: functions and innovation engines

Innovation systems analysis of a transition to a circular economy

The innovation system analysis (ISA) was carried out to identify the actors and processes that affect the development and use of specific technologies. The fundamental idea behind ISA is that the success of emerging technologies is not only determined by technological and economic characteristics, but also by the quality of the interaction between actors in the system (businesses, governments, knowledge institutes, social groups), institutions (rule, laws, routines) and technologies.

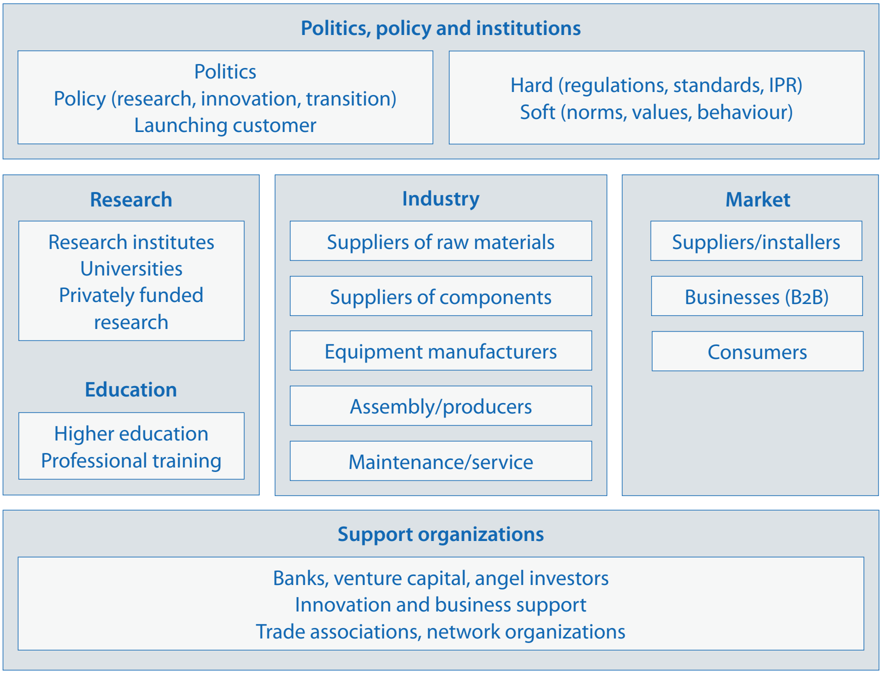

Figure 1. An innovation system.
Source: Hekkert et al. (2011).[1]

Table 1 summarizes the most important characteristics of each innovation engine.

Table 1. Characteristics of innovation engines			
	S&T engine	Entrepreneurial engine	
Developing knowledge: Develop new knowledge or new combinations of existing knowledge	Fundamental knowledge Concept development Studies in laboratory	Knowledge that can be used Feasibility studies Pilot studies	
Disseminating knowledge: Knowledge diffusion and exchange of practical experiences Share positive expectations	Knowledge sharing between developers and through academic channels	Exchange knowledge within projects, between developers, funders and launching customers	
Entrepreneurial activities: Develop new products and services and introduce them to market	Entrepreneurs not involved Potentially a later role when articulating market demand or as potential launching customer	Entrepreneurs (often SMEs) identify market opportunities Businesses initiate feasibility and pilot studies	
Mobilizing resources: People, skills, facilities, funding and risk capital	Public funding Temporary programmes Limited use of people and resources	Public–private funding Businesses participate with R&D resources Cooperation at project level	
Market mechanisms: Develop niche market into mature market, develop user demand	There is no real market Positive market expectations communicated in visions/ roadmaps	Market prospects very uncertain. Market niches for initial applications Test and communicate positive market expectations in pilots	
Guiding the search process: Ideas and expectations converge, develop appeal and support	Large diversity of expectations Ideas guide knowledge programmes Appeal and support are limited and diffused	Ideas converge Interaction between developers and governments feed promise and support Result of pilot studies determine strength of appeal	
Support from interest groups: Lobbying by opinion leaders and stakeholders	Lobbying only by well-organized interest groups with controversial issues	Parties position themselves Signs of criticism spark debate Entrepreneurs lobby for project funding Political playing field not fully developed yet	

Sources: Based on Suurs (2009); Suurs and Hekkert (2011).

	System engine	Market engine
	Research and pilot projects Knowledge to upscale commercialization	Knowledge for optimization Knowledge about market trends Mitigate negative side effects
	Disseminate knowledge to projects Coordinate knowledge flow through platform organizations or intermediaries	Dissemination of knowledge completely formalized in networks and training institutes Coordination by trade and sector associations
	Entrepreneurial activities are developed by financially strong businesses	Entrepreneurial activities have become part of mainstream developments within trade/sectors
	Public–private funding Financially strong businesses invest in production facilities and infrastructure Coordinated cooperation in consortiums and temporary institutes Scarcity of well-educated labour	Private funding by banks, among others Investment decisions in relatively stable market conditions Production resources, such as raw materials and staff, sufficiently available
	Concrete prospects of a substantial market size Scaling up requires technology, facilities, infrastructure organization and regulations to be adapted	Mature, relatively stable market conditions Substantial market size Companies aim to expand market share and develop spin-offs
	Ideas and expectations are underpinned by financially strong businesses and formal structures Substantial appeal and support Social acceptance still uncertain Negotiations about desired regulations, infrastructure and standards	Ideas consolidated in regulations, infrastructure and organization of market Businesses operate within boundaries and routines of this market
	Professional lobbying by newly formed platforms and existing interest groups Negotiations and/or conflict about political-economic issues Playing field levels out	Professional lobbying by trade associations aimed at safeguarding existing market structures

In a well-functioning innovation system, illustrated in figure 1, the various elements, actors, institutions and technologies are more or less geared towards each other. A transition to a circular economy can only be understood if we examine the underlying processes that take place at the organizational, chain and sector levels. Technological innovation as a process plays an important part in this, as well as social and economic innovation. Innovation system analysis focuses on the dynamics that encourage or impede technological innovation. As soon as a technological innovation begins to circulate, it is expected to replace or alter the key structures supporting the existing technology. This enables the innovation to make a potential contribution to a transition. In the case of a transition to a circular economy, various technological innovations have to developed, circulated and used in society for them to be able to contribute to a transition. The theory behind innovation system analysis assumes that there are specific conditions and elements that either impede or encourage the development of a technological innovation. An ISA provides an understanding of the situation related to this development by describing and analyzing these elements and their development.[2]

In this innovation system there are seven specific functions or key processes that must function well if the system is to have any success in generating innovations. For this study, these system functions have been grouped into four categories:
– knowledge: developing and disseminating knowledge;
– business: entrepreneurial activities, market mechanisms and mobilizing resources;
– policy and rules and regulations (government-related framework activities); and
– lobbying activities and framework activities (non-government-related).

These system functions have to be sufficiently well defined to enable innovations to be used in the market. Support for this argument can be found in the work of Roald Suurs, Simona Negro and Marko Hekkert.

The development of an innovation system accelerates when the system functions begin to reinforce each other. The term innovation engine was introduced to describe this kind of interaction. Four innovation engines have been identified to date: the science and technology engine, the entrepreneurial engine, the system engine and the market engine. Even if innovation engines are ideal characterizations of a complex reality, their relative simplicity makes appropriate tools for envisioning how the development phases of an innovation system will evolve towards maturity. Every innovation engine has specific strengths and weaknesses. It is important to be aware that a weak engine needs to instigate the development of emerging innovation systems before it can become strong. Coincidences and external factors still have a great deal of influence during the early stages of an innovation process, but as the innovation process progresses, and the innovation process matures as an entity, the sensitivity of the process to external factors diminishes.

Appendix 2: Interviewees

The individuals interviewed for this study included representatives of:
- research and education (knowledge institutes, universities, higher education, professional training);
- industry and marketing (suppliers of raw material and components, equipment manufacturers, assembly, producers, maintenance and service, installers, B2B businesses, consumers);
- politics, policy and institutions (politics, policy, rules and regulations, standards, values); and
- support organizations (banks and investors, trade associations, network organizations, innovation and business support).

Biotic waste streams:
- Port of Rotterdam: Monique de Moel, Nico van Dooren (industry and marketing);
- Company from food industry, CSR officer (marketing);
- Ministry of Infrastructure and the Environment: Arnoud Passenier (politics, policy and institutions);
- Netherlands Institute of Ecology (NIOO-KNAW): Professor Louise Vet (research and education); and
- BVOR, trade association for organic waste: Arjan Brinkmann (support organization).

Abiotic waste streams:
- WE Cycle: Hendrik Bijker (support organization);
- BRBS Recycling trade association: Max de Vries (support organization);
- TNO: Professor Arnold Tukker (research and education); and
- Agency NL: Hans Paul Siderius (support organization).

General:
- Rabobank: Daan Dijk (support organization);
- Turntoo®: Ruben van Doorn (market);
- Radboud University Nijmegen: Professor Jan Jonker (research and education);
- CSR Netherlands: Michel Schuurman (support organization); and
- Interstudie NDO (consultancy firm): Jan Oosting (research and education).

Appendix 3: Workshop participants, 19 March 2013

Biotic session (led by Elsbeth Roelofs and Alwin Hoogendoorn, TNO):
- Floow2: Kim Tjoa;
- Port of Rotterdam: Monique de Moel;
- MUD Jeans: Bert van Son;
- Ministry of Infrastructure and the Environment: Kees Veerman;
- Ministry of Infrastructure and the Environment: Daphne Blokhuis;
- SuikerUnie: Paul Hagens; and
- Wageningen University and Research Centre: Wolter Elbersen.

Abiotic session (led by Ton Bastein and Elmer Rietveld, TNO):
- ACE Reuse: Ad Comperen;
- Agency NL: Ellen Hoog Antink;
- EERA: Norbert Zonneveld;
- FME-CWM: Kasper Beuting;
- FNsteel: Tjitze Postma;
- HKS Metals: Dominique Martens;
- Ministry of Infrastructure and the Environment: Tjeerd Meester;
- Shanks: Marcel Koen; and
- UMICORE: Christina Meskers.

Appendix 4: Summary of technological options for creating added value from biotic waste streams

	Biorefining	Pet food	Insect breeding
Mixed kitchen and supermarket waste		×	×
Animal fat (Cat. 1/2)	×	×	×
Household waste			
Sewage sludge	×		
Feather meal	×	×	
Flower auction waste	×	×	×
Horticultural crop residues	×		×
Biodegradable waste			×
Onion waste	×		
Poultry manure			×
Cattle slurry			×
Pig slurry			×
Spent mushroom compost			×
Sugar beet leaves	×		
Fish waste	×		×
Potato haulm	×		
Yeast extract (wet)	×		
Potato peel	×	×	×
Maize stalks and cobs			×
Potato pulp	×		×
Wet sugar beet pulp	×		
Cocoa shells			
Draff	×		
Straw (wheat, barley)	×		
Grain byproducts	×		
Dry sugar beet pulp	×		
Rapeseed meal	×		
Sunflower meal			
Meat and bone meal (Cat.3 food)			
Frying oil			
Animal fat C1			
Whey powder	×		
Soybean meal	×		
Animal fat (Cat.3 + food)		×	

	C_5 & C_6 sugars	Fermentation of solids	Tech. use of paper/ packaging/ bioplastics	Biogas	Soil improvement
				×	
	×				×
				×	
			×		×
				×	
			×		
	×			×	
				×	×
				×	×
				×	×
				×	×
					×
				×	
				×	×
	×	×	×		×
	×	×			
	×	×			
	×	×			
	×	×			
	×	×	×		
	×	×			

Notes

Chapter 1: Introduction

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7 WWF (2007) *One Planet Business: Creating Value within Planetary Limits*. World Wide Fund for Nature. http://assets.wwf.org.uk/downloads/one_planet_business_first_report.pdf

8 Ellen MacArthur Foundation (2012, 2013) *Towards the Circular Economy: Opportunities for the Consumer Goods Sector*. vols 1 & 2.

9 Rijkswaterstaat (2013) *Dutch Waste in Figures: Data for 2006–2010*. Utrecht: Rijkswaterstaat Leefomgeving, p.35.

10 Note that this report was written before Croatia joined the European Union.

11 Bol, D. and Bastein, T. (2012) *Kritieke Materialen van de Nederlandse High-tech-industrie*. Study by TNO and the Materials Innovation Institute (M2i) for the FME Association.

12 Organizations such as SHFT (www.shft.nl/themas/circulaire-economie) and Duurzaam Middelbaar BeroepsOnderwijs (DMBO: www.duurzaammbo.nl/index.php/kennisbank/concepten/circular-economy).

Chapter 2: The abiotic circular economy

1 Note that the total value of new products from the metal and electrical sectors given here deviates slightly from the totals published by these sectors. This is because a new classification of sectors and products was recently introduced; see background document.

2 Eurostat (1997) *The Capital Stock in the European Union: Structural Diagnosis and Analytical Aspects; Cambridge Econometrics;* CBS (1998) Perpetual Inventory Method. Central Statistical Bureau.

3 Kimura, F. et al. (2000) Product modularization for parts reuse in inverse manufacturing. *Ann. Int. Acad. Production Engineering (CIRP)*, 50(1): 89–92.

4 Huisman, J. et al. (2012) *The Dutch WEEE Flows*, UN University Institute for Sustainability and Peace, Sustainable Cycles Unit (ISP–SCYCLE). www.vie.unu.edu/file/get/9654

5 UNEP (2011) *Recycling Rates of Metals: A Status Report*. UNEP International Resource Panel.

6 VAMIL – willekeurige afschrijving milieu-investeringen.

7 The electrical engineering industry as a whole paid more in salaries than it made in profits in 2010. This points to a negative operating result, i.e. a loss. An appraisal of the potential situation after 2010 has not been included in the calculation.
8 All emissions are based on 2010 figures.
9 Surface water, groundwater and tap water.
10 Sevenster, M.N. et al. (2010) *Nederland importland: Landgebruik en emissies van grondstofstromen*, CE Delft.

Chapter 3: The biotic circular economy

1 Elbersen, W. et al. (2010) *De beschikbaarheid van biomassa voor energie in de agro-industrie*. Wageningen University and Research Centre.
2 CBS Statline.
3 CBS Statline on arable crops.
4 PDV, 2011.
5 Elbersen, W. et al. (2010) *De beschikbaarheid van biomassa voor energie in de agro-industrie*. WUR.
6 a.r. = as received (or wet) basis.
7 Bouwmeester, H., Bokma-Bakker, M.H., Bondt, N. and van der Roest, J. (2006) *Alternatieveaanwending van (incidentele) reststromen buiten de diervoedersector*. Rapport 2006.008. Rikilt, Wageningen.
8 Broekema, R. and Blonk, H. (2009) *Milieukundige vergelijkingen van vleesvervangers*. Blonk Milieuadvies.
9 Of this, 3.2 Mt were collected as sorted waste; the price indication is derived from incineration plant rates. Dutch citizens pay a higher amount through a waste tax.
10 *Compendium voor de leefomgeving 2010; Afval!* Jaarboek 2011.
11 E.g. AEB Amsterdam, E.ON Energy from Waste Delfzijl, Attero Wijster.
12 Koppejan, J.H.W. et al. (2009) *Beschikbaarheid van Nederlandse biomassa voor elektriciteit en warmte in 2020*. SenterNovem.
13 Bondt, N. et al. (2010) *Afval uit de landbouw*. LEI/WUR.
14 CBS, figures for 2011.
15 VAR, HVC, Shanks Orgaworld: 40–100 m3 biogas per tonne of biodegradable waste.
16 CBS Statline 2010, transported.
17 Huisman (2009), own calculations, 40 tonnes leaf/ha.
18 Approximately 11 t/ha (159,700 ha surface area) according to CBS Statline 2011, and Rabou, L.P.L.M et al. (2006) *Biomassa in de Nederlandse energiehuishouding in 2030*. ECN and WUR.
19 Elbersen, W. et al. (2010) *De beschikbaarheid van biomassa voor energie in de agro-industrie*. WUR.
20 Vis, M. (2002) B*eschikbaarheid van reststromen uit de voedings- en genotmiddelenindustrie voor energieproductie*. BTG Biomass Technology Group BV, Enschede.
21 16,000 ha times 32 t/ha. CBS Statline.
22 DEN /LEI (2012).
23 Approximately 25% of this is assumed to remain on the land.
24 PDV (2010), *Veevoedergrondstof 2010* / LEI, *2012 tarwegriesprijs*.

25 Oosterkamp, E.B., Hoste, R. and Aramyan, L.H. (2012) *Liberalisering verwerking categorie 1- en categorie 2-slachtbijproducten: een marktanalyse.* LEI/WUR.

26 A number of new incineration plants have been built in recent years. There are now 12 plants that can each handle 7.5 Mt of waste, and there is now surplus capacity so that incineration fees have been under pressure for some time.

27 C_5 sugars – hemicellulose; C_6 sugars – starch and cellulose.

28 In this scenario, DHV, a consultancy group, estimates that savings of €250 million could be achieved if the volume of waste being sorted were increased about a third, although it may not be easy to achieve such an improvement in large cities. Further research is necessary.

29 Delivering solid manure (for example by introducing new forms of animal stalls) to biogas plants seems an obvious thing to do. After all, solid manure will provide more biogas, which will improve profitability.

30 RuBisCo (ribulose-1,5-bisphosphate carboxylase oxygenase) is an enzyme involved in carbon fixation, a process by which plants convert atmospheric CO_2 to produce sugars.

31 Benschop, A. (2012) *Nieuwe materialen uit bestaande teelten*. Paper presented at the Biobased Economy symposium, Emmen, 29 November.

32 Elbersen, W. et al. (2011) *De beschikbaarheid van biomassa voor energie in de agro-industrie.* WUR Food & Biobased Research.

33 Van der Eijk, A. et al. (2012) *Meer waarde uit GFT-afval*, Vereniging van Afvalbedrijven.

34 Elbersen, W. et al. (2010) *De beschikbaarheid van biomassa voor energie in de agro-industrie*. WUR.

35 Benschop, A. (2012) *Nieuwe materialen uit bestaande teelten*. Paper presented at the Biobased Economy symposium, Emmen, 29 November.

36 Elbersen, W. et al. (2011) *De beschikbaarheid van biomassa voor energie in de agro-industrie*. WUR Food & Biobased Research.

37 Koppejan, J.H.W. et al. (2009) *Beschikbaarheid van Nederlandse biomassa voor elektriciteit en warmte in 2020*. SenterNovem.

38 Rough estimate based on investment indicators for fermentation plants, and sugar and ethanol plants, for example. As specific investment indicators, the following general values (for reference) have been used: fermentation plants €0.1 million/kt input, conventional ethanol plants €0.3 million/kt input and second-generation ethanol plants based on lignocellulose €0.5 million/kt input. The authors assume that the investment indicators for biorefining are similar to those for second-generation ethanol production processes.

Chapter 4: The impacts of increased circularity on the Dutch economy

1 Floow2 describes itself as a 'business-to-business marketplace where companies and institutions can rent out or rent equipment and the skills and knowledge of personnel' (www.floow2.com).

2 The share of the entire Dutch economy vis-à-vis the EU 27 is 4.8%.

3 Regenersis (www.regenersis.com) organizes the repair of consumer electronic goods and professional equipment, such as MRI scanners and cash dispensers. An extensive range of consumer products are repaired and acquired for further sale if they do not meet the standards

when purchased: mobile phones, laptops, tablets, TVs, etc. The company has branches in 12 countries worldwide.

4 Interview conducted for this project.

5 Discussion with colleague from the Council for the Environment and Infrastructure (Raad voor de leefomgeving en infrastructuur, Rli), a strategic advisory council for the Dutch government.

Chapter 5: Drivers and obstacles on the road to a circular economy

1 HCSS, TNO (2012) *Staat van Nederland innovatieland 2012*, Amsterdam University Press.

2 www.ksinetwork.nl; the websites of the other two programmes can no longer be accessed.

3 Competence Centre for Transitions: www.transitiepraktijk.nl/en/

4 Kamm, B. (2008) *Definition and Technical Status of Biorefineries*, presentation at BioFuture 2008, Brussels.

5 Weterings, R., Roelofs, E., Suurs, R. and Van der Zee, F. (2011) *Tussen gouden bergen en groene business. Systeemverkenning van een biobased economie*, TNO report 2011-08, HCSS and TNO.

6 Sources: interview conducted for this project; www.nutrientplatform.org

7 Sources: interview conducted for this project, and interviews organized by a sustainable supply chain platform. Roelofs, E. and Willems, M. (2010) *Op weg naar duurzame materiaalketens*. TNO-034-DTM-2010-00733, TNO, Delft.

8 Sources: interviews and workshop conducted for this project; Ellen MacArthur Foundation (2012) *Towards the Circular Economy*.

9 Aldersgate Group (2012) *Skills for a New Economy: A paradigm shift in education and learning to ensure future economic success.*

10 Interview conducted for this project.*

11 Interviews in the context of previous research on sustainable supply chains; Roelofs, E. and Willems, M. (2010) *Op weg naar duurzame materiaalketens*. TNO-034-DTM-2010-00733, TNO, Delft.

12 HCSS, TNO (2012) *Staat van Nederland innovatieland 2012*, Amsterdam University Press, p.25.

13 Roelofs, E. and Willems, M. (2009) *Op weg naar duurzame materiaalketens*. TNO memorandum TNO-2009-RSE-21683. TNO Delft. Hupperts, P., Embrechts, F., Crol, J., Bor, A., and de Nijs, I. (2012) *Cradle to Cradle loont! Bedrijven uit de C2C Leercommunity over hun ervaringen en leerpunten*. The Terrace & Agentschap NL symposium, 'Closing the loop', November 2012.

14 Letter from the Nutrient Platform to the Dutch House of Representatives, 'Uitvoering Ketenakkoord Fosfaatkringloop', 15 February 2013.

15 Weterings, R., Roelofs, E., Suurs, R. and Van der Zee, F. (2011) *Tussen gouden bergen en groene business. Systeemverkenning van een biobased economie,* TNO report 2011-08, HCSS and TNO.

16 *Afval! Jaarboek 2012*.

17 Peene, A., Velghe, F. and Wierinck, I. (2011). *Evaluatie van de vergisters in Nederland.* Organic Waste Systems and Agency NL.

18 www.turntoo.com and www.floow2.com

19 For an assessment of various product service systems based on their contribution to sustainable development, see Tukker, A. (2004) Eight types of product service systems: eight ways to sustainability? Experiences form SUSPRONET. *Business Strategy and the Environment* 13(4): 246–260.

20 UNEP (2022) *Product Service Systems and Sustainability: Opportunities for Sustainable Solutions*. UNEP–DTIE, Paris, p.9 (cited in Tukker, 2004).
21 Interview conducted for this project; such an app was being developed at the time of writing.
22 *Afval! Jaarboek 2012*, and NRC, 'Beloon burgers voor hun afval', 4 June 2011, based on research by DHV.
23 Interviews conducted for this project
24 *Afval! Jaarboek 2012*.
25 Interviews conducted for this project.
26 Bordes, O., Feenstra, L. and Roelofs, E. (2001) *Materiaalkringloopsluiting gips in de bouwsector. Haalbaarheidsproject*, TNO report, R-2004/046; Roelofs and Ekelenkamp (2001).
27 See AMEC and Bio Intelligence Service (2011) *The Opportunities to Business of Improving Resource Efficiency* (European Commission contract 070307/2011/ 610181/ETU/F.1), p.85.
28 Willems, M. and Weterings, R. (2011) *Eindnotitie Duurzame Materiaalketens;* Van Elburg, J.C. (2009) *Het perspectief van de koploper – 10 oplossingen om een groene loper voor innovatie te realiseren*. RebelGroup.
29 Sources: TNO experts; Weterings, R., Roelofs, E., Suurs, R. and Van der Zee, F. (2011) *Tussen gouden bergen en groene business. Systeemverkenning van een biobased economie,* TNO report 2011-08, HCSS and TNO; interviews conducted for this project.
30 Ellen MacArthur Foundation (2012, 2013) *Towards the Circular Economy*.
31 Information from the workshop with stakeholders.
32 HCSS, TNO (2012) *Staat van Nederland innovatieland 2012*, Amsterdam University Press.
33 Interviews conducted for this project.
34 Bex, P.M.H.H. and Blank, R.E. (2011) *Botsende belangen in de biobased economy. Een inventarisatie en een analyse van de belemmeringen in de transitie naar een biobased economy.* SIRA Consulting.
35 Bex, P.M.H.H. and Blank, R.E. (2011) *Botsende belangen in de biobased economy*, SIRA Consulting.
36 Willems, M. and Weterings, R. (2011) *Eindnotitie Duurzaam Materiaalbeheer*, TNO-060-DTM-2011-02308-WSR-PEM-21683. TNO.
37 Bex, P.M.H.H. and Blank, R.E. (2011) *Botsende belangen in de biobased economy*. SIRA Consulting.
38 Nova Institut, presentation 28 November 2012; Weterings, R., Roelofs, E., Suurs, R. and Van der Zee, F. (2011) *Tussen gouden bergen en groene business. Systeemverkenning van een biobased economie*, TNO report 2011-08, HCSS and TNO.
39 Sources: interview conducted for this project and *Afval! Jaarboek 2012*; Weterings, R., Roelofs, E., Suurs, R. and Van der Zee, F. (2011) *Tussen gouden bergen en groene business. Systeemverkenning van een biobased economie*, TNO report 2011-08, HCSS and TNO.
40 Source: interview conducted for this project.
41 This obstacle was also identified in the SIRA study. Bex, P.M.H.H. and Blank, R.E. (2011) *Botsende belangen in de biobased economy*. SIRA Consulting.
42 Source: interviews conducted for this project.
43 Tertium (2013) My 2030's. *Burgers over de Biobased Economy.* Study commissioned by the BE-Basic Foundation. www.tertium.nl/my2030s/
44 MotivAction study of *Generation Y*, www.motivaction.nl

45 Tertium (2013) *My 2030's. Burgers over de Biobased Economy.*

46 Science of the Time (www.scienceofthetime.com), a company run by Carl Rohde, professor of trendwatching and innovation at Fontys Universities of Applied Sciences in the Netherlands; *NIMA Trendkompas 2008*, Netherlands Institute of Marketing.

Chapter 6: Towards a circular economy: an action plan for the Dutch government

1 Letter from the Nutrient Platform to the Dutch House of Representatives, 'Uitvoering Ketenakkoord Fosfaatkringloop', 15 February 2013, regarding progress with the phosphate chain agreement.

2 Based on Willems, M. and Weterings, R. (2011) *Eindnotitie Duurzaam Materialenbeheer*. TNO.

3 The European Commission is very clear about this: 'Member states should review their fiscal policies and instruments with a view to supporting resource efficiency more effectively, and in this context reflect on incentives to support consumer choices and producer action in favour of resource efficiency (by 2013)'. EC (2011) *Roadmap to a Resource Efficient Europe.* SEC(2011) 1067 final, p.11.

4 NSOB (2012) *Visie op NWW – Provincie Zuid Holland in het netwerk*, 26 November.

5 EL&I (2021) *EL&I als netwerkpartner in beleidsprocessen. Eindrapport fase 1: Verkenning van ervaringen op de EL&I werkvloer en uit de literatuur*. Ministry of Economics, Agriculture and Innovatiion (EL&I).

Appendix 1: Innovation systems

1 Hekkert, M., de Boer, S. and Eveleens, C. (2011) *Innovatiesysteemanalyse voor beleidsanalisten, een handleiding*, Universiteit Utrecht.

2 Suurs and Hekkert (2012), p.152.

A circular economy is a realistic way to provide an expanding world economy with the raw materials that will be required. A more circular economy envisages increased reuse, repair and recycling of manufactured goods and the utilization of the waste streams generated by modern society. This book analyzes the economic, social and environmental impacts of increased circularity, and presents an action plan for the government to accelerate the transition to a circular economy in the Netherlands.

TNO innovation for life

Rijksoverheid

Green Deals

Peter Henkens
Coördinator Green Deals
Ministry of Infrastructure and the Environment – NL

Contents

- What is a Green Deal?
- How does it work?
- Examples
- Going international

Core of the Dutch Green Deal approach: Focus on society

- Bottom up
- Boost sustainable innovations from within society
- Collaboration of Central Government and private parties.
- Scaling up: inspiring others; improving framework conditions; creating new networks
- Economic Affairs and Min. of the Environn

What is a Green Deal?

Voluntary agreement between private parties and central government..

..with clear roles and actions for both participants and central government..

..to achieve green growth!

Ownership is with the private partners

Roles of Central Government

- Strengthening networks
  - Independent party
- Eliminating legal and regulatory barriers
  - Issuing licenses
  - Amending laws
  - Experiments
- Supporting the market
  - Procurement
  - Certification
- Knowledge

How does it work? - Application

Apply for a Green Deal:

- via internet, or
- through contacts with ministry

Basic Principles

- realistic and with a clear target
- cost-effective
- stimulate sustainable growth
- economic viable
- generate spin off / imitated by others
- results in the short term (~3 years)
- clear role for the government
- initiator has to take the lead

How does it work? - Negotiation

1. Develop with participants the Green Deal document

2. Specify goals and actions (SMART)

3. Legal assessment

4. Signing of the Green Deal

5. Public commitment


Green Deal
Hier wordt gewerkt aan een Green Deal
Photo: Min EL&I / Robert Goddyn


Green Deal
naar 100.000 deelauto's in 2018


Green Deal
Green Deal


Hier wordt gewerkt aan een
Deal
Photo: Min EL&I / Robert Goddyn


Green Deal
Duurzaam GWW


Green Deal
Green Deal Scheepsafvalketen


Relish
Enthusiasm
Spirit
Passion
Energy


Green Deal
Verduurzamen Voedselconsumptie
Albron

Extra added value for participants

New partnerships
between participants

Green Deal
“label” attracts
visibility

More cooperation and
understanding between
government and
participants

Green Deal Bottom Ashes (2012-2016)

Initiative
- Converting contaminated reusable material into a viable building component

Initiators
- Waste-energy plants, central government

Input by field parties
- Half of bottom ash processed by 2017, and 100% by 2020, with 75% of non-ferrous metals being recovered by 2017

Input by central government
- Investigation into adjusting leaching norms; involvement in examining ways of using bottom ash in infrastructure projects

Green Deal
Dutch Water Authorities

Initiative

• Making sewerage water purification sustainable by generating sustainable energy and recovering nutrients and raw materials

Initiators

• Dutch Water Authorities, Norske Skog Parenco (paper factory)

Input by field parties

• Completion of twelve energy factories; recovery of nutrients and raw materials; in due course, all major wastewater purification treatment

Input by central government

• Amendments to laws and regulations; support for research

Green Deal

Making the concrete industry sustainable

Initiative

• Making the concrete industry sustainable

Initiators

• MVO Nederland and 20 parties with large building companies, branches, and ENCI

Input by field parties

• CSR strategy for the concrete industry 2020/2050: by 2020, 20% of the concrete construction market in the Netherlands will be sustainable, and 100% by 2050; joint approach across the industry, and knowledge sharing

Input by central government

• Participation in stakeholder dialogue; elimination of legal and regulatory barriers; knowledge

Green Deal Circular Procurement

Doel

• Integrating Circular procurement in operational management

Initiatiefnemers

• MVO, NEVI, CE, PIANOo

Input by private parties

•Pilots Circular Procurement, Communities of practice, sharing experiences

Input by central government

• Devellopping policy instruments, education, exchange of knowledge

Green Deal Zero Emission Public Busses (2012-2015)

Initiative

• Run pilots for cost-effective implementation of zero emission public transport concession in 2025

Initiators

• Foundation Zero Emission Public Busses (PPP)

Input by field parties

• Run pilots

• Use results for nation wide cost model to support local authorities (grantors) and market participants with their investment decisions

Input by central government

• follow the pilots and consider proposals to remove barriers in legislation

Result

•Adaptation of EU-regulations

International developments

- International interest UNEP, EC, France, UK, Germany, Belgium and Nordic countries
- North Sea Recources Roundabout
- Pragmatic start:
  'small and beautiful' with 'coalition of willing'
- Find suitable innovative initiatives for Circular Economy

Global Green Deals
From Trash to Treasure


time for questions

Dutch government policy on resources and waste (and more)

The Hague,
September 8, 2016

Wytske van der Mei

Head of Division
Resource Efficiency

Ministry of
Infrastructure & the
Environment

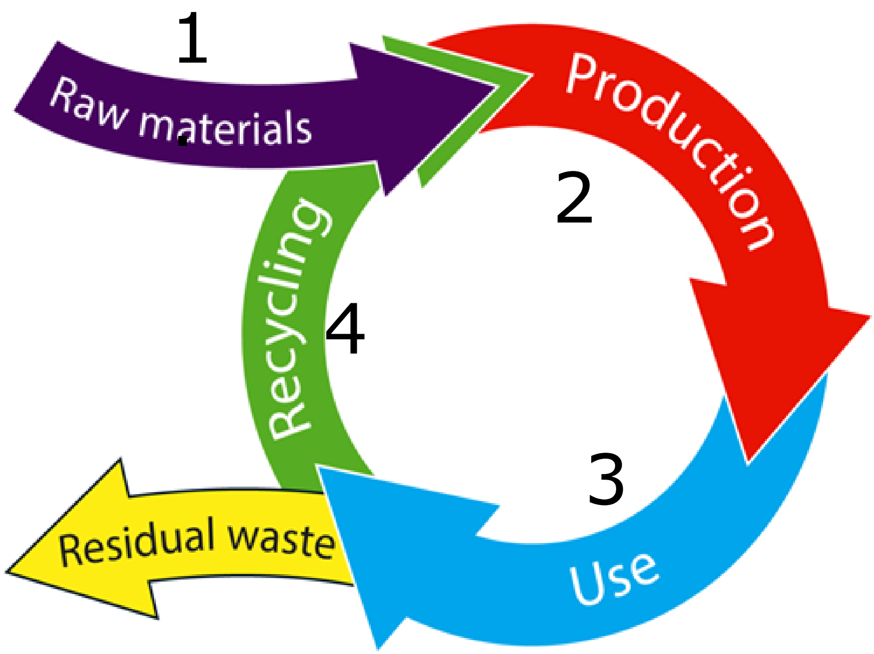
Circular economy: four key components

1) Conservation of natural capital and sustainable sourcing of raw materials

2) More sustainable products on the market

3) Sustainable consumption

4) Re-use, remanufacturing, recycling, etc.



Scarcity

Old scarcity

Private goods such as minerals may become scarce, but:

Market mechanism leads to

- Efficiency improvements
- Substitution
- Technological development

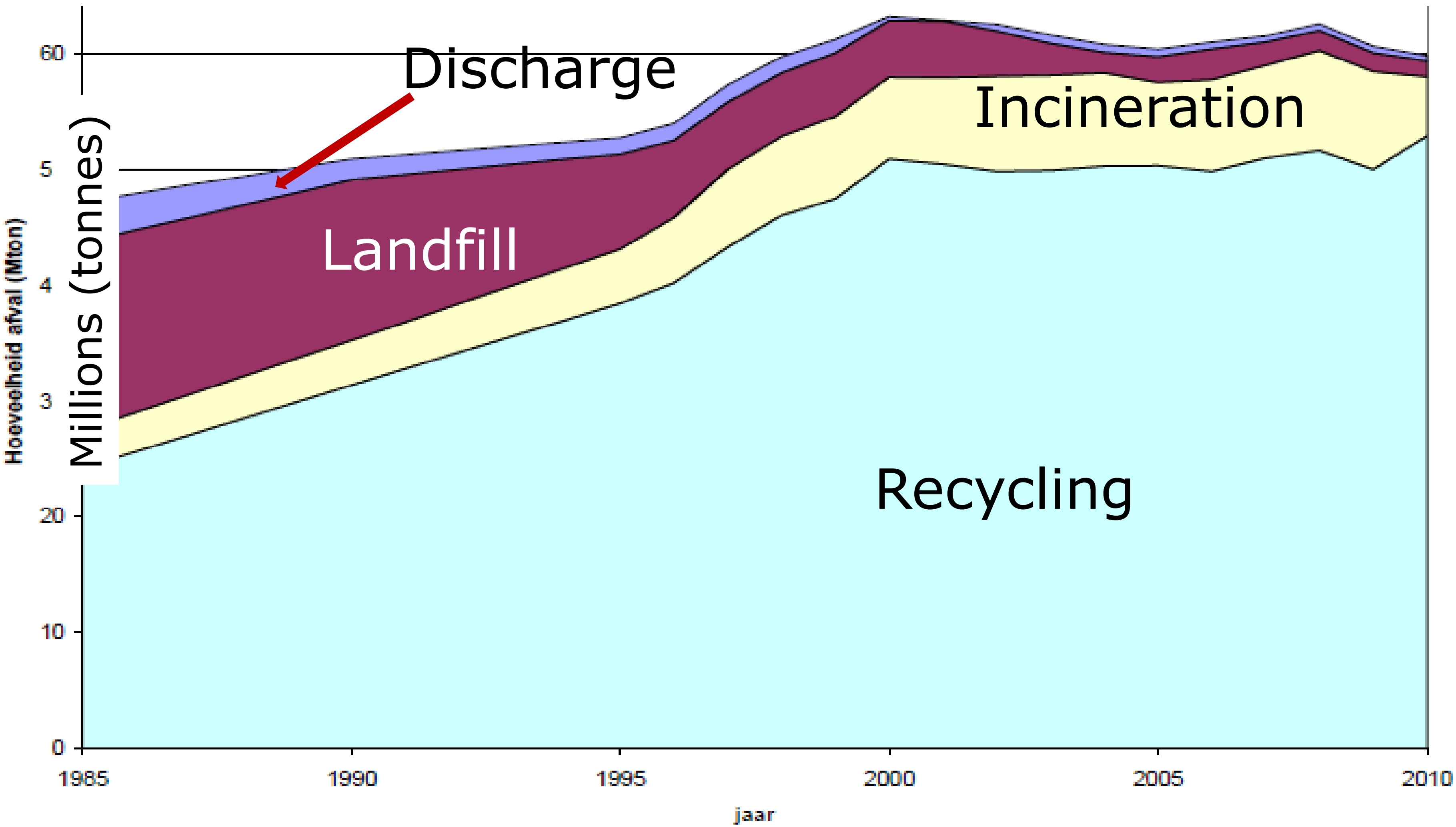
New scarcity

Public goods such as air, water, climate, biodiversity

Markets deficiencies cause

- Climate change
- Air and water pollution
- Ecosystem damage

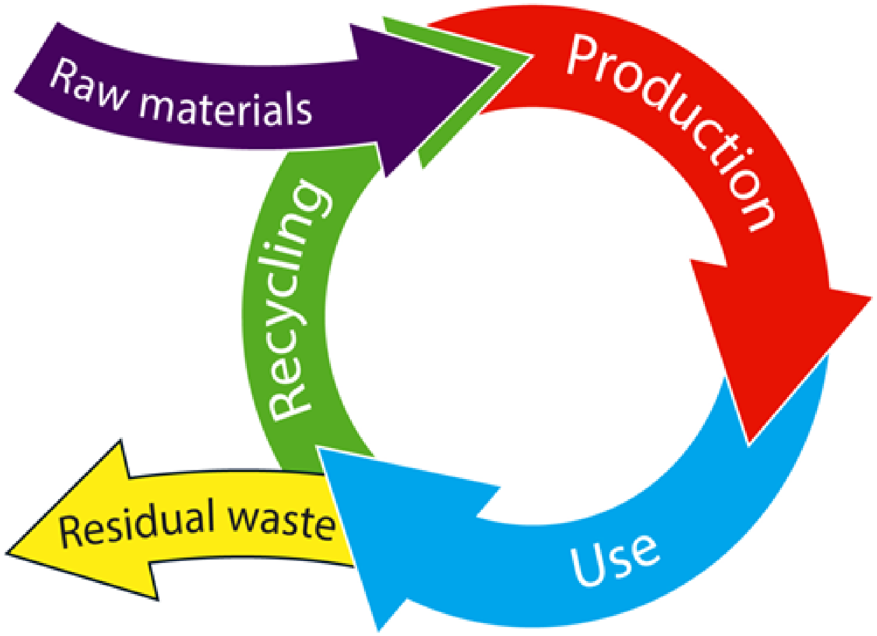
Development in waste-figures



Ambitions of waste to resource program

- Reduce losses: 10 to 5 million tonnes in 10 years
- Improve 75% separation of household waste: 50% now, 75% in 2020 finally 100%, zero waste
- Creating economic incentives
- Working with frontrunners
- Removal of counter productive (legal) restraints
- Vision and Program for Household Waste

Moving up in the value chain requires for example:



- ➢Ecodesign
- ➢New concepts of ownership
- ➢Value chain information system (product passport)
- ➢Sustainable trade
- ➢Changing lifestyles
- ➢European context

Three key actions for realising the Circular Economy

1.RACE –coalition =

Realising Accelaration towards Circular Economy

- Circular design
- High quality re use
- Inventory obstacles
- Chain transitions

- best practices
- communication
- education

2. Reducing legal barriers: examples:

- Is-it-waste-tool
- End-of-waste criteria
- Byproduct versus waste
- Take back chemicals

Three key actions for realising the Circular Economy

3. (International) Green Deals

Public –Private Deals on Resource Efficiency

Participants: governments, private companies, science

Concluding remarks

-Challenges and opportunities are big

-Systemic changes are needed

-EU-wide cooperation is important

-And: cooperation between neighboring countries is promising

-International Green Deals:

from Trash to Treasure

Thank you

Dutch government policy on resources and waste (and more)

The Hague,
September 8, 2016

Wytske van der Mei
Head of Division
Resource Efficiency

Ministry of Infrastructure & the Environment

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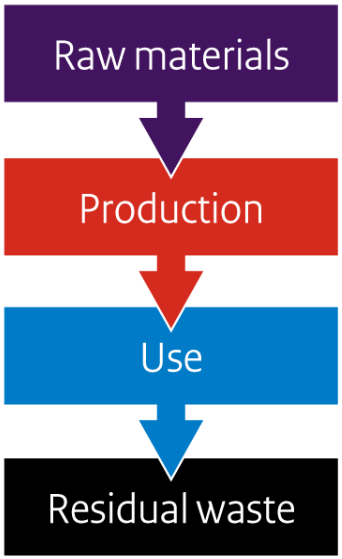
Ministry of Infrastructure and the Environment

Government-wide programme on Circular Economy

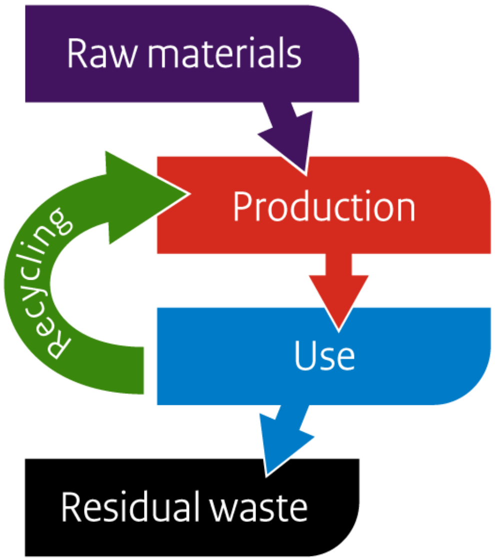
Kees Veerman

Policy Coordinator CE

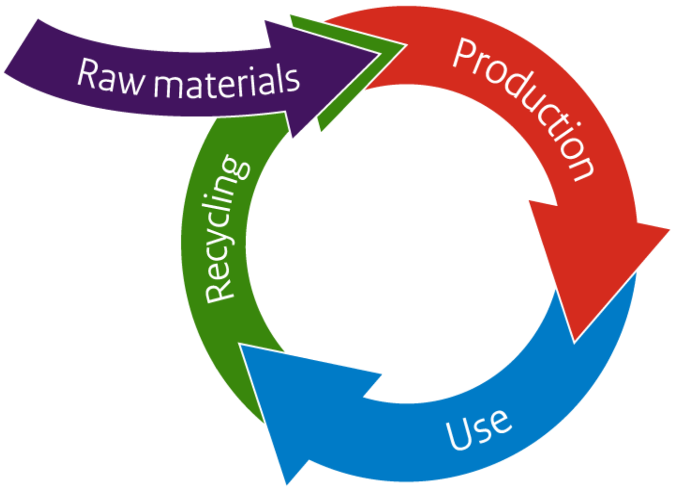
Linear economy



Economy with recycling



Circular economy



Opportunities circular economy in the Netherlands

Savings on raw materials

+7.3 billion euro/yr

More work

+54,000 jobs

Less emissions of carbon dioxide

-17,000 kiloton/yr

Less usage of raw materials

-100,000 kiloton/yr

Less land and water use

-2,180 km^2 en -0.7 billion m^3

Government-wide programme on Circular Economy

Vision

- Circular Economy by 2050
- From linear to circular
- Change of the economic system

Strategic Goals:

1. High-value (re-)use of resources in existing material chains
2. Sustainably produced and abundant resources substitute for fossil, critical and non-sustainably produced resources
3. New ways of production, design, and consumption/use

Ambitions and actions for 2020

- Overcome barriers
  - In legislation
  - External adverse environmental effects
  - Knowledge gaps
  - Non-circular behaviour
  - Lack of coordination within material chains
  - Existing investments and interests
  - Limited international influence

- Interventions
  - Enabling legislation and regulations
  - Market instruments
  - Expertise and innovation
  - Circular behaviour
  - Common dynamics
  - Funding of smart private sector incentives
  - International perspective

Government: interventions

- Stimulating regulations
- Smart market push
- Financing
- Expertise and innovation
- International cooperation

Government: priority sectors

- Biomass and food
- Plastics
- Manufacturing industry
- Construction
- Consumption goods

Way forward

Circular economy agreement

Transition roadmaps for the priority sectors

In cooperation with stakeholders

Thank you

More information

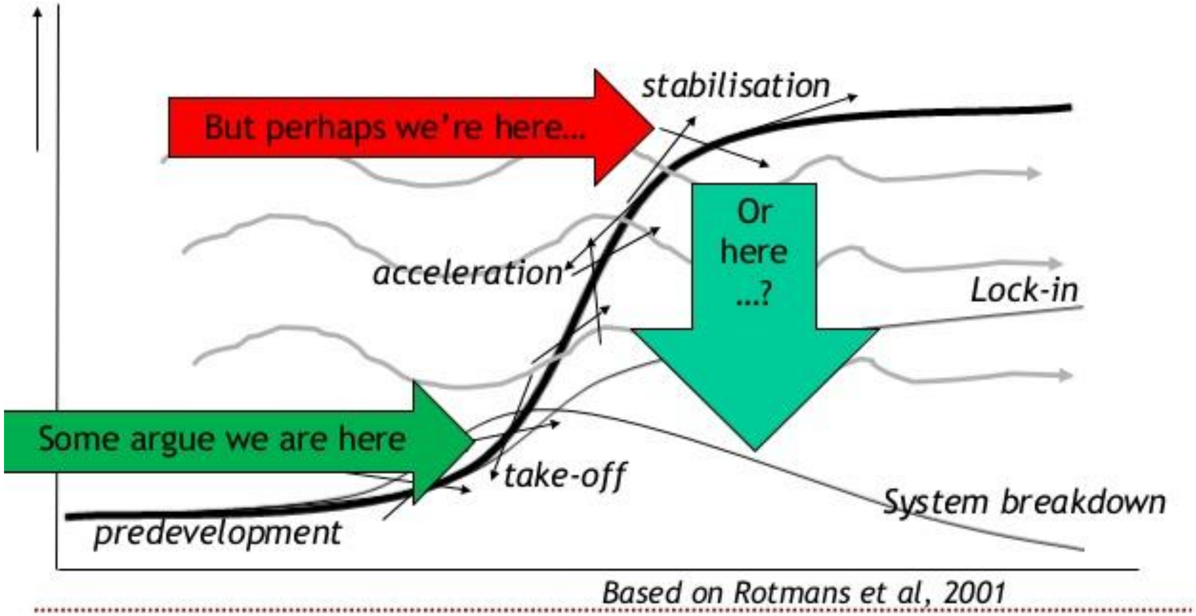
https://www.government.nl/
search keywords = waste & circular & economy

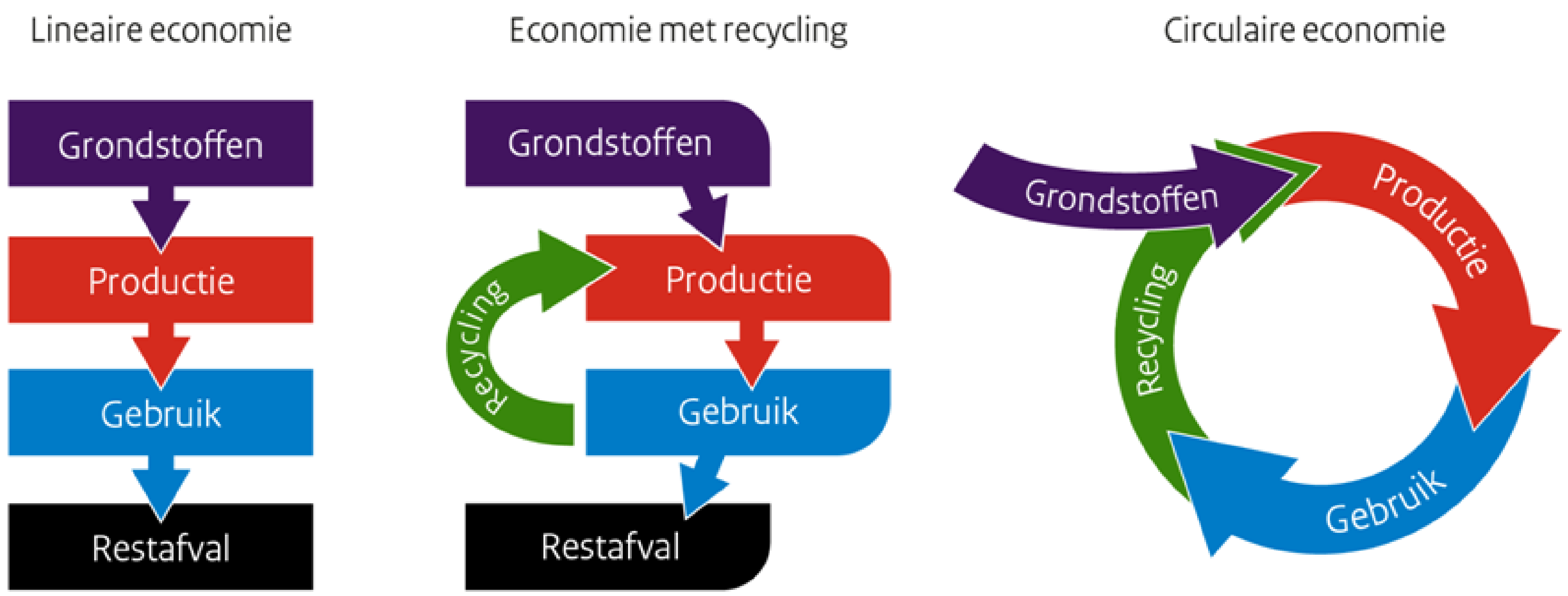
http://www.wastematters.eu/

http://www.greendeals.nl/english/

Kees Veerman
Policy Coordinator
Kees.veerman@minienm.nl

What's going on?



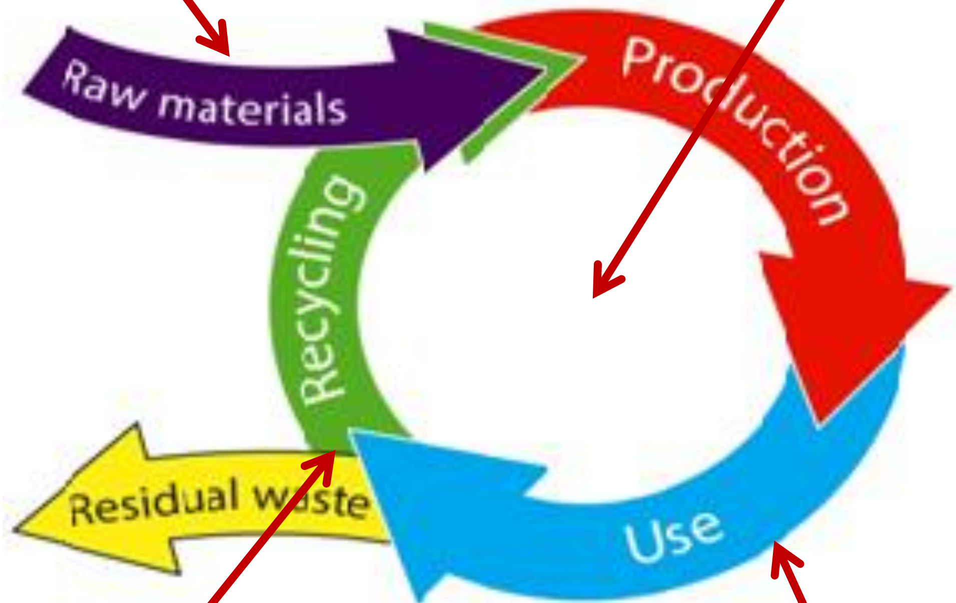


Lineaire economie
Grondstoffen
Productie
Gebruik
Restafval
Economie met recycling
Grondstoffen
Productie
Gebruik
Restafval
Recycling
Circulaire economie
Grondstoffen
Productie
Gebruik
Recycling

Towards a Circular Economy in NL and in Europe

Sustainable sourcing

Circular Product Policies



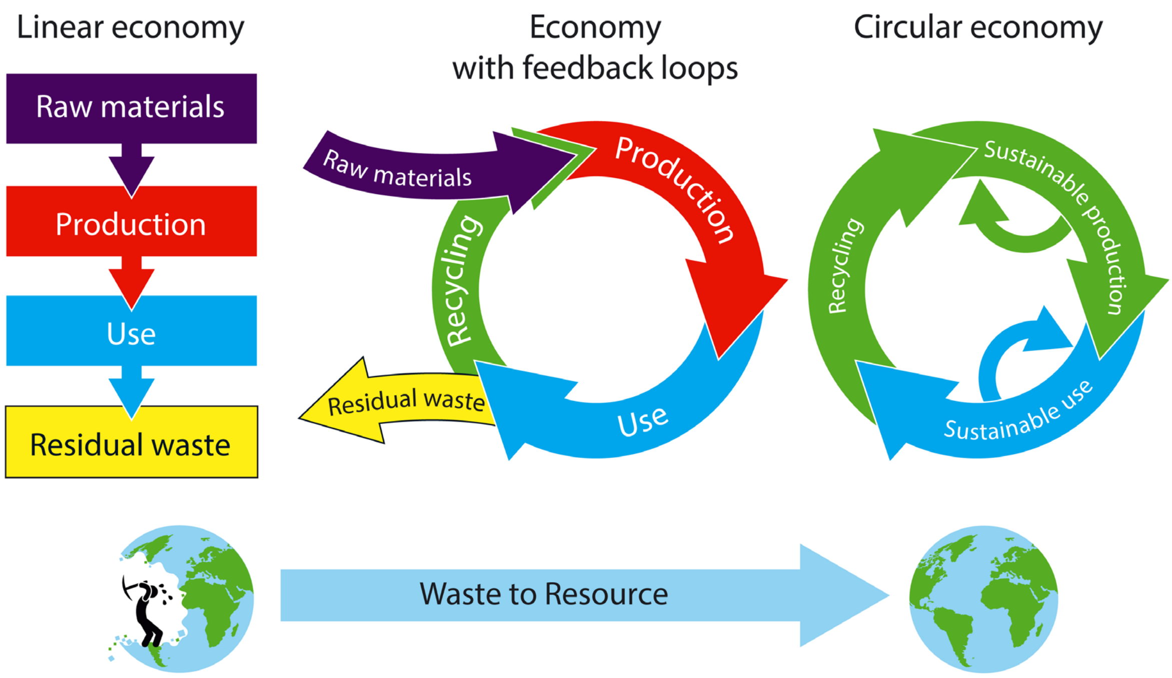
Frontrunner approaches
Initiatives from society

Waste = Resource

Consumers choose

Waste to Resource

Elaboration of eight operational objectives



Annex 1 to the Letter to the House of Representatives headed *Implementation of the Waste to Resource* programme

January 2014

Contents

Introduction

The *Waste to Resource* programme is this Cabinet's effort to stimulate the transition to a circular economy during its term of office. This document elaborates eight operational objectives in the sequence of the value chain.

A broad, integral and Cabinet-wide approach is necessary for the transition to a circular economy. Although this programme was set up under the responsibility of the Ministry of Infrastructure and the Environment ('the Ministry'), there is intensive cooperation with other ministries.

For the implementation of the *Waste to Resource* programme, it is important to exert effective influence on policymaking in Europe. The Netherlands is also pursuing a more circular economy outside the EU. The Netherlands exports a lot of knowledge and environmental technology that can help establish a circular economy in other countries. Economic environmental diplomacy makes an important contribution to this goal.

At the start of the programme the Netherlands Environmental Assessment Agency ('PBL') will make a general analysis of its likely effects on the environment and on the economy. Progress and effects will be monitored during the programme.

Waste to Resource builds upon the *Netherlands Waste Prevention* Programme that the Netherlands established under the European Waste Framework Directive.

The programme contains the Ministry's waste and resource policy. This annex provides an overview of the parliamentary motions and commitments being put into effect as part of the programme.

1. Promoting sustainability at the front of the chain

A circular economy reuses products and raw materials and conserves natural resources. Products are made and marketed in a way that makes them fit perfectly into a circular economy. The creation of closed natural cycles is also promoted. Therefore, the Cabinet is pursuing:

- ensure the circular design of products;
- close local and global cycles.

Ensuring the circular design of products

Circular product design is necessary in order to optimise the sustainable use of products and to recover materials from them. Besides considering the environmental impact at all stages of a product's life-cycle, a circular design takes into account the product's recycling, re-use and maintenance. Products are designed to enable environmentally friendly production, sustainable use, simple repairs and effective recycling. The Cabinet wants to continue stimulating circular design in the Netherlands. Together with educational institutions, industry organisations and businesses, a programme is being set up to promote circular design. This includes examining how the business community can get structural access to knowledge and experience. One of the matters under scrutiny is whether a knowledge institute is required and effective for this purpose.

Ecodesign is regulated under the European Ecodesign Directive that will be revised in 2014. The Directive forms the basis for laying down legal requirements – mostly energy-related – for products. The Netherlands advocates widening the scope of the Directive and wants to add material usage to it to ensure that the designs of all products make allowance for recycling. As part of the *Waste to Resource* programme, there will be an examination of the possibilities for embedding legal requirements for material usage in the Directive. The Dutch findings from this study will be contributed to EU decision making on widening the Directive. The Cabinet also aims to widen the scope of the Ecodesign Directive to include all products, instead of just electrical equipment.

Nationally, packaging is being designed and made more sustainably. Municipalities, producers, importers and central government opened the *Kennisinstituut Duurzaam Verpakken* (Sustainable Packaging Knowledge Institute) and the *Meldpunt Verpakkingen* (Packaging Reporting Desk) in 2013. Members of the public can contact the support desk if they have questions about packaging or want to report non-sustainable packaging. At the same time, the Reporting Desk provides a platform for producers and importers to respond to these questions and reports. The direct relationship between manufacturer and consumer serves as an additional stimulus for making their products sustainable. Producers are adapting their packaging thanks to useful and critical ideas put forward by members of the public.

The Cabinet is currently working on a new General Administrative Order for the management of packaging, allowing the highest attainable goals for sustainable packaging to be included in legislation. This follows on from the *Packaging Master Agreement 2013-2022* that was concluded with the packaging sector and municipalities and from the *Packaging Sustainability Agenda* that was sent to the House of Representatives on 2 September 2013. This General Administrative Order will be used to lay down by law that the packaging sector must work structurally towards making packaging more sustainable.

Finally, research is currently underway aimed at defining and establishing the feasibility of a material label (Commitment AO resources and waste, 29 May 2013, 30 872, No. 147). A material label contains information about the composition of and materials used in a product. This facilitates recycling. The research is examining, with the involvement of producers, the material value chains for which voluntary introduction will contribute to the desired transition. The results will be available in spring 2014.

Closing local and global cycles

Closing cycles is not confined to re-using materials from consumer products. Production chains rely on the continuous availability of natural resources. The resources include not only materials, but also natural processes that keep the system running, such as water, carbon and nutrient cycles. Excessive use has put pressure on the continuity of the resources. To use our resources sustainably, it is necessary to close cycles both locally and globally. Synergy is also required between biological and technical cycles.

In order to close technical or biological cycles and achieve synergy locally, it is necessary to use what is present locally instead of obtaining raw materials from far away. Concepts that build upon this idea, such as *Blauwe Economie* (Blue Economy), are an important source of inspiration for this way of thinking.[1] Producers in the Dutch food and beverage industry in particular are already using smart local combinations. This can include the smart use of locally present ecosystem services and eco-engineering or the utilisation of industrial residual waste via the concept of industrial symbiosis. The *Waste to Resource* programme is built on the ambition to make the transition from good examples to the widespread use of these concepts. Local authorities have an important role to play in this regard. Local customisation is necessary in order to leverage specific circumstances and this requires knowledge, effort and time. It will be possible to support local initiatives by means of the *Waste to Resource Local* programme that makes knowledge available. The programme will be worked out in more detail with municipalities.

In order to close biological cycles it is important to possess an insight into the presence and the condition of the natural resources in the Netherlands and the value that they represent to society. A *Digital Atlas of Natural Capital* (known by the Dutch acronym DANK) is being developed to obtain an insight into the presence and quality of natural resources. This will inform companies, authorities and the public of the location of particular ecosystems and services. It will then be easier to factor them into the decision-making process on area design and management. By means of the information from DANK, it will be possible to determine the value of the natural resources and thus develop revenue models. Studies into *The Economics of Ecosystems and Biodiversity* (TEEB) explore the implementation of this approach. In the *Natural Capital Implementation Agenda* (parliamentary papers TK 26 407, No. 85), the Cabinet stated the actions that it wishes to take to establish the sustainable utilisation of natural capital.

Internationally, the body of scientific knowledge about the sustainable use of natural resources is rapidly increasing. The effective utilisation of this knowledge is crucial. This is something that the Netherlands wants to promote. The *UNEP International Resource Panel* (IRP) is making this knowledge accessible to policymakers and the business community. In 2014, the Netherlands wants to host the IRP's 15th conference. The conference will address awareness, research and policy programming.

One of the main global challenges in the sustainable use of natural resources is its financing. Increasingly, the private sector must also make its contribution. Improving the transparency of projects is crucial for this purpose. This programme supports the *Green Development Initiative* that in 2014 will produce a global register of projects concerning the sustainable use of land. In addition to the preservation and sustainable use of natural resources, the recovery of impaired resources is crucially important. Worldwide, two billion hectares of land have already become greatly degraded and unproductive. The *Ecosystem Return Foundation* is receiving support from the Cabinet. The foundation wants to remediate millions of hectares of degraded agricultural land together with large investors (public and private). This will greatly reduce the present economic incentive to open up new land.

[1] See for example: Gunter Pauli (2012) *Blauwe Economie*

Most important actions

	What	How	Who	When
1	Stimulate circular design	Set up a circular design programme	Central government together with the business community	Year-end 2014
2	Widen scope of Ecodesign Directive	Study the legal possibilities	Central government	2014 and beyond
3	Make packaging more sustainable	Define highest attainable goals in a General Administrative Order	Central government together with the business community	General Administrative Order ready in 2014, in force on 1 January 2015
4	Create a material label	Conduct a feasibility study	Central government and stakeholders	Ready in Q2 2014
5	Stimulate preservation of Vital Natural Capital	Digital Natural Capital Atlas	Central government	First version year-end 2014, extending to 2020
6	Close local cycles	Support other authorities by means of *Waste to Resource Local*	Central government, provincial authorities and municipalities	Operational in 2015
7	Finance natural capital	Support the Green Development Initiative and the Ecosystem Return Foundation	Central government	Ready in Q4 2014

2. Making consumption patterns more sustainable

To accelerate the transition to a circular economy, it is important for members of the public to start consuming sustainably. As a major purchaser, the national government also has a possibility to use its purchasing power to speed up the transition. With this in mind the Cabinet wants to:

- develop an approach to sustainable consumption patterns based on behavioural knowledge;
- strengthen the role of the retail sector, thrift stores and repair companies;
- use the purchasing power of the government to create a more circular economy.

Developing an approach to sustainable consumption patterns based on behavioural knowledge

An effort is being made to promote sustainable consumption, which can be achieved by purchasing fewer products and, for example, borrowing, sharing or renting more products. But it can also be accomplished by buying the sustainable variants of products and using and handing them in properly. This will lower the environmental impact of our consumption and will encourage producers to market sustainable products. To achieve this goal effectively it is important to possess knowledge of how consumption behaviour comes about and the possibilities that exist for influencing it. In recent years behavioural science has produced new insights and provided new instruments. Behaviour appears to come about largely unconsciously. Traditional instruments like information campaigns thus appear to have little effect. Incentives ('nudges') that make the desired behaviour attractive and easier have a greater effect.

In the textile and food sectors, pilot projects with different influencing instruments are being carried out to increase knowledge of behaviour. The results are expected in early 2014. The Cabinet is also eagerly awaiting the advisory report of the *Council for the Environment and Infrastructure* (RLI) on the influencing of behaviour, which will be published in early 2014. Over the course of 2014, the results of the projects and the Council's report will be used to develop an approach to make consumption patterns more sustainable. This will include scaling up projects in textile and food, and widening the approach to include other consumer goods, such as personal care products and household appliances. The approach will not be confined to the purchasing phase of products. Knowledge of behaviour will also be used to improve the waste separation behaviour of households, to stimulate the harmonisation of certification labels and to strengthen public support for sustainability. The Cabinet will examine whether it is desirable to ask an organisation to coordinate the acquiring, bundling and disseminating of this behavioural knowledge. These actions will be carried out partly by means of the 'Duurzaam Doen' (≈ Sustainable Action) programme. This programme will be presented in the Cabinet's letter on the modernisation of environmental policy that will be sent to the House of Representatives early 2014.

Strengthening the role of the retail sector, thrift stores and repair companies

The retail sector is an important partner when it comes to making consumption sustainable. Retailers have the possibility to make the range of products on their shelves sustainable and to make a sustainable choice easy and attractive for consumers. In consultation with the retail sector an assessment will be made of the role they can play in making consumption sustainable. Thrift stores and repair companies fulfil an important role in the use/reuse of products. Together with them there will be an examination of whether the infrastructure for the re-use and repairs of products can be strengthened.

Using the purchasing power of the government to create a circular economy

The government can stimulate the sustainability of offered products by means of its procurement policy. Public bodies should set an example by practicing sustainable procurement. An evaluation of the sustainable procurement policy is expected to be submitted to the House of Representatives in January 2014. It will contain recommendations for making the instruments for sustainable procurement more targeted, simpler and more forward-looking.

The *Circular Procurement* Green Deal includes measures that companies and the government will take to increase circular procurement. The knowledge obtained through practical application will be disseminated. There will also be a circular procurement roadmap and circularity will be made an integral part of the procurement processes of the participants.

Most important actions

	What	How	Who	When
8	Make consumer behaviour and waste separation more sustainable	Consumer strategy	Central government, business community and civil society organisations	Approach to consumers ready in Q2 2014 Implementation in 2016
9	Use the retail sector to make consumption more sustainable	Green Deal with retail trade	Central government and retail trade	2016
10	Promote re-use and repair	Green Deal with thrift stores and repair companies	In cooperation with sectors	2015-2016
11	Sustainable procurement by public bodies	Evaluation of sustainable procurement	Central government	Early 2014
12	Circular procurement	Carry out Green Deal for Circular Procurement	Public bodies and companies	2014-2015

3. Improving waste separation and collection

In a circular economy there is no waste. The Cabinet's ambition is to minimise the volume of recyclable materials ending up in incineration plants. The separation of waste – particularly at the source – is a precondition. The programme seeks to:

- minimise the quantity of residual Dutch waste in incineration plants;
- facilitate municipalities in improving the separation and collection of waste;
- inspire households to improve their separation of waste;
- separate waste from offices, shops and public spaces.

Minimising the quantity of residual Dutch waste in incineration plants

Recyclable materials do not belong in a waste incineration plant. The ambition of the Cabinet is to reduce the quantity of material that 'leaves' the economy. Almost 10 million tonnes of material from the Netherlands was still being offered to these plants in 2012. The Cabinet's ambition is to halve this quantity within ten years. The overcapacity at waste incineration plants must not be allowed to obstruct recycling. Therefore, there will be an examination to identify specific streams that are still being incinerated but could be recycled by (improved) separation, as well as the instruments best suited to stimulate this. Separation at the source is preferable if it is practicable, but there are significant potential efficiency gains in the area of post-collection separation. An effort will be made with the sorting industry in 2014 to increase the effectiveness of post-collection separation. The technical possibilities of the front-runners should become the norm for the entire sector. For this purpose the available technologies and the related costs and benefits will be studied. These analyses will be used to formulate additional policy; a lot is still achievable by using various instruments (such as the National Waste Management Plan, legislation, a Green Deal, or a combination). The prime consideration is that improvement of waste separation is a joint ambition and the way forward will be worked out together with the collection and sorting sector.

The Netherlands is already a leader when it comes to recycling as much waste as possible. The quantity of incinerated Dutch waste is decreasing steadily. This programme is pursuing a further reduction of waste that goes into landfills or is incinerated. However, the incineration of waste for which no other processing possibilities exist will remain a final phase in the transition towards a circular economy from a long time to come. We extract energy from waste incinerated in the Netherlands. The waste incineration capacity in the Netherlands is greater than the national supply of residual waste. To utilise the overcapacity waste can be imported. The Dutch public would otherwise have to foot part of the bill for the non-utilisation of capacity. Putting waste into landfills and incineration plants without energy recovery remains the norm in many European countries. Our incineration plants provide a higher-quality alternative for those countries. After all, it is better to recover energy from waste than to send it to landfills or incinerators without recovering any energy. The research into increasing opportunities for post-collection separation is also focused on these foreign streams. It will allow the Netherlands to recover materials from foreign waste. Importing waste ensures high-quality processing in an international perspective, keeps Dutch waste incineration plants profitable, and reinforces the position of the Netherlands as a recycling hub. The waste that is imported must obviously be compliant with prevailing legislation and must not increase the environmental burden in the Netherlands.

The residues (or bottom ashes) from waste incineration plants still come out of the furnace polluted and may be reused only under strict conditions, particularly in the civil engineering sector. It has been agreed with waste incinerators in the Green Deal called *Making the Useful Application of Waste Power Plant Bottom Ash More Sustainable* that bottom ashes will be completely reprocessed (i.e. cleaned up) in 2020 so as to become a freely usable building material. Metals released from bottom ashes will then be available as a raw material. As a reference point it has been stipulated that by 2017 50% of the produced bottom ashes must be reprocessed. This Green Deal includes a proviso for the availability of reprocessing technologies. In practice the proviso still causes some obscurity. Work will be done in 2014 together with the sector (operators of incineration and reprocessing plants) to eliminate this proviso.

Facilitating municipalities in improving waste separation and collection
Municipalities are free to decide how separate collection of domestic waste takes place. Various municipalities get good marks, but overall there is still room for improvement. The previous Cabinet expressed the ambition to achieve 60-65% separate collection by 2015. Together with municipalities, this programme wants to set up a plan of action that contains acceptable, realistic goals.

Together with the municipalities, the public framework for sustainable waste management will be defined more concisely. This framework will be a basic principle for medium- and long-term policy aimed at reducing the quantity of residual waste. It goes without saying that the waste processing and recycling industry must be involved in this effort. The intention is that improved separate collection will, in due course, lead to more recycling and lower costs for the public. Pending a plan of action, the *Waste to Resource* programme will seek to strengthen contacts between municipalities and facilitate a situation where municipalities are better able to learn from each other. At present there are two benchmarks for comparing the collection results of municipalities, i.e. one of the Directorate-General for Public Works and Water Management (RWS) and one of the Royal Society for Waste and Sanitation Management (NVRD). The goal is to have one national benchmark in 2014 so as to create a common basis. An analysis of differences in performance and the sharing of best practices will help municipalities to improve their approach. This presents an opportunity to expand and further facilitate the existing network of individual municipalities. The network, which is a collaborative effort between RWS, the municipalities and other stakeholders, is working on the details of this idea. If the municipalities are enthusiastic about it, the Cabinet is willing to invest in it.

Inspiring households to improve their separation of waste
Members of the public as well as municipalities play an important role in the separate collection of domestic waste. The success of separate collection stands or falls with their efforts. The *Waste to Resource* programme employs a second programme, entitled *Duurzaam Doen* (≈ Sustainable Action), to spotlight existing initiatives and to put forward perspectives for action, also for improving separate collection. Together with producers tools and tips are being provided and brought to the public's attention more effectively. This concerns concrete actions such as the separate collection of plastic packaging (*Plastic Heroes*), glass, airborne waste (*Clean Netherlands*), textiles, electrical appliances (*WeCycle*) and batteries, and there is also an app that helps people to separate their waste.

Separating waste from offices, shops and public spaces
There is still considerable potential for separating waste categories that are similar to domestic waste. The *Waste to Resource* programme will intensify the efforts being made in relation to waste from the office, retail and services sector, where more than half of all waste is still not being recycled. Arrangements will be agreed with the relevant parties to examine which sub-sectors and waste streams present the most potential. Attention is also being devoted to waste from public and semi-public spaces. A few municipalities have carried out trials with separate street litter bins, waste separation during street litter removal, and post-collection separation of public waste. Municipalities and other parties that manage public and semi-public spaces and want to take up recycling encounter obstacles and need knowledge and practical examples. Building on the initial trials and experiences, an approach will be formulated in 2014 for these and possibly other similar waste streams.

As the national government we must set a good example. Therefore, the national government will improve its waste separation practices. Since 2013 this has been a standard element of new waste collection contracts.

Most important actions

	What	How	Who	When
13	Stimulate improved waste separation	Conduct research and agree instruments	RWS, collection sector, sorting sector	Q2 2015
14	Ensure sustainable use of bottom ashes	Carry out Green Deal on Bottom Ashes	Central government with waste incineration sector	Implementation until 2020
15	Collect more separated domestic waste	Set down a vision and approach Establish a knowledge-sharing network	Central government, municipalities and RWS	Adopt approach in Q2 2014 Implementation 2014 – 2015
16	Stimulate people to separate waste	Inspire and facilitate via *Duurzaam Doen*	Central government, municipalities and business community	Launch early 2014
17	Improve waste separation in public/semi-public spaces and in offices, shops and services sector	Plan of action	RWS with sector	Q4 2014

4. Focusing existing waste policy on a circular economy

The goal of waste policy must be to reuse materials. At present, legislation is often seen as obstructing this goal. The following needs to be done:

- identification and elimination of unnecessary obstacles in legislation;
- stimulate the application of end-of-waste status;
- promotion of recycling by means of a level European playing field for waste;
- creation of scope for innovation in legislation and in standards.

Identifying and eliminating unnecessary obstacles in legislation

Obstacles in legislation can come about because insufficient consideration was given to the innovative possibilities for using waste as a resource at the time when the legislation was framed. By means of the *Waste to Resource* programme, the Cabinet wants to identify and eliminate unnecessary obstacles. This examination of legislation must also take into account the circumstance that the legislation serves purposes such as environmental protection and public health, and provides a basis for taking action when it is necessary to do so.

The programme will check whether legislation like the Registration, Evaluation, Authorisation and restriction of Chemicals (REACH), the Waste Framework Directive and other European and Dutch laws create unnecessary barriers for optimal recycling of high-grade materials from waste streams. A similar review of the obstacles experienced by enterprises for using waste as a raw material has already occurred for bio-based materials and, where possible, the obstacles are being eliminated. The Netherlands is also looking at the current evaluation and possible amendment of EU legislation covering waste. The Netherlands is making a contribution to the EU process and is consulting on this matter with value chain partners. The programme will in any event check the scope that REACH offers for simpler registration of recycling. This will be followed in 2014 by an assessment of practical problems and a position paper agreed with stakeholders on Dutch efforts in the EU in the REACH field.

Stimulating the application of end-of-waste status

European waste legislation provides a possibility to give waste the status of resource under certain conditions. The earlier lifting of the waste status will lower administrative costs and may have a positive effect on recycling. The European Commission has already set down end-of-waste criteria for glass, metal and copper scrap and criteria for various other materials are under preparation. Member states may additionally define national criteria if no European criteria are in force. In the Netherlands, for example, national criteria are being prepared for recycling granulate and priority will soon be given to their legal elaboration. The Dutch business community has expressed interest in using the end-of-waste concept. Companies can obtain information about end-of-waste from the Directorate-General for Public Works and Water Management (RWS). In 2014 RWS will unveil a test tool (e-tool) that enables companies to make their own assessment of the status of a material. RWS can subsequently be asked for its opinion. Together with value chain partners, the programme will also take stock of the wishes for the use of end-of-waste to determine whether an extra effort is relevant in this respect.

Promoting recycling through a level European playing field for waste

Cross-border transport of waste plays an important role in the transition to a circular economy. The European Waste Shipment Regulation (WSR) sets out the frameworks. The Netherlands is endeavouring to make good use of the scope within these frameworks. Additionally, the Netherlands is pursuing a level playing field at European level, among other things for the standardisation of enforcement and the interpretation of the WSR. The Cabinet is also attempting to separate high-quality and low-quality recycling in European legislation to prevent a shift to foreign countries with low-quality recycling. Minimum European standards might be a solution. They could then play an important role in implementing the WSR.

Creating scope for innovation in legislation and in standards
Waste policy must stimulate innovation. Interim changes are being made to the current National Waste Management Plan ('LAP') in order to promote innovation. It is no longer allowed to export recyclable waste for use as a fuel or to fill mines. In the European revision of the *BREF for Waste Treatment* – the reference document for best available waste processing techniques – the Netherlands wants to ensure the inclusion of innovative and proven techniques.

The use of national and international standards (NEN, CEN and ISO), in combination with certification or otherwise, presents opportunities to close material loops. But existing standards can actually be a barrier to closing them. Therefore, the Netherlands Standardization Institute (NEN) is going to examine whether prevailing standards and certification schemes can stimulate sustainability and whether amendment of these documents is desirable. The goal is twofold. Scrutinising a number of practical cases will help selected material chains and chain partners (including new ones) and will yield generic knowledge. An important matter requiring attention is that all relevant parties must be tied in the standardisation process. Results are expected at year-end 2014. Within Europe the Netherlands is striving to make the prevailing standards for products and processes more dynamic. This will allow faster alignment with the most advanced technology and method of approach. Dynamic standardisation is part of the Eco-innovation Action Plan.

Most important actions

	What	How	Who	When
18	Review of obstacles in legislation	Conduct a study into obstacles Position paper on REACH	Central government in cooperation with the sector	Year-end 2015
19	Stimulate end-of-waste status application	E-tool for companies	Together with Directorate-General for Public Works and Water Management (RWS)	Q3 2014
20	Define national end-of-waste criteria	Criteria for granulate Take stock of wishes for other streams	Central government in cooperation with the sector	2014-2015
21	Make optimum use of the WSR	Utilise the scope offered by the WSR Pursue amendment of the WSR	Central government in cooperation with the sector	2014-2015
22	Stimulate innovative recycling	Amend the WSR	Central government	Q1 2014 (consultation)
23	Focus standards of the circular economy	Scrutinise practical cases Pursue dynamic standardisation in Europe	Netherlands Standardization Institute (NEN) Central government together with EU	2014-2015

5. Adopting an approach to specific material chains and waste streams

An advantage of focusing on specific material chains is that all parties in the value chain are stimulated to establish a common approach for the entire chain. A specific approach to a material chain is geared more to the use of specific material and product chains. Central government can stimulate and facilitate the process of making a value chain sustainable. It can facilitate consultations between chain parties, enabling them to formulate joint goals and define what they need from each other in order to achieve those goals. This focus on specific material chains is being expanded and institutionalised by the *Waste to Resource* programme. This entails:

- setting up a support desk for a material chain approach;
- accelerating specific material chains such as the one for plastics;
- stimulating high-quality recycling in each chain;
- high-quality use of biotic residual materials.

Setting up a support desk for a material chain approach

In practice companies sometimes find that they are obstructed in their activities aimed at improving the closure of a material chain because legislation seems to be working against them. The obstacles they experience are of a diverse nature and often complex. They sometimes concern environmental laws, but may also involve competition rules, safety requirements, accession law and so on. A central support desk for the material chain approach will be set up for this purpose in 2014. The object of the support desk is to provide information to market players, to review and analyse the difficulties and opportunities in each material chain, and to ensure speedy resolution. The support desk will also be given a role in the sharing of knowledge and improving the image of recyclates and the demand for it. Besides tackling actual problems that are encountered, this will also yield extra input for scrutinising environmental legislation and, possibly, this may lead to new material chains that need to be addressed. The support desk for the material chain approach will operate under the direct responsibility of the Ministry and will cooperate with value chain parties. Inspectorates and licensing authorities will also be involved. In short, the support desk will accelerate the closing of material chains. This will tie in with the *Conflicting Interests in the Bio-Based Economy* programme about which you have been informed in April 2013 (Parliamentary paper 32637, No 55).

Accelerating specific material chains such as the one for plastics

Central government has opted for a role aimed at accelerating developments in a number of specific material chains, because the environmental burden of the chain concerned is considerable and there is sufficient support in society for closing the chain. Ambitions and efforts will be set down in a Green Deal, covenant or material chain agreement. A good example is the *Phosphate Value Chain Agreement* under which the parties are closing the cycle and a market is being created for recycled phosphate. After the agreement was signed on 4 October 2011, the government acted as a network director for two years. An update of the progress of this agreement will be sent to the House of Representatives in summer 2014.

The Cabinet is utilising the dynamics present in material chains to stimulate the transition to a circular economy. Examples are the Green Deals for making the concrete and wood chains sustainable, the deal that ensures better recycling of bottom ashes, the master agreement for packaging that stimulates improving recycling and making packaging structurally more sustainable, and implementation of the EU Directive for electrical appliances that regulates collection, certification and registration.

This approach is highly effective and ties in with the growing support among stakeholders.
The *Waste to Resource* programme wants to build upon this approach. A material chain approach includes examining how new production processes and changing ownership structures can be conducive to establishing closed chains. During the *Innovatie-estafette* (Innovation Relay) on 14 November 2013, for example, a *Plastic Value Chain Agreement* was signed with more than

50 parties. Its object is to reduce ‘plastic soup’ by tackling littering and to increase the recycling of plastics. The joint implementation of this agreement will get underway in 2014.

Together with other partners in the *Green Deal for the Netherlands as a Circular Hotspot*, the Cabinet is examining which new material chains can be enhanced most effectively, for example by directing efforts towards the care sector or by stimulating the useful application of CO_2.

Stimulating high-quality recycling in each material chain
High-quality recycling is necessary to recover raw materials and goes hand in hand with a circular economy. It is difficult to promote this because the term ‘high-quality’ is ambiguous and the way it is interpreted can be different for every stream and every chain. Therefore, a number of waste streams will be examined to see how high-quality recycling could be implemented in practice. This research will be conducted as far as possible in association with value chain parties. A clear definition of ‘high-quality recycling’ will create a method for managing waste. There will be an examination of the types of waste for which criteria for high-quality recycling can be formulated. Besides looking at the environmental gains there will be an examination of the financial costs/benefits ratio, the technical possibilities for recycling, the consequences for importing and exporting, and the market situation for recycling. If the foregoing presents a reason for doing so, relevant minimum standards will be made part of the National Waste Management Plan. This will embed high-quality recycling in the verification framework for issuing licences.

Using residual biotic streams in a high-quality way
Residual streams of biomass are separated into several building blocks that are used in the most high-quality way possible by means of a process of cascading, for example for the production of high-quality bio-based plastics. Developments in this field will be accelerated via this programme. The Directorate-General for Public Works and Water Management (RWS) is examining whether the biomass released from sources like road verges can be utilised as a high-quality material. RWS is going to step up its coordinating role, and it has found an expert partner for the sale of biomass in forest management agency Staatsbosbeheer. Additionally, a Green Deal for Kitchen and Garden Waste (KGW) was concluded during the Innovation Relay. The deal includes creation of a pilot installation for the production of degradable plastics made from KGW.

Important preconditions for closing cycles are the environmental frameworks that indicate when a material can be (re)used. This applies to organic waste such as biowaste, sewage sludge or digistat from co-fermentation, but also to diffusely polluted soil, dredging sludge and secondary building materials. There will be an examination in 2014 of the possibilities that exist for establishing new cycles through responsible modification of the environmental frameworks.

Certification is important to ensure the sustainable use of biomass, it is important for it to be certified. For liquid biofuels there is already a European legal regime. For solid and gaseous biomass for energy and bio-based products, there are some steps that still need to be taken. Arrangements were made in the Dutch National Energy Agreement to develop national legislation for biomass for energy. The Netherlands is also aiming for sustainability criteria being defined for these streams at European level. Regarding criteria for bio-based products, possibilities are being explored with the chemical sector for setting up a Green Deal. Various applications use the same biomass products (at least in part). Harmonised sustainability criteria for the biomass of different sectors will be rolled out in 2014 to create a level playing field. This will allow the most efficient possible use of these streams.

Most important actions

	What	How	Who	When
24	Optimise and speed up the material chain approach	Support desk for a material chain approach	Central government with chain parties	2014
25	Make new material chains sustainable	Accelerate material chains as chain coordinator	Central government with chain parties	2014-2015
26	Promote high-quality recycling	Draw up a method Modify minimum standards for specific streams	Central government with chain parties and knowledge institutions	Mid-2015
27	Focus environmental standards for organic substances on closing material chains	Evaluate standards	Central government	Q4 2014
28	Make the use of biomass sustainable	Continue developing sustainability criteria	Central government, EU and sectors	2014-2015

6. Developing financial and other market incentives

To close material chains and reduce the burden on the environment, it is important for financial incentives to stimulate circularity. Unless there are good business cases, the opportunities for a circular economy will not be seized by the market. For that reason, the Cabinet will:

- stimulate the use of new business models;
- drive the dissemination of knowledge and the widespread application of innovative solutions;
- adapt landfill tax rules to ensure they tie in with promoting the circular economy.

Stimulating the use of new business models
Various examples show that 'new business models' contribute to the more efficient use of raw materials or the reduction of the burden on the environment. By placing the total cost of ownership with one party in the chain, for example, it may provide an incentive for optimising the chain and bring about a shift away from the supply of products (quantity) to the supply of services (quality). *Het Groene Brein* (The Green Brain), a network of scientists specialising in New Economy strategies, and the Netherlands Organisation for Scientific Research (NWO) are among those conducting research into business models that promote sustainability. The government is involved in a number of pilot projects already in progress in the field of new business models. The Directorate-General for Public Works and Water Management (RWS) is playing a front-runner role in the European REBUS project focusing on experiments with new business models in the EU. The government is also participating in a project for chemical leasing. In chemical leasing arrangements, chemicals remain the property of the supplier, while users pay for the functionality. For this concept the government and a number of businesses are cooperating on five cases to put chemical leasing into practice. This process will be completed in 2015. Based on these different cases and the experience gained, a decision will be taken not later than in 2015 as to how the government can contribute effectively to the use of new business models.

Driving the dissemination of knowledge and widespread use of innovative solutions
A transition to a circular economy depends on modernising-minded companies that devise and market innovative ideas. Precisely for modernising and innovating projects it is often difficult to obtain financing. Many innovative ideas come from small companies, while the large companies hold the position to change the market. Knowledge dissemination and widespread application of innovative solutions do not occur automatically. The Cabinet will examine possibilities for setting up a revolving fund for the circular economy to give a helping hand to companies that are already experimenting with new business models, developing circular products or innovating in a technologically pioneering way. The fund can be fed by institutional investors, regional investment funds and private equity. By mid-2015 the Cabinet wants to have a detailed plan of how this can best be accomplished.

Adapt landfill tax rules to ensure they tie in with promoting the circular economy
The Cabinet will introduce a temporary version of the landfill tax on 1 April 2014. At the same time research will take place into a more definitive form of the landfill tax that will come into effect on 1 January 2015. The objective of this tax is to promote the transition to a circular economy. Together with other stakeholding authorities, the Cabinet will look at how this tax can best be designed. There will also be an examination of the possibilities for fiscal measures other than landfill tax so as to create a dynamic incentive to promote the circular economy. The challenge is to come up with a smart market incentive that brings about a clear change of behaviour and environmental improvement and at the same time is practicable and generates stable tax revenues. The tax must bring in structurally €100 million per year. The Cabinet is also going to adapt the MIA and VAMIL schemes that stimulate environmentally friendly investments to make sure they also stimulate investments in the sustainable use of materials. The Environmental List 2014 reflects these developments. In 2014, all this will be worked out in more detail.

Most important actions

	What	How	Who	When
29	Stimulate new business models	Elaborate chemical leasing Formulate a general approach	Government with companies	2015
30	Promote circular innovation	Set up a revolving fund for the circular economy	Central government	2015
31	Provide a fiscal incentive for the circular economy	Adapt landfill tax to tie in with circular economy Bring the circular economy into the MIA and VAMIL schemes	Central government	2014

7. Connecting knowledge and education to the circular economy

The transition to a circular economy requires system innovation, including technical innovation as well as institutional and cultural changes. This programme seeks to promote the development and sharing of knowledge in the field of the circular economy. For that reason the Cabinet will:

- set up knowledge and education programmes for *Waste to Resource*;
- focus European research programmes on the circular economy;
- make the Netherlands a circular hotspot.

Setting up knowledge and education programmes for *Waste to Resource*

By means of the Top Sectors policy, the government, business community and knowledge institutions are working on knowledge and innovation in a so-called 'golden triangle' approach. The Cabinet wants to make the transition to a circular economy a structural part of the research programmes of the relevant top sectors. Part of the Top Sectors policy is the SME innovation stimulation scheme for top sectors (MIT). Top sectors may put forward themes for which the MIT can be used, such as themes appropriate to the circular economy. Increased attention will be devoted to this matter in 2014.

Research and educational programmes will be started up for *Waste to Resource*, based on the golden triangle approach. The programmes will be a specific add-on to the Top Sector agendas, so harmonisation with the top sectors is a requirement. The educational programmes will focus on the joint development and thus reinforcement of specialised and higher education, with new insights obtained from the circular economy. For the time being the programmes will address metal/electrical, plastics and biomass streams. The programmes will be laid down and started in 2014.

Focusing European research programmes on the circular economy

System innovation that accompanies the transition to a circular economy is likely to lead to entirely new business models and requires changes in behaviour, policy and legislation. European cooperation between industry, knowledge institutions and policymakers is necessary to redesign processes, products and services to enable the economy to meet the needs of society based on the circular model. The Cabinet is supporting this within the European research programme called *Horizon2020* and by participating in *Eco-Innovera*, a programme for transnational cooperation for knowledge and policy development.

The participation of Dutch knowledge institutions and industries in European research programmes is being facilitated to the fullest possible extent. European financing or co-financing increases opportunities and mitigates risks for front-runners, while cooperation is likely to yield new market opportunities. The Cabinet supports innovative companies in their programming for *Horizon2020*.

Making the Netherlands a circular hotspot

The cooperation that exists with front-running enterprises will be stepped up. For this purpose the Cabinet has concluded a green deal with MVO Nederland (knowledge centre for corporate social responsibility), the *Circle Economy* foundation and the *Amsterdam Economic Board* aimed at making the Netherlands a circular hotspot. The green deal supports the transition to a circular economy by aligning with sectoral and regional practical cases. The resulting knowledge and experience will be shared and disseminated among a wide range of stakeholders in order to accelerate and scale up the transition. A joint effort is being made to produce a roadmap that defines areas of attention and themes that facilitate a faster transition to a circular economy in the Netherlands.

Most important actions

What	How	Who	When

32	Inject the circular economy into the Tops Sectors and MIT	Structural part of research programmes	Central government and top sectors	Year-end 2015
33	Produce a research and education agenda for *Waste to Resource*	Prepare research programmes and knowledge transfer	Central government, businesses and knowledge institutions	Year-end 2014
34	Use Horizon2020 for Dutch policy goals	Participation of Dutch knowledge institutions and industries	Central government, businesses and knowledge institutions	2014-2016
35	Make the Netherlands a hotspot for the circular economy	Green Deal	Central government, MVO, Circle Economy and AEB	2014 - 2016

8. Simplifying measurement methods, indicators and certification labels

Criteria, assessment methods, indicators and quality labels provide transparency. They help consumers, companies and policymakers to make informed choices. The Cabinet wants to promote the use of reliable and unambiguous methods and also innovative measurement methods. Therefore, the programme will:

- harmonise and standardise methods and indicators;
- improve information about waste streams.

Harmonising and standardising methods and indicators
There are various methods and indicators for measuring sustainability. The Netherlands is one of the leaders in this field. However, the methods and indicators are not always entirely in keeping with each other. To create more uniformity, the Cabinet is consulting with *Statistics Netherlands (CBS)*, the *Global Reporting Initiative* (GRI) and *The Sustainability Consortium* (TSC). The objective is to achieve greater harmonisation between important international methods for assessing sustainability at national, organisational and product level, respectively, and a possible link with the *Sustainable Development Goals* (SDGs). In addition, consultations are being held with CBS, the National Institute for Public Health and the Environment (RIVM), TNO, the Netherlands Bureau for Economic Policy Analysis (CPB) and the Netherlands Environmental Assessment Agency (PBL) about more mutual cooperation in matters relevant to measuring sustainability. The website www.metenvanduurzaamheid.nl compares the most important assessment methods. RIVM and the Agricultural Economic Institute (WUR – LEI) will update the site in 2014. When it comes to certification labels, there is considerable variety and this can cause confusion. To create clarity for members of the public and businesses, Milieu Centraal (foundation promoting awareness of sustainability and energy consumption) developed the *KeurmerkenWijzer*, a free app for smart devices that gives users more information about the different eco labels on products. It is updated regularly.

The circular economy takes into account the value of natural resources and focuses on their conservation and sustainable use. Transparency about the effect of the economy on natural capital is part of this and it is an important first step. Identifying key factors offers perspectives for companies and sectors to take action. Work is in progress with companies and knowledge institutions on a method and an indicator to make this possible. The initial results will be available in 2014.

The Ministry is also supporting the Dutch *True Price Platform*. True Price is developing an open-source method for internalising external costs, allowing circular decisions to be factored into business economics decisions. This method will make it possible to determine the value of social and ecological costs. Companies can use the method to find out how they can achieve sustainability. The transparency of external costs of different products and companies may also incentivise companies to innovate. True Price is likely to be able to launch their method in 2014.

Improving information about waste streams
Monitoring waste provides insights that can be used to exercise control. There is still sometimes some obscurity about this matter. The ex-post evaluation of the National Waste Management Plan takes into account the availability, quality and use of the data available about waste streams. This evaluation will form part of the audits of sustainability policy that will take place in 2014.

To monitor the effects of this programme it is in any event possible to use the monitoring of waste policy. This is aimed at increasing recycling, and the indicators are geared to this goal. One of the indicators in the National Waste Management Plan, for example, is 83% recycling in 2015. The *Waste to Resource* programme focuses (among other things) on reducing the quantity of materials that exit the chain. This concerns the waste streams that go to landfills and incinerators. The removal indicator is easily measurable and from now on will be included in the National Waste Management Plan because it says something about the quantity of waste being recycled, as well as about the effect of making designs and consumption more sustainable. Based on waste policy the reduction of the removal of materials has a reduction potential of approximately 2.5 million tonnes per year. Ambitions are formulated in consultation with business sectors to lower the quantity of material that is removed from each stream. The potential for sustainable production and sustainable consumption is unknown. This is another field in which the Cabinet will define ambitions together with civil society partners. A gain of 2.5 million tonnes per year is likely to be achievable. In this way the Cabinet expects to fulfil the ambition of halving the total removal in 10 years.

Most important actions

	What	How	Who	When
36	Standardise methods for measuring sustainability	Cooperation for different measurement methods	Central government with parties including CBS GRI and LEI	Implementation in 2014
37	Update the supply of comparative information	Update website Metenvanduurzaamheid.nl and *KeurmerkenWijzer* app	Cooperation with RIVM, LEI and Milieu Centraal	Ongoing
38	Create transparency about the impact of the economy on natural capital	Develop indicator and method	Central government in consultation with business community and NGOs	2014
39	Improve information about waste streams	Make the availability, quality and use of information about waste part of a structural policy evaluation	Central government	2014

Commitments and motions concerning *Waste to Resource*

Commitments:

ID	Reference	Entry date (dd-mm-yyyy)	Description
11506	Parliamentary agenda item[29-05-2013] - Waste and raw materials	30-05-2013 10:05	The House will be informed in the first quarter of 2014 about the progress of recycling by municipalities.
11619	Parliamentary agenda item[14-11-2013] - Raw materials and waste	15-11-2013 10:44	In January 2014, the House will receive an overview of the performance levels of municipalities in collecting domestic waste.*
11620	Parliamentary agenda item[14-11-2013] - Raw materials and waste	15-11-2013 11:29	The State Secretary will inform the House before summer 2014 about the development of a vision of sustainable waste management by municipalities
11621	Parliamentary agenda item[14-11-2013] - Raw materials and waste	15-11-2013 11:32	The State Secretary will inform the House about international waste streams and waste incineration plants
11631	Parliamentary agenda item[26-11-2013] - Raw materials and waste	28-11-2013 13:11	The State Secretary will examine the possibility of getting WeCycle to draw up and submit to the House an annual report on the recycling of electrical equipment. **
11645	Parliamentary agenda item[10-12-2013] – Environmental Council	11-12-2013 10:be	The State Secretary will enter into talks with relevant parties about stopping the handing out of free plastic bags and will inform the House about this matter before 1 April 2014.

*) An overview of the performance of municipalities will be sent to the House before the end of January 2014.

**) In a monitoring report WeCycle already reports to the Ministry of Infrastructure and the Environment about the results of collecting and recycling electrical equipment and low-energy lighting. By so doing WeCycle is fulfilling the statutory duty on behalf of member producers and importers. The monitoring reports of the past 3 years are available on the website http://www.wecycle.nl/mediatheek/monitoringsverslag. Each monitoring report consists of three parts. The first part is the report required by law on:

- the quantity of electrical equipment put on to the market;
- the quantity of collected electrical equipment;
- the quantity of reused material and useful application.

The second part contains a comprehensive validation of the figures published in the first part. The third part addresses the reliability of the figures. KPMG Sustainability has examined the monitoring reports.

Motions:

ID	Reference	Entry date (dd-mm-yyyy)	Party	Description
10555	Parliamentary agenda item[05-06-2013] - Raw materials and waste (requested by Mulder/CDA)	13-06-2013 09:59	VVD	Motion tabled by Remco Dijkstra c.s. 30872-136, asking the government to consult with the sector to ascertain obstacles and to strive in a European context for uniform European implementation, thus enabling the Dutch recycling sector to use a level European playing field, and further asking the government to inform the House on this matter before the end of 2013***
10556	Parliamentary agenda item[05-06-2013] - Raw materials and waste (requested by Mulder/CDA)	13-06-2013 10:02	CU	Motion tabled by Dik-Faber 30872-000 (was 137), asking the government to assess how and for which products it is possible to effectively establish manufacturer responsibility for waste streams such as mattresses, and to inform the House about this matter before 1 April 2014.

ID	Reference	Entry date (dd-mm-yyyy)	Party	Description
10557	Parliamentary agenda item[05-06-2013] - Raw materials and waste (requested by Mulder/CDA)	13-06-2013 10:05	CU	Motion tabled by Dik-Faber c.s. 30872-000 (was 139), asking the government to ensure strict enforcement of the new rules for civic amenity sites/recycling centres and to instruct the Shipping Inspectorate to conduct research into the environmental gains of mandatory post-sorting of residual waste.
10558	Parliamentary agenda item[05-06-2013] - Raw materials and waste (requested by Mulder/CDA)	13-06-2013 10:07	SP	Motion tabled by Van Gerven 30872-140, stating that firm arrangements need to be agreed with industry to bring about a short-term switch to biodegradable plastics for product packaging.
10589	Parliamentary agenda item[05-11-2013] - Green growth (requested by Dik-Faber)	13-11-2013 15:07	SP SP	Motion tabled by Van Gerven/Smaling 33034-24, noting that the Netherlands is a leader in the recycling of domestic waste, and asking the government to uphold this position in its standardisation and pricing behaviour
10612	Parliamentary agenda item[26-11-2013] - Raw materials and waste	04-12-2013 13:11	D66 VVD	Motion tabled by Van Veldhoven/Remco Dijkstra 30872-150, asking the government to endeavour to ensure that all recyclers and processors of electronic products are certificated by 1 January 2015.
10613	Parliamentary agenda item[26-11-2013] - Raw materials and waste	04-12-2013 13:14	SP	Motion tabled by Van Gerven 30872-153, asking the government to identify, in consultation with plastic recyclers, which possibilities for improving the qualitative results of recycling there are, as well as the obstacles that prevent their implementation, and to inform the House before 1 May 2014 of how these possibilities can be utilised more effectively.
10614	Parliamentary agenda item[26-11-2013] - Raw materials and waste	04-12-2013 13:16	VVD	Motion tabled by Dijkstra 30872-154, asking the government to examine, at Dutch and European level, the amendments that are possible to specific standards in order to promote the contribution of secondary raw materials in the circular economy and to use its best endeavours to achieve this, and asking the government to inform the House on this matter before summer 2014.
10615	Parliamentary agenda item[26-11-2013] - Raw materials and waste	04-12-2013 13:18	CU	Motion tabled by Dik-Faber 30872-155, asking the government to agree arrangements at European level on the percentage of recycled materials in electronic appliances.
10616	Parliamentary agenda item[26-11-2013] - Raw materials and waste	04-12-2013 13:20	D66 PvdA	Motion tabled by Leenders/Van Veldhoven 30872-157, asking the government to show the scale of the overcapacity, how long it is likely to continue and the extent to which some of this capacity can be used for incinerating foreign waste, so that in the meantime those countries will invest in recycling capacity; and asking the government to show which incentives can be used to ensure waste is reused to the highest possible standard, and thereby also show the financial effects for shareholders of waste incineration plants.
10620	Parliamentary agenda item[05-11-2013] – Debate on budget of Ministry of Infrastructure and the Environment (week 5/6-11)	04-12-2013 13:33	D66	Motion tabled by Van Veldhoven 33750-XII-00 (was 39), asking the government to make an extra effort in consultation with stakeholders to assign SMART objectives to each green deal and to specify any possible scale-up opportunities.

***) By means of the *Waste to Resource* programme, the Cabinet is implementing this motion. The elaboration of the programme describes the effort the Cabinet is making in consultation with the sector to eliminate obstacles and to arrive at a level European playing field.

Inashco

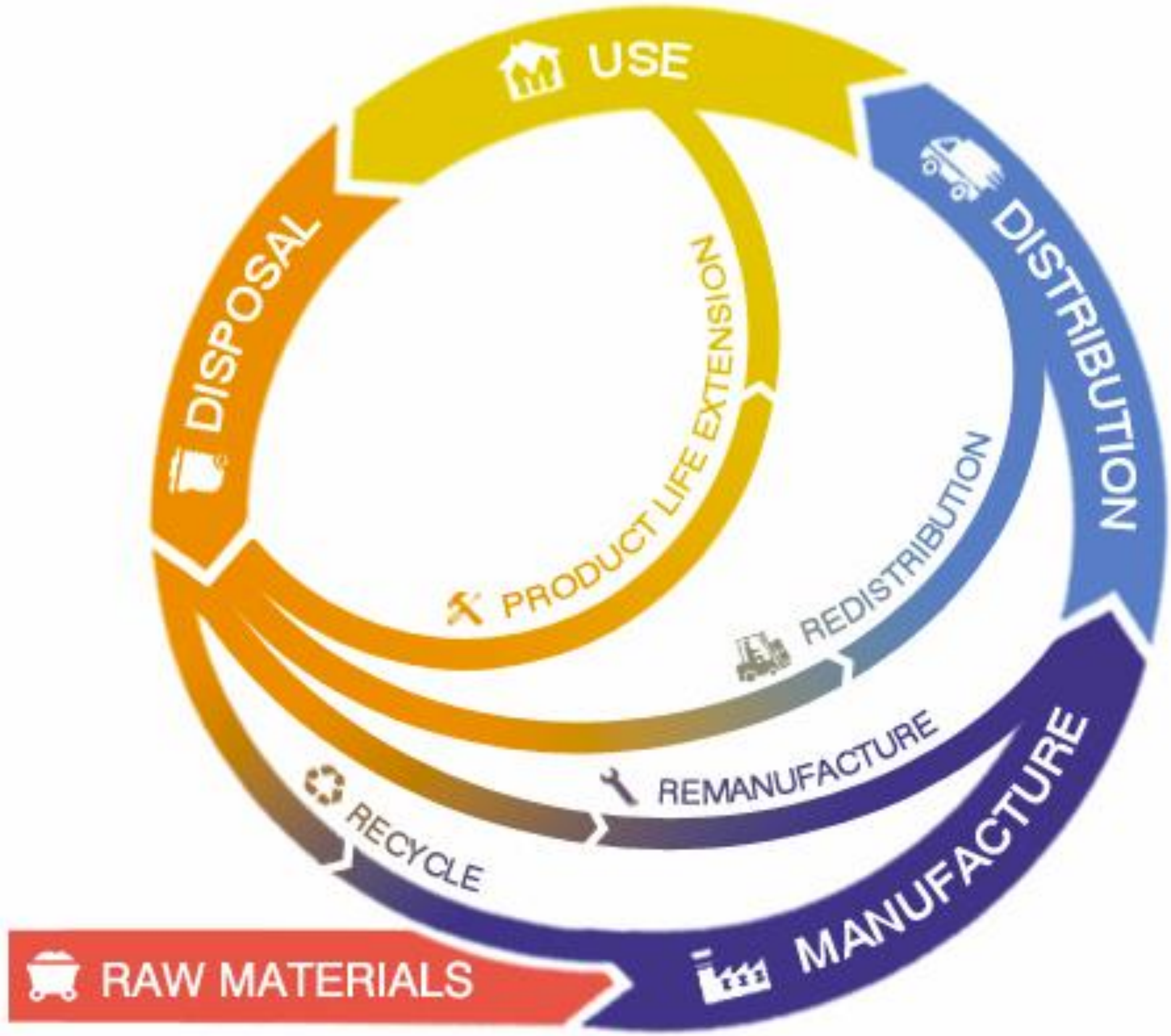
Circular Economy, Urban Mining

September 2016

Circular Economy – General

A circular economy is a living system which creates value based on usage, instead of consumption. Durability of products and resources is key. Basic principles of the circular economy are using pure and non-toxic products, design for disassembly and use only renewable energy.
Ellen MacArthur (2013), Towards the Circular Economy 1

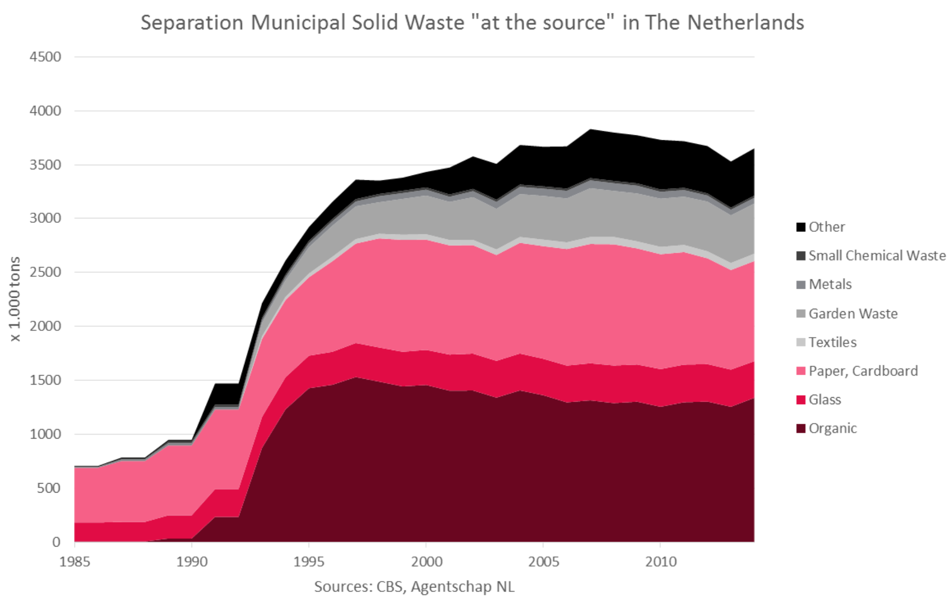
A circular economy is an economic system that takes the reusability of products and materials and the conservation of natural resources as starting point. It also strives for value creation for people, nature and the economy in each part of the system.
Dutch Government (35 750 XIII)

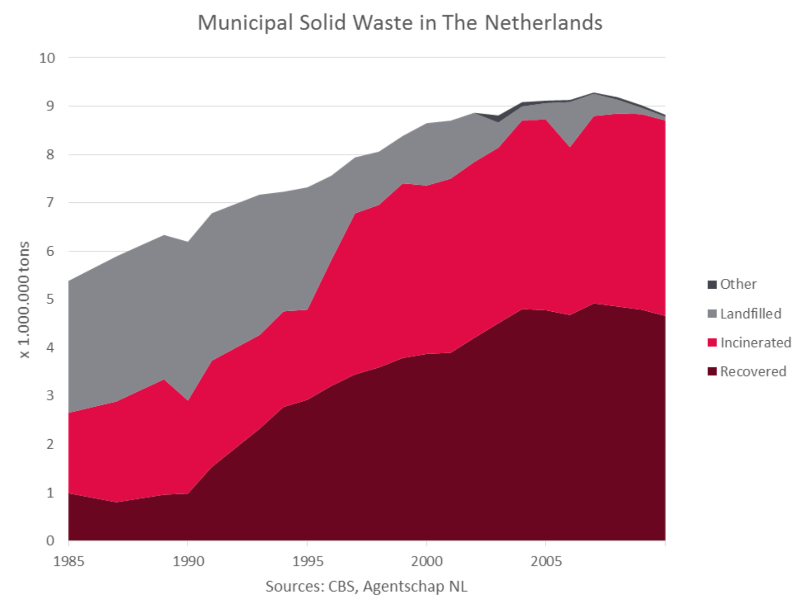


Circular Economy – Waste Management in The Netherlands

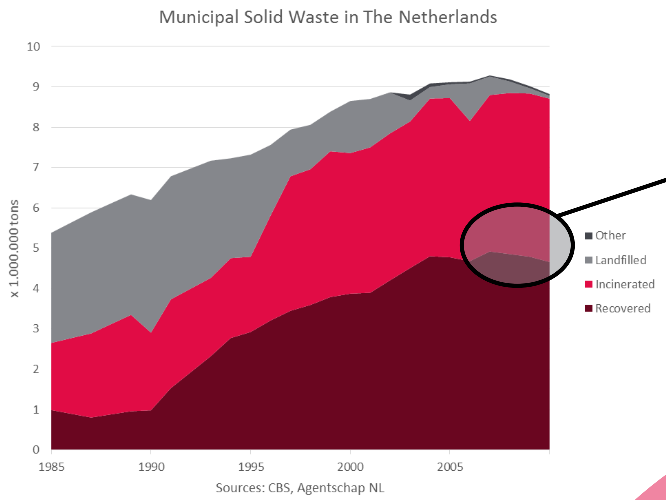
First steps were taken in the early nineties to stimulate recovery and sorting “at the source” and to avoid landfilling municipal solid waste.
As a consequence, today all municipal solid waste is either recovered for reuse, remanufacturing or recycling, or transformed into sustainable energy in the form of electricity, steam to industries and district heating.
The next step in closing circles is to reduce the waste flows to Waste to Energy facilities by sorting “at the source” and by means of Multi Reuse Facilities (MRF’s).

At the same time Waste to Energy Facilities still have circles to close !

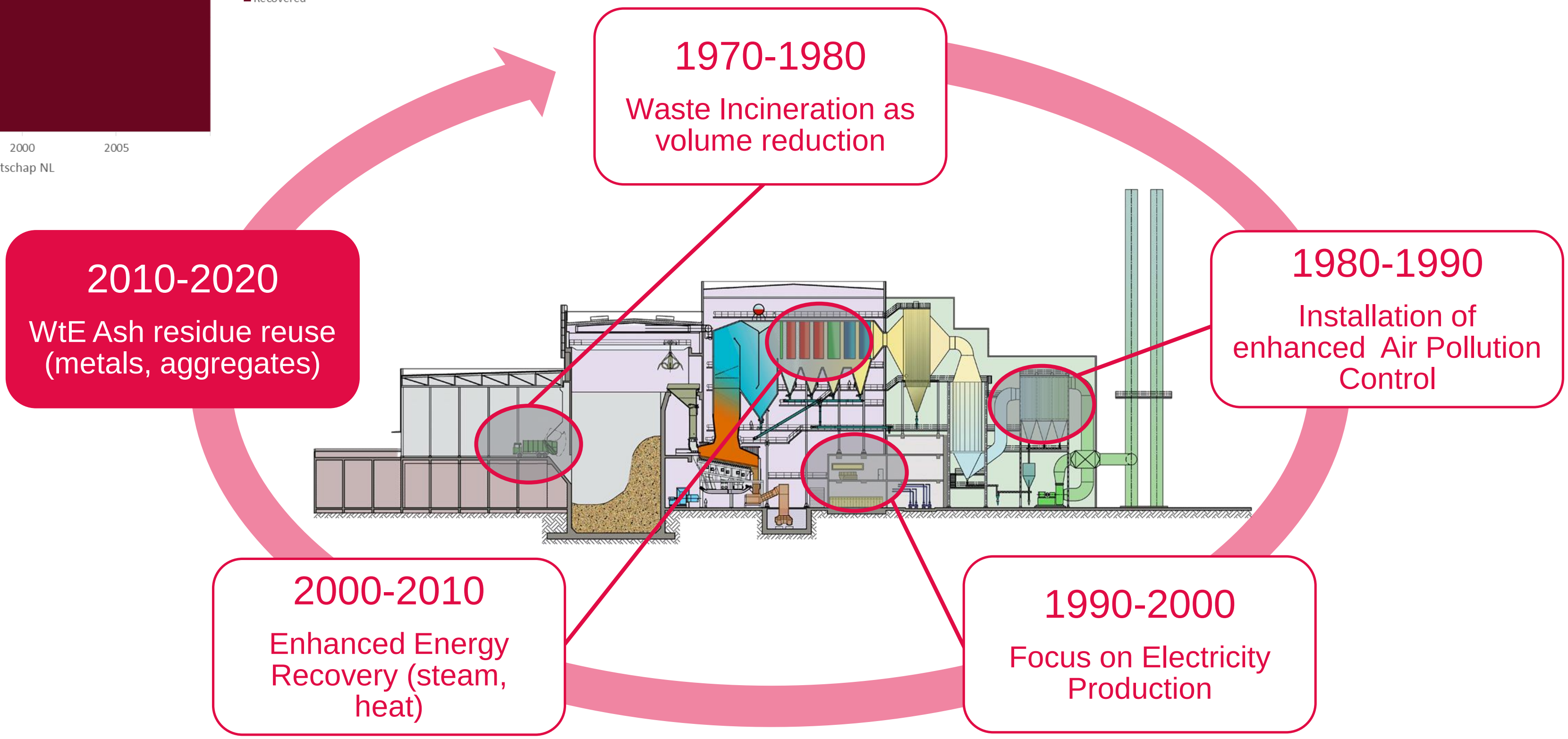




Waste to Energy – Closing the Circle



Every ton of incinerated waste represents 200 kg of Ash residue (20%). Re-use of the metals and minerals in the Ash residue increase the recovery of resources with 10% !



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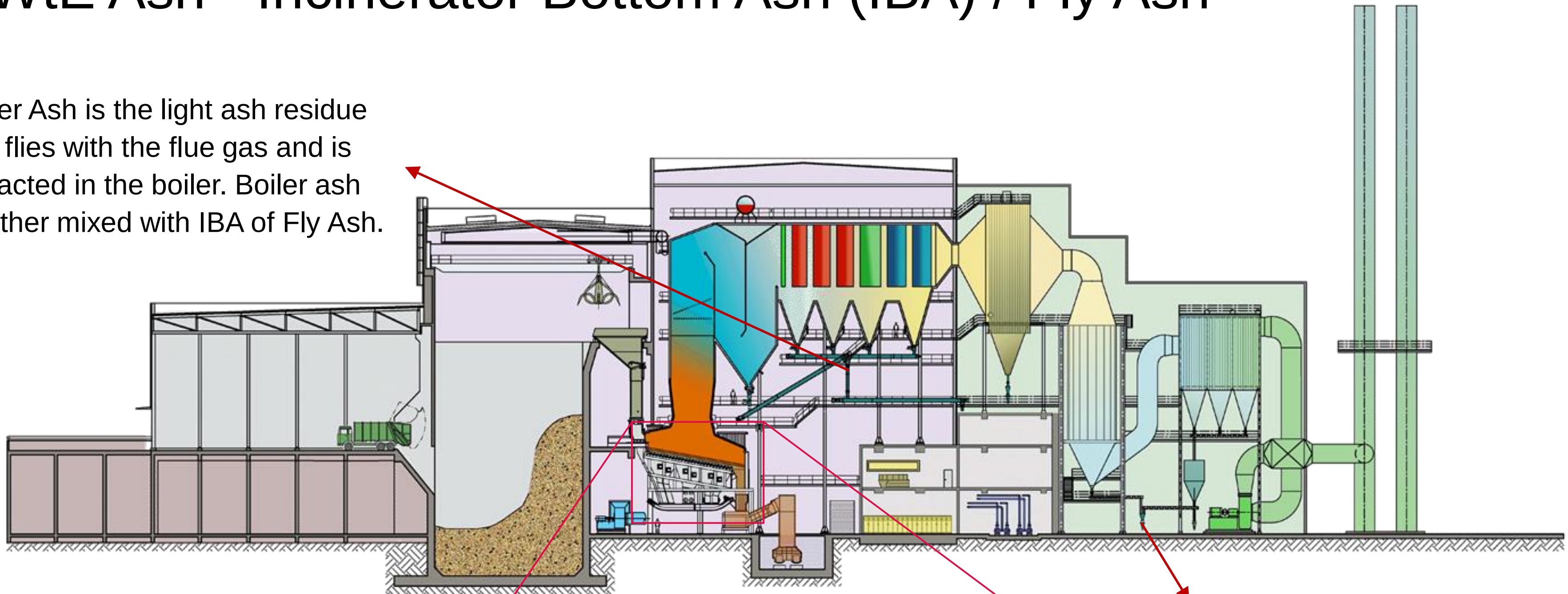
WtE Ash - Incinerator Bottom Ash (IBA) / Fly Ash

Boiler Ash is the light ash residue that flies with the flue gas and is extracted in the boiler. Boiler ash is either mixed with IBA of Fly Ash.

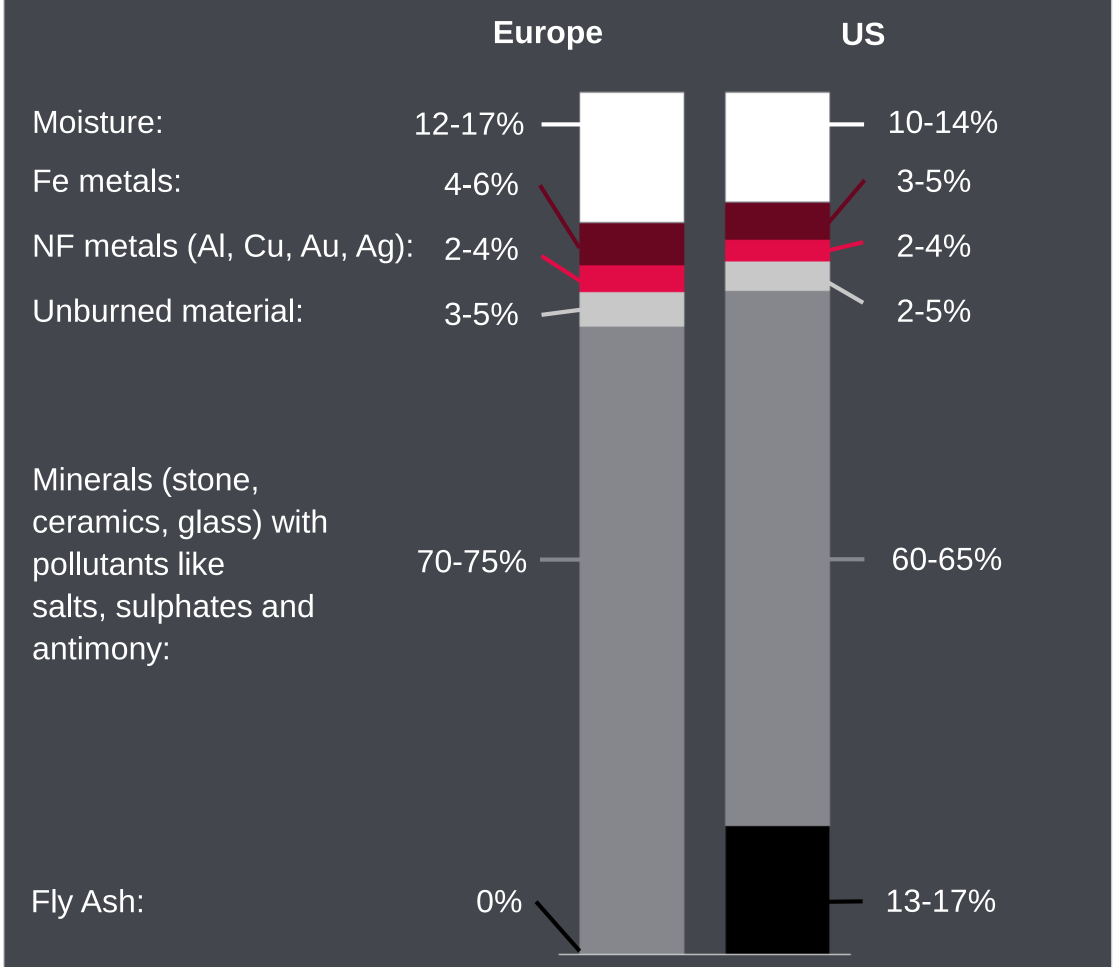


Fly Ash is the residue from flue gas cleaning. In Europe Fly Ash is kept separate from IBA. In North America Fly Ash & IBA are discharged combined.

The waste is burned in the incinerator between 900 and 1000 °C.
The residue, Incinerator Bottom Ash (IBA), is then transported into a wet discharge to be quenched (cooled).

Untreated WtE Ash

Typical composition of WtE Ash:



Inashco portfolio of urban mining technologies

WtE Facility

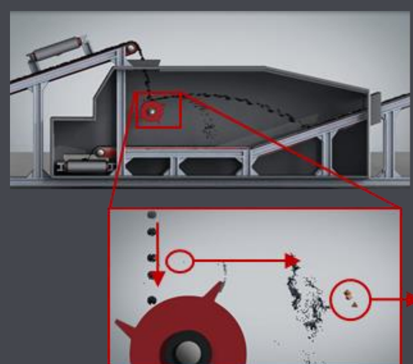
IBA

Upstream - De-centralized processing of IBA

1 Sieves & Magnets

2a Conventional Dry separation

2b ADR – Dry Ballistic separation

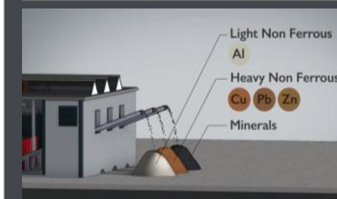


2c Wet separation

3 Eddy Current separators

Downstream - Centralized upgrading

4 NF separation



Trading Metals

Trading & marketing

NF concentrate

NF products

Fe scrap

NF products

Trading Aggregates

IBAA

INASHCO

ADR – Dry Ballistic separation

“Tailor-made” processing strategy for optimal urban mining

WtE Ash residue (IBA) – Application in The Netherlands

Today:
Application in infrastructural projects and road construction.
Set leaching criteria for a.o. Bromide, Chloride, Sulphate and Antimony require extensive measures to isolate, monitor and supervise (IBC) the applied ash residues.

Future:
Application as clean aggregate in cement, concrete products and construction projects.
Set leaching criteria for a.o. Bromide, Chloride, Sulphate and Antimony no longer require IBC measures.

How to get there:
"Green Deal" between Dutch Government and all Dutch WtE facilities arranging:

- 50% non IBC-application in 2017, 100% in 2020
- 75% recovery of Non Ferrous metals > 6mm
- Transition arrangement for IBC application until 2020

Ministerie van Infrastructuur en Milieu

Vereniging Afvalbedrijven

Group Characteristics

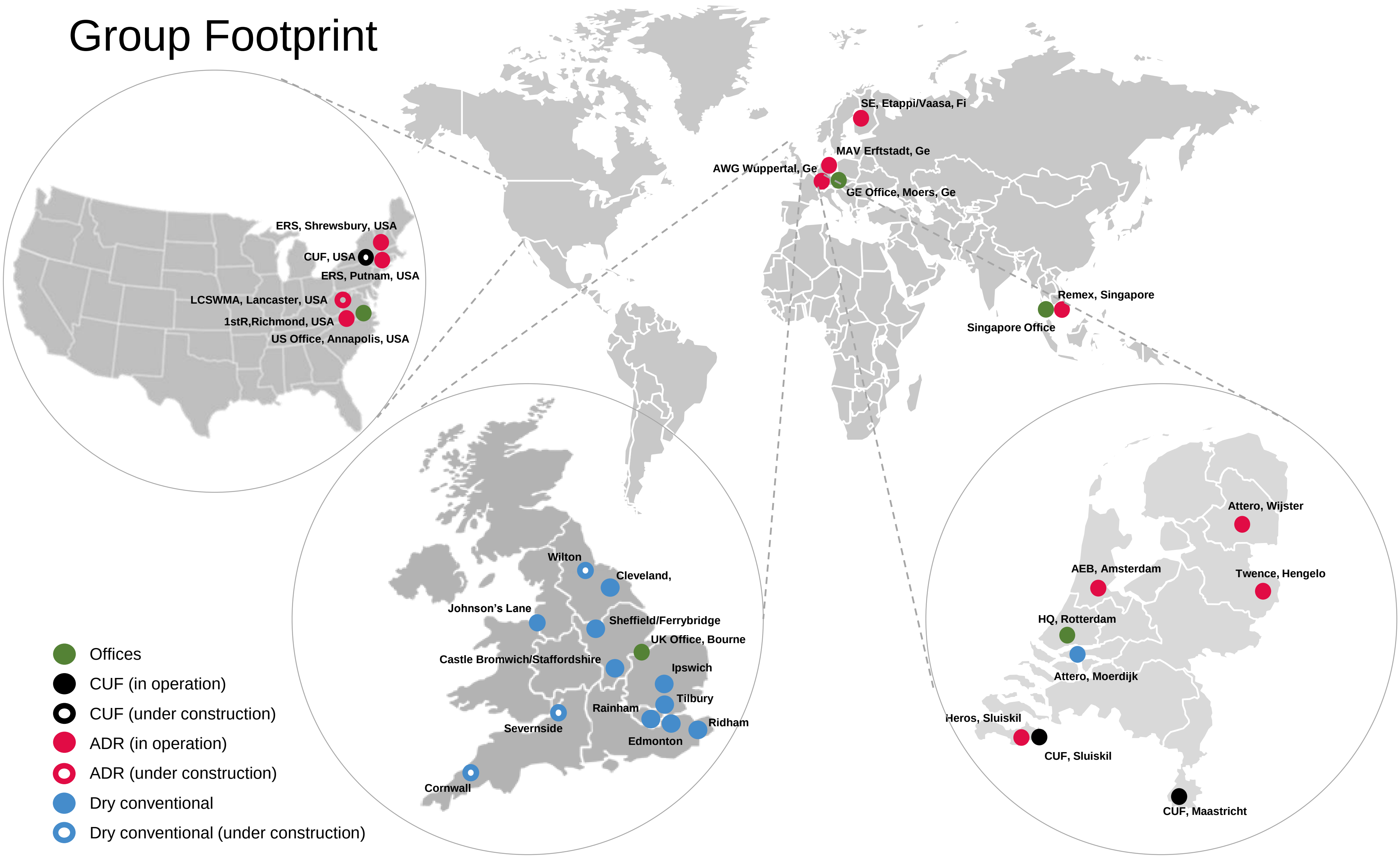
Shareholders:
- Waterland (majority)
- Fondel
- TU Delft
- Management

Key figures:
- Locations:
  - Offices: 5 (head quarters in Rotterdam, NL)
  - Upstream: 21 (and 4 under construction)
  - Downstream: 2 (and 1 under construction)
- IBA processed per year: 5 million tons
- Number of employees: 250
- Annual Revenue: $ 135 million

Group history:
- BPL established in 1998
- Inashco established in 2008
- Inashco and BPL merged in 2015 to become Inashco Group

INASHCO

Group Footprint



INASHCO

Typical facilities

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主旨：有關貴委員會於本（105）年6月30日大院第9屆第1會期經濟委員會第25次全體委員會議書面提案，請本會召集內政部、經濟部及行政院環境保護署等相關部會就國家發展、國土規劃、產業升級及轉型、環境永續等面向切入，研議規劃國家級循環經濟計畫之可行性報告，並送立法院經濟委員會一案，本會綜整書面報告，敬復如附件，謹請鑒察。

說明：依據105年6月30日大院第9屆第1會期經濟委員會第25次全體委員會議書面提案第三案辦理。

正本：立法院經濟委員會、林委員岱樺、陳委員明文、蘇委員治芬、王委員惠美
副本：內政部（含附件）、經濟部（含附件）、行政院環境保護署（含附件）、本會秘書室 電子公文交換章 2016-08-31 12:08:24

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立法院第9屆第1會期經濟委員會
第25次全體委員會議

國家級循環經濟計畫之可行性
報告

報告單位：
國家發展委員會(彙整)
內政部
經濟部
行政院環境保護署

105年8月30日

大院本(105)年 6 月 30 日第 9 屆第 1 會期經濟委員會第 25 次全體委員會議，貴委員會林岱樺委員、陳明文委員、蘇治芬委員、王惠美等 4 位委員，提出臨時提案：請國發會於 2 個月（105 年 8 月 30 日前）召集內政部、經濟部及行政院環保署等相關部會就國家發展、國土規劃、產業升級及轉型、環境永續等面向切入，研議規劃國家級循環經濟計畫之可行性報告。謹研提報告如下：

壹、循環經濟與國家發展

一、循環經濟的重要性

全球經濟發展長期建立在消耗大量的資源上，由於資源的稀缺性和環境容量限制，人類經濟發展壓力日增，長期以來大量開採、大量生產、大量消費、大量廢棄(Take, Make, Use, Dispose)之線性發展方式，已造成環境沈重的負擔。循環經濟(circular economy)嘗試打破以往發展的窠臼，經由使用再生能源、將廢棄物轉化為原料、再創造新產品、拒用妨礙再利用之有毒物質等等方式，增加資源使用效率，同時達成經濟和環境衡平之永續發展，因此各國紛紛將發展循環經濟當做經濟轉型的重要戰略方向。

二、國際推動循環經濟作為

(一)歐盟未來可實現幾乎零浪費的經濟

歐盟執委會於 2012 年發表「歐洲資源高效化宣言

（Manifesto for a Resource-Efficient Europe）」，鼓勵在高效科技、系統上進行創新及加速投資，開始歐盟轉型為循環經濟之系列變革。歐盟執委會認為，透過循環經濟，歐盟未來可以實現幾乎零浪費的經濟模式，並創造多贏的局面，包括為歐盟企業省下 6,000 億歐元、創造 58 萬個就業機會，且每年減少 450 萬噸的碳排放量。

2015 年底歐盟公布最新「循環經濟方案(Circular Economy Package)」，運用所有可利用政策工具，致力於經濟轉型，期望能增加歐盟競爭力、促進經濟永續成長並創造就業。在此一方案中，並訂定了歐盟產品從生產到廢棄物處理，和再生材料管理的執行目標和確切時間表，例如預期 2030 年可回收 65％的城市垃圾及 75％包裝廢棄物。

(二)荷蘭以熱點計畫行銷循環經濟理念

荷蘭政府體認到循環經濟之重要性，亦積極推動循環經濟發展，先於 2013 年發表「荷蘭循環經濟的契機」（Opportunities for a circular economy in the Netherlands）報告，接著於 2014 年公布「循環經濟加速實現方案」（Realisation of Acceleration of a Circular Economy Programme），並於 2016 年推出「荷蘭循環熱點(Netherlands Circular Hotspot)」計畫，通過博覽會等方式，向全世界展示其循環經濟發展。

荷蘭將首都阿姆斯特丹北區 Buiksloterham 規劃為循環區域實驗場域，內有許多創新和永續的企業積極推廣循環經

濟概念，每年可創造 700 個就業機會，經濟效益 8,500 萬歐元。因為循環經濟領域的傑出表現，阿姆斯特丹 2016 年打敗了來自 20 個國家、145 個參與角逐的城市，獲選為歐洲創新首都(European Capital of Innovation，iCapital)。

(三)日本致力建設為循環型社會

日本從資源減量(Reduce)、再利用(Reuse) 和回收(Recycle)之 3R 基礎模式上推動循環經濟，將 2000 年訂為「資源循環型社會元年」，並陸續通過「循環型社會形成推進基本法」、「循環型社會形成推進基本計畫」等系列法規及計畫，積極發展循環經濟，將日本打造為循環型社會。

日本在建構循環生態城市方面亦有相當進展，重工業城市川崎在近百年工業化發展後，環境汙染問題嚴重，日本政府於 1997 年通過「川崎市生態城市計畫」，運用循環經濟模式，將工廠排出物及副產物作為另一工廠的原料，促成該地區資源和能源高度有效循環利用；此外並充分利用臨海地區中鋼鐵、化學、石油化工、水泥等各種產業集中的優勢，通過生態城地區內各設施之間和大公司及中小企業之間的合作，促成該地區資源和能源高度有效循環利用。

三、我國循環經濟發展政策方向

臺灣地狹人稠、資源貧瘠，隨著環保意識提升，國人對生活及環境品質要持續提升，循環經濟也日益受到重視。在環境永續方面，我國推動廢棄物管理已逐步納入循環經濟精

神，從 1980 年代「管末處理」發展到 2000 年代「源頭減量」與「資源循環再利用」，為求與國際接軌，參考歐盟、荷蘭及日本等國經驗，於 2013 年推動我國「資源永續循環利用推動計畫」，目標即在於使資源使用效率最大化及環境衝擊最小化。

在產業發展方面，經過多年來的努力，循環經濟觀念亦已逐步深化，如中鋼公司及台塑雲林六輕均已應用循環經濟理念，將區域內能資源加以整合運用，後續並將擴大試點。未來發展應以循環經濟角度，重新檢討、設計新的生產模式，同時投入資源強化創新技術、創新產品及創新服務，讓產品原物料能在企業內部、產業供應鍊或跨產業體系中循環，同時達成產業升級暨轉型；在商業模式部分，可結合物聯網、大數據、雲端等科技應用，引導業者投入以共享及以租代售等共享經濟模式，發展新創事業。

目前政府積極推動五大創新產業，並將研發綠色創新化學材料，提供做為其使用之關鍵材料，後續推動過程中將導入循環經濟概念，符合產業永續發展、能資源再生利用之目標，達到兼顧環境保護及經濟發展的雙贏目標。

至於國土規劃方面，內政部刻正辦理「全國區域計畫」之修正作業，增列區域性部門計畫等內容。依「全國區域計畫」修正案（草案）內容，其中有關區域性產業發展計畫及區域性環境保護計畫，內容已含括綠色能源產業、資源循環

零廢棄等空間發展策略及構想。

貳、循環經濟與環境永續

一、我國廢棄物管理政策及推動

過去五十年來，我國從農業社會轉變為工商業社會，仍依循大量生產、大量消費、大量廢棄的經濟模式，歷經許多工程手段解決環境問題，再經深層反省導入許多節省能資源及環境友善的措施，已逐步將循環經濟的相關方法、技術、制度、國際標準和管理系統引進國內推動。為加速促進我國產業朝循環經濟發展，開創經濟需檢討過去以廢棄物管理的末端管控策略，改以更全面的資源永續管理的角度，加強相關科技的發展與應用，投入資源/補助研發，或引進國外先進技術與設備，以強化有助於循環經濟的創新技術、產品或服務商業化，並積極運用創新技術，發展創新的商業模式。

我國廢棄物管理從 1980 年代的「管末處理」發展到 2000 年代的「源頭減量」與「資源循環再利用」，現今 2010 年代更與國際接軌，參考日本、荷蘭、歐盟及經濟合作與發展組織(OECD)等國家永續物料管理的理念及措施，於 2013 年至 2017 年推動我國「資源永續循環利用推動計畫」，其中「永續物料管理(Sustainable Materials Management, SMM)」係以物料鏈、價值鏈、物質足跡及廢棄物產生的驅動方式進行分析，俾使資源使用效率最大化及環境衝擊最小化。

二、國際趨勢

工業革命以來，全球發展以「線性經濟」(linear economy)，即原物料的挖掘、製造、使用、丟棄(Take, Make, Use, Dispose)的生產與消費模式為主，消耗大量的資源，同時也導致地球所含的自然資源越顯匱乏，環境惡化日益嚴重。為使自然資源的使用與消費最佳化、創造最大的價值，國際間大力提倡循環經濟，期藉由重新設計材料、產品及商業模式，以消除廢棄物並使資源能夠更有效率地被循環再利用，降低產品生產、使用、棄置造成環境衝擊。

三、未來推動方向

推動廢棄物轉換為再生資源，包括回收有機廢棄物產製再生能源（有機污泥、木材）、應用物料回收技術，創造廢棄物再使用價值（廚餘、廢溶劑）、自廢棄物料中回收貴重金屬，循環使用，以及將廢棄之不適燃物質運用於水泥添加料、海事工程等，促進資源循環。

參、循環經濟與產業升級及轉型

一、 五大創新研發產業導入循環經濟概念

全球經濟發展長期建立在消耗大量的資源上，致地球所含的有限資源越顯匱乏及環境惡化日益嚴重，爰國際趨勢提倡綠色創新與循環經濟之概念，以消除廢棄物並使資源能夠更有效率地被利用，創造價值與降低環境衝擊。

目前政府推動五大創新研發產業，並將研發綠色創新化學材料，提供做為其使用之關鍵材料，透過以創新、就業、分配為核心的經濟發展新模式，去帶動產業競爭力，而在推動過程中將導入循環經濟之概念，符合產業永續發展、能資源再生利用之目標，達到兼顧環境保護及經濟發展的雙贏目標。

二、國內推動現況

(一)背景說明

1.循環經濟：我國能源資源自給率低、水資源匱乏、環境承載有限，發展循環經濟的基礎著重在廢棄物減量以及資源回收再利用，並應加強產品生態化設計與清潔生產相關科技的發展與應用。

2.綠色創新化學材料：

(1)聚焦於綠色創新化學材料的發展，推動綠色創新化學材料產品試量產研發，將著重於材料高值化與環保低碳化，提供可供五大創新研發產業所需之關鍵原料。

(2)高值化材料開發同時也導入環保安全製程、智慧製造、三零之概念。環保低碳化材料則追求產品的低污染、低毒性、低排碳及 6R 原則(Reuse/Recycle/Reduce/Recovery/Repair/Redesign)。

(二)願景

1.循環經濟：將循環經濟理念深植於產業發展中，從產品設計與生產導入綠色創新科技,並提高資源生產力，活絡綠色經濟。

2.綠色創新化學材料

(1)推動化學材料產業高值低碳轉型，邁向零廢棄、零排放、零工傷三「零」境界；接軌五大創新研發產業，提供關鍵綠色創新化學材料。

(2)高值新材料發展推動：推動綠色製程，導入智慧化生產概念，朝向環保、 安全、高附加價值產品開發。

(3)環保低碳新材料發展推動：加速低汙染、低毒性、低碳循環產品技術深耕與應用，開發環境友善新材料。

(三)推動情形

1.循環經濟:目前國內已有針對循環經濟理念加以施行，包括中鋼及雲林六輕，均有將區域內能資源加以整合運用，未來工業局將推動全國循環專區試點計畫，以工業區為範圍，選定適當區域與能資源循環項目，先行推動示範鏈結。

2.綠色創新化學材料：以研發五步驟為基礎(設立研發中心、關鍵材料研發聯盟、試量產研發、產品應用研發聯盟、完成設廠量產)，從研發到量產提供完整輔導，

其中由於試量產研發所需時程長，且需投入大量研發資金，藉由協助業者完成，將可引導業者加速完成量產，完成產業轉型升級及永續發展。

三、成功案例

(一)循環經濟：中鋼公司為達到資源有效利用之目的，98 年起於南高雄地區推動廢酸與礦泥資源化鏈結、廢油資源化鏈結、煤灰、爐渣、集塵灰資源化鏈結及蒸汽等 5 項鏈結(詳圖 1)，另台塑集團於雲林離島工業區亦針對相關能資源加以整合鏈結，包括水、電、熱源、CO2、廢棄物等均於區域內予以整合運用(詳圖 2~3)，並達到符合環保及增加產業競爭力之成效。

(二)綠色創新化學材料：經濟部工業局現已規劃 21 項試量產研發計畫，針對綠色創新化學材料進行研發，目前已有 9 案試量產計畫通過審查及進行，相關範例如圖 4。

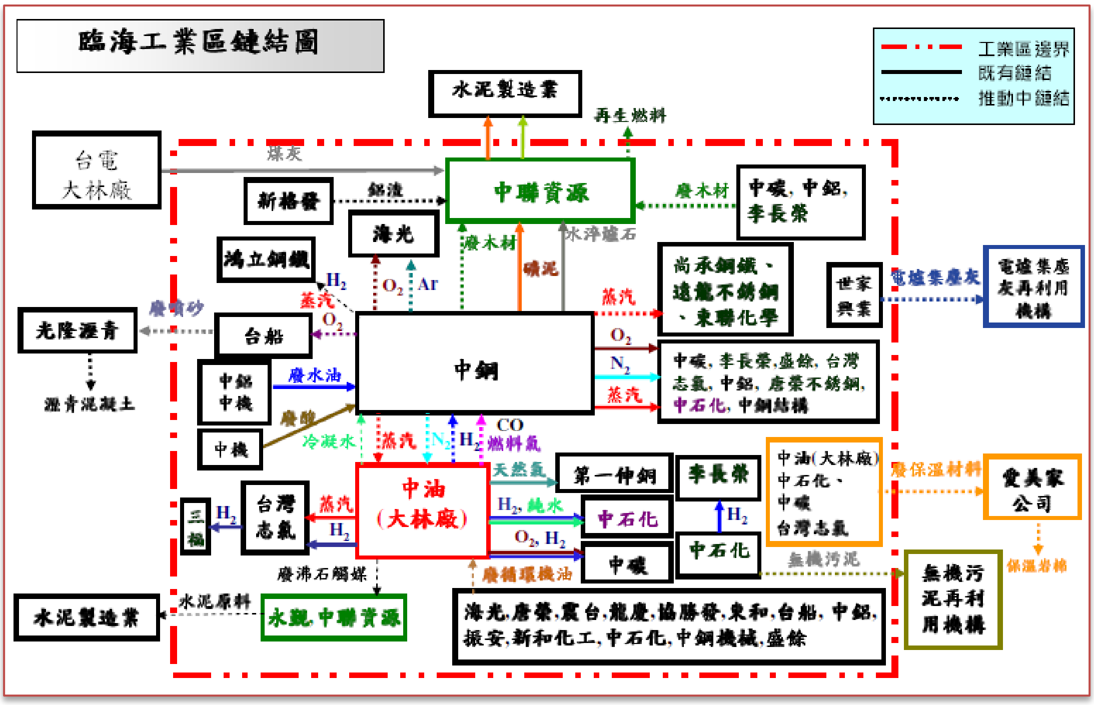

圖 1　中鋼公司於臨海工業區能資源整合示意圖

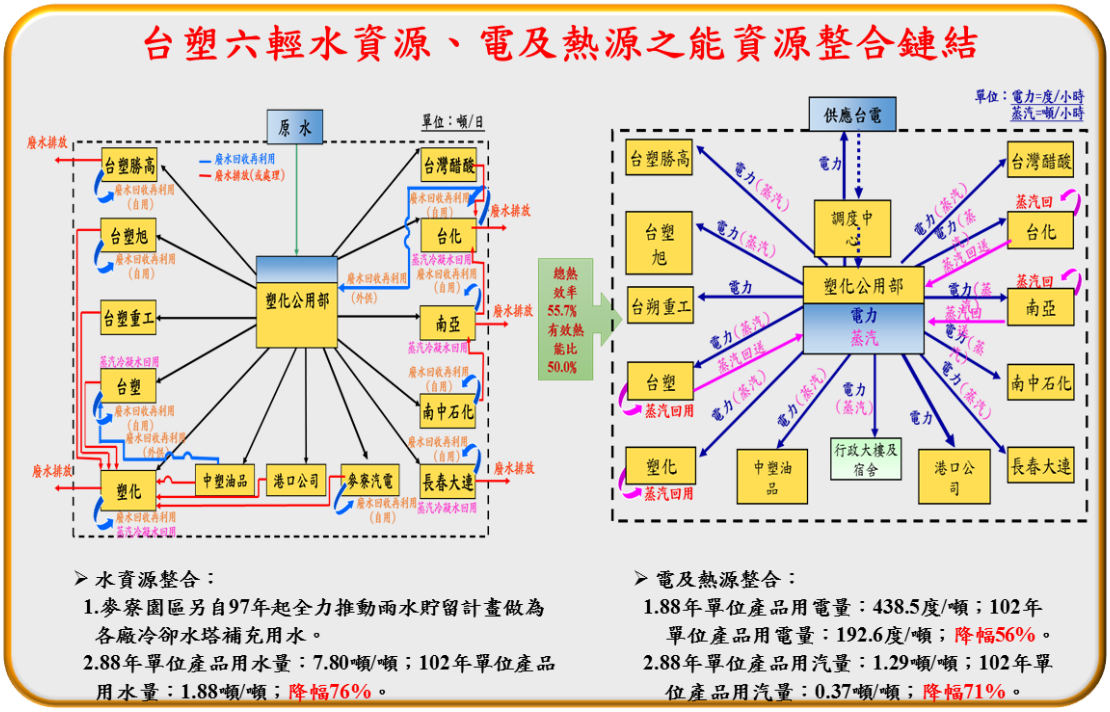

圖 2　台塑集團於雲林離島工業區能資源整合示意圖(水資源、電、熱源)

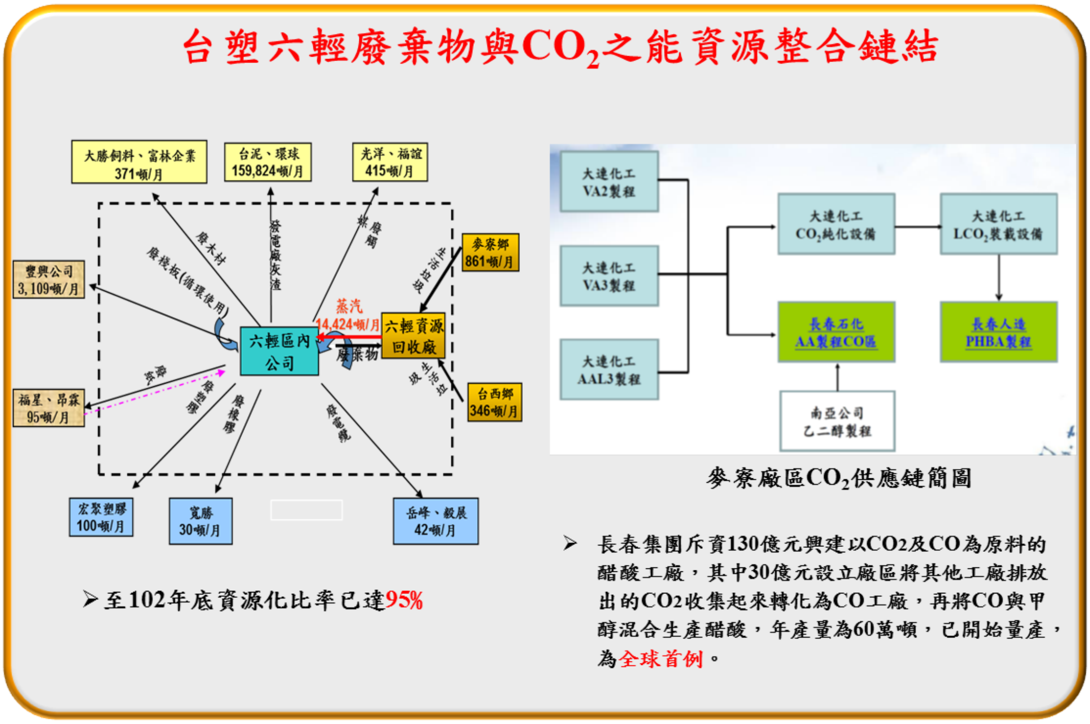

圖 3 台塑集團於雲林離島工業區能資源整合示意圖(廢棄物與 CO_2)

註: 環狀嵌段共聚物(中文俗名)：CBC (英文縮寫)，Cyclic block copolymer (英文全名)，
苯乙烯-丁二烯共聚物(中文全名)：SBC (英文縮寫)，Styrene-Butadiene copolymer (英文全名)。

圖 4 台聚公司綠色創新化學材料研發案例

四、未來推動方向與具體作法

(一)連結在地

1.循環經濟

(1)推動能資源整合鏈結，促進多元永續利用，如推動汽電共生廠餘裕能源鏈結、設置能資源循環供應中心、發展廢熱回收技術、建構事業廢棄物生質能源中心，及整合區域內放流水循環再利用等。

(2)發展物質循環核心技術與創新產業應用，盤點與分析稀貴資源之儲備潛勢與策略，透過產學合作加速物質合成與資源精煉技術的發展與應用。

2.綠色創新化學材料

(1)打造綠色創新化學材料科技聚落

A.整合中央與地方資源，建構綠色創新化學材料產業鏈。

B.結合都市發展規劃，提供產業發展腹地與示範場域。

C.加速轉化石化大宗、過剩、副產物等原料，並結合上中下游之業者進行產品策略與應用聯盟，拓銷全球市場布局。

(2)整合產學研能量

A.協助業者轉型朝向環保、安全、高附加價值發展。

B.加強產政學研合作，推動技術整合與培訓專業人

才。

(二)連結未來

1.循環經濟

(1)推動產品生態化設計： 協助企業於產品設計階段導入生命週期思維，推動產品生態化設計，使產品於廢棄階段有利於再使用、拆解、分類再生，以增加資源循環再使用，及協助企業發展具循環經濟理念的商業與營運模式。

(2)推動綠色工廠技術發展應用與環境資訊揭露：鼓勵與促進節能、減碳、節水、環保、綠能等相關綠色技術的發展與應用，健全綠色工廠標章制度運作機制與清潔生產評估系統內涵，引導企業落實綠色工廠理念，並透過環境資訊揭露等管理制度，以降低生產與營運過程所帶來的環境衝擊，落實企業社會責任，營造永續產業。

2.綠色創新化學材料

(1)以科專核心技術與研發五步驟提供完整輔導 (包括研發中心設立、關鍵材料研發聯盟、試量產研發、產品應用研發聯盟、設廠量產投資障礙排除)，應用端鎖定五大創新研發產業所需關鍵材料。

(2)協助業者投入百~千噸級高值新材料試量產研發，並以環保安全製程與智慧化生產為推動重點，導入產

品 6R 原則，提升產品綠色價值與延長產品生命週期。

(3)依據應用市場需求,賦予環保低碳新材料(低碳/生分解/生質材料)所需功能，朝向加值應用提升與差異化價值發展，形成完整產業鏈。

肆、循環經濟與國土規劃

一、「全國區域計畫」納入循環經濟構想

(一)依據區域計畫法規定，內政部於 102 年 10 月 17 日公告實施「全國區域計畫」,並按行政院 102 年 9 月 9 日函示意見，內政部再另案辦理該計畫之修正作業，增列區域性部門計畫、建立基本容積制度、農地及修正環境敏感地區等內容。

(二)依「全國區域計畫」修正案（草案),區域性部門計畫包括區域性產業發展計畫、區域性運輸系統計畫、區域性公共設施計畫、區域性觀光遊憩設施計畫、區域性環境保護計畫等。其中區域性產業發展計畫及區域性環境保護計畫，係由經濟部及環保署配合研提計畫內容予內政部彙整，該內容含括有綠色能源產業、資源循環零廢棄等空間發展策略及構想。

(三)「全國區域計畫」修正案業經內政部區域計畫委員會審議同意，後續俟完成政策環評，報請行政院備案後公告

實施。

二、國際趨勢與成功案例

(一)基於對於國家土地使用政策簡要及明確化要求下，英國於 2004 年後，原規劃政策綱領 Planning Policy Guidance Notes (PPGs) ，改以規劃政策說明書 Planning Policy Statements (PPSs)取代，嗣於 2012 年再調整為國家規劃政策架構(National Planning Policy Framework)。並配合將國土計畫層級調整為二層級，最上層級即為國家規劃政策架構 NPPF（National Planning Policy Framework）及地方發展架構 LDF（Local Development Framework）。

(二)參考英國過去作法，國家規劃政策的內容皆敘述在 PPS（Planning Policy Statement），例如：PPS1 永續發展、PPG2 開發限制與綠帶、PPS3 住宅、PPS4 經濟永續發展計畫、PPS10 永續廢棄物管理計畫、PPS12 地方空間計畫及 PPS22 再生能源等內容，已含括有循環經濟或資源永續利用之概念，並提出區位考量及空間策略等內容；又地方政府再依照 PPS12 地方空間計畫及其他 PPS 規定之計畫目標訂定符合當地的地方發展架構。

三、未來推動方向與具體做法

(一)為因應氣候變遷，確保國土安全，保育自然環境與人文資產，促進資源與產業合理配置，強化國土整合管理機制，並復育環境敏感與國土破壞地區，追求國家永續發

展，內政部推動制定國土計畫法。

(二)國土計畫法業經大院 104 年 12 月 18 日三讀通過，並經總統 105 年 1 月 6 日公布，行政院定自 105 年 5 月 1 日起施行。有關循環經濟內容，涉及國土規劃作法如下：

1.依國土計畫法規定，全國國土將依據自然環境條件、糧食自給率目標及城鄉發展願景等，劃設為「國土保育地區」、「海洋資源地區」、「農業發展地區」及「城鄉發展地區」及其分類，以計畫引導土地使用。是以，未來循環經濟相關設施（如資源回收再利用設施、循環園區），其土地使用應符合國土計畫法第 21 條國土功能分區及其分類之使用原則，不得因土地利用需求任意變更國土功能分區。

2.依國土計畫法及其施行細則規定，內政部應擬訂全國國土計畫，該計畫應載明產業、重要公共設施等部門空間發展策略（部門空間發展政策、現況、課題及對策、空間發展定位、分布區位、用地供需規模總量及直轄市、縣（市）分派數量等），故後續相關部門機關（如經濟部、環保署），可就循環經濟涉及空間規劃、土地使用部分，配合研提相關內容，以供內政部納入規劃參考，並據以指導土地利用。

3.依國土計畫法第 8 條：「・・・各目的事業主管機關擬訂之部門計畫，應遵循國土計畫。」及第 17 條：「各

目的事業主管機關興辦性質重要且在一定規模以上部門計畫時，除應遵循國土計畫之指導外，並應於先期規劃階段，徵詢同級主管機關之意見。中央目的事業主管機關興辦部門計畫與各級國土計畫所定部門空間發展策略或計畫產生競合時，應報由中央主管機關協調；協調不成時，得報請行政院決定之。‧‧‧‧。」是以，未來部門計畫均應遵循國土計畫之指導，且各目的事業主管機關興辦性質重要且在一定規模以上部門計畫時應於先期規劃階段，徵得同級國土主管機關意見。

伍、結語－台灣邁向循環經濟發展

台灣經濟發展刻正面臨商品出口及投資動能需加強，以及產業升級、節能環保及 PM2.5 等課題，朝向循環經濟發展應是可行作法，因此蔡總統於 520 就職演說時揭示未來循環經濟之政策方向:「我們也不能再像過去，無止盡地揮霍自然資源及國民健康。所以，對各種汙染的控制，我們會嚴格把關，更要讓台灣走向循環經濟的時代，把廢棄物轉換為再生資源。…因為，我們只有一個地球，我們也只有一個台灣」。綜上，就本報告未來相關政策之推動方向，期盼大院能夠持續支持，以利於經濟順利轉型及未來永續發展。