出國報告（出國類別：研究）

赴日本亞太能源研究中心研究

服務機關：台灣電力公司綜合研究所

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派赴國家：日本

出國期間：97 年 5 月 13 日至 100 年 5 月 12 日

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分類號/目

關鍵詞：亞太經合會 APEC (Asia Pacific Economic Cooperation)、APEC 亞太能源研究中心 APERC (Asia Pacific Energy Research)、

內容摘要：（二百至三百字）

本報告以在日本 APERC 期間參與主要能源研究相關計畫為基礎，並以電力產業有關部份為此報告之主要內容:

1. 亞太地區能源供需之展望(APEC Demand and Supply Outlook 4th Edition):就亞太經合會 21 個經濟體分別就其經濟、能源資源、能源政策、終端能源需求(工業、交通與其他)與一次能源供應、電力與二氧化碳排放之展望，並應用其電力模型就台電長期電力負載下，進行電源開發規劃與二氧化碳排放量之模擬分析。
2. 瞭解中國能源政策-各區域之能源效率 (Understanding Energy in China-Geographies of Energy Efficiency): 中國能源政策中相當重要的變化在地區層面表現為：中央把降低能源強度的總體指標在地區層面進行分解、落實；地區把降低能源強度的指標與地區整體經濟社會發展結合起來，並按照中央政策要求執行政策或者使國家條令附有法律效應。到目前為止，事實證明中國所有地區採取了相應的措施來實現它們各自的節能目標，許多地區的節能成績也在幫助推動“十一五”期間 20%這個整體目標的最終實現
3. 介紹日本以太陽能為主再生能源之發展與智慧電網計畫之規劃時程；韓國發展智慧區域、智慧再生能源、智慧交通，並结合智慧電力市場與電網之規劃與目標。

本文電子檔已傳至出國報告資訊網（http://open.nat.gov.tw/reportwork）

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第一章　出國的目的與過程

一、出國的目的

赴日本亞太能源研究中心 APERC (Asia Pacific Energy Research Centre) 從事能源相關議題之研究。

二、出國的過程

行程由台北至東京亞太能源研究中心，研究期間除在 APERC 進行能源研究計畫外,另由 APERC 派至智利(37 屆)與汶萊(40 屆) 參加 EWG (Energy Working Group)會議。香港參加 EGEEC (Expert Group on Energy Efficiency and Conservation)會議、新加坡參加 Expert Group on Energy Data and Analysis (EGEDA)會議、紐西蘭與台灣參加 PREE (PEER Review on Energy Efficiency)專家小組審閱兩經濟體之能源效率政策與執行方案，日本仙台參加 Expert Group on New and Renewable Energy Technologies (EGNRET)會議、中國上海、杭州與北京計畫訪問、韓國參加 APERC 與韓國瓦斯公司(Korea Gas Company)之年會及在東京參加能源相關之國際會議。

第二章 APEC 能源負載與供給之展望(APEC Energy Demand and Supply Outlook 4th Edition)

一、電力部門

1. 歷史趨勢

亞太經合會所有 21 個經濟體之電力負載成長快速，在 1990 至 2005 年間，年平均成長率為 3.4%，用電量從 1990 年 5716.9Twh 至 2005 年 9385.2Twh。成長最快為越南(14.3%)，其次為中國(9.9%)、馬來西亞(9.8%)及印尼(9.6%)，如表 2-1 所示。

表 2-1　APEC's electricity demand

APEC's electricity demand (TWh)

Economy	1990	2005	2030	1990-2005 (%)	2005-2030 (%)
Australia	129.2	206.5	310.7	3.2%	1.6%
Brunei Darussalam	1.0	3.1	4.2	7.7%	1.2%
Canada	418.1	512.2	688.9	1.4%	1.2%
Chile	15.4	48.1	121.6	7.9%	3.8%
China	481.8	1994.9	5196.8	9.9%	3.9%
Hong Kong, China	23.8	40.1	69.0	3.5%	2.2%
Indonesia	27.1	107.1	275.8	9.6%	3.9%
Japan	749.7	976.7	1202.1	1.8%	0.8%
Korea	94.4	357.7	575.3	9.3%	1.9%
Malaysia	19.9	80.8	245.1	9.8%	4.5%
Mexico	100.2	184.2	425.5	4.1%	3.4%
New Zealand	27.8	38.1	56.3	2.1%	1.6%
Papua New Guinea	1.7	2.8	7.5	3.6%	4.0%
Peru	11.8	22.7	59.2	4.5%	3.9%
Philippines	20.9	45.3	136.5	5.3%	4.5%
Russia	826.8	650.1	1000.9	-1.6%	1.7%
Singapore	12.6	32.4	91.4	6.5%	4.2%
Chinese Taipei	76.0	199.0	319.1	6.6%	1.9%
Thailand	38.4	121.3	401.1	8.0%	4.9%
United States	2634.0	3716.3	5023.0	2.3%	1.2%
Viet Nam	6.2	46.1	232.1	14.3%	6.7%
APEC	5716.9	9385.2	16442.1	3.4%	2.3%

Source: APERC analysis (2009)

2. 預測結果(Outlook Result)

APEC 電力負載預期持續成長，年成長率 12.3%，於 2005 年至 2030 間，依區域別，北美地區，尤其是美國，其電力負載在 APEC 內為最高，到 2030 年，預測將達到 5023Twh 之用電量，約佔 APEC 地區總用電量之 30.5%。但中國高經濟成長，其電力用電成長快速，預計到 2030 年達到 5197Twh，將超越美國，其用電量佔所有 APEC 總用電量之 31.6%。

表 2-2 所示，APEC 各經濟體未來電力用電量佔所有終端能源之比例均呈現成長趨勢，僅汶萊呈現負成長，由 2005 年 32%降至 2030 年 20%，其原因即汶萊有豐富之天然氣資源，政府也鼓勵天然氣當地

使用政策所致。

表 2-2　APEC electricity as percentage of TFED

APEC electricity as percentage of TFED

Economy	1990	2005	2030
Australia	19	23	24
Brunei Darussalam	20	32	20
Canada	22	22	23
Chile	12	19	20
China	6	15	22
Hong Kong, China	29	29	39
Indonesia	3	7	10
Japan	21	24	30
Korea	12	21	23
Malaysia	12	17	23
Mexico	10	15	22
New Zealand	25	25	25
Papua New Guinea	23	24	32
Peru	12	17	26
Philippines	12	15	26
Russia	11	13	16
Singapore	16	18	29
Chinese Taipei	21	27	27
Thailand	11	15	24
United States	17	20	25
Viet Nam	2	9	19
APEC	14	18	23

Source: APERC analysis (2009)

3. 電力供應

APEC 區域之電力供應在 2005 至 2030 年間，其平均負載成長率約為 2.2%。APEC 區域內電力產生大都使用煤，燃煤發電佔所有發電之 40%以上，惟從 2005 年 48%緩降至 2030 年之 44%如圖 2-1 所示，天然氣發電佔比增加由 2005 年 18%至 2030 年 21%。其餘發電佔比如圖 2-1。

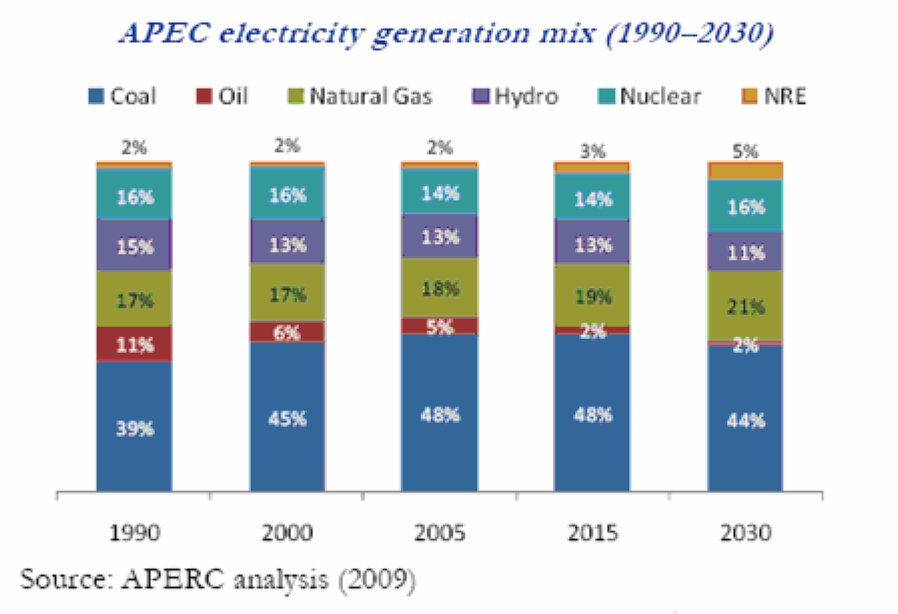


圖 2-1　APEC electricity generation mix

4. 發電裝置容量

為解決增加之電力需求， APEC 區域之電力發電裝置容量從 2005 年 2286GW 增加至 2030 年 4361GW。當新裝置容量加入，其發電結構也隨燃料價格、當地政府環境管制、可用資本、核能發電之政策及 LNG 價格風險等改變。從 2005、2015 至 2030 年，發電結構之裝置容量到 2030 年，仍以燃煤 1522GW 最大，其次為天然氣 1115GW，各類型態之裝置容量如圖 2-2 所示。

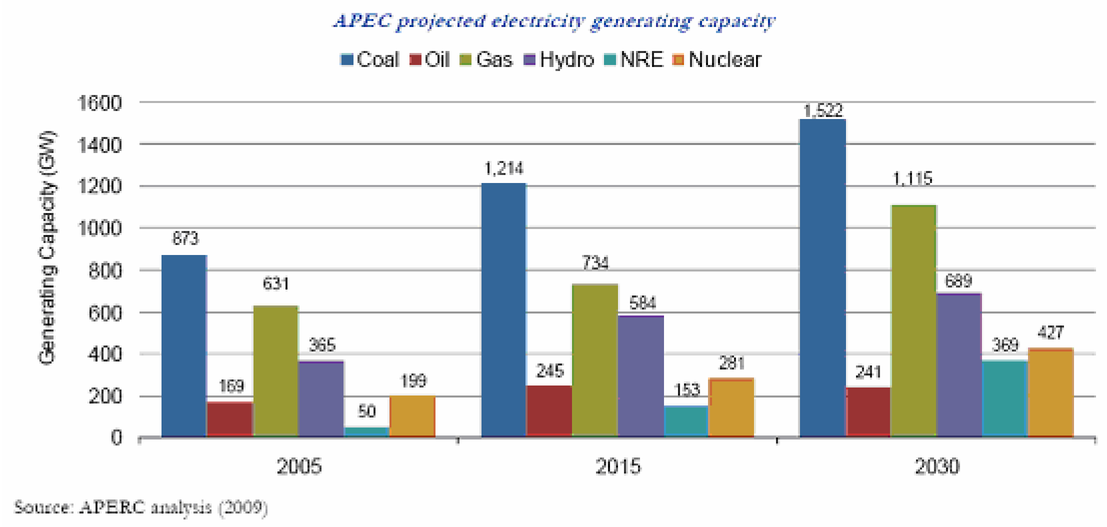


圖 2-2　APEC projected electricity generation capacity

整個預測期間，石油與天然氣價格，相對於儲量多且較穩定燃煤機組呈價揚之趨勢。所以煤仍是未來發電之主體，惟燃煤發電與其他燃料機組相比，其產生較多之温室氣體。現今考量氣候變遷之重要議題時，可能會影響燃煤機組之擴充。燃煤機組預計會以 2.3%年成長率成長，而其發電裝置容量佔比從 2005 年之 38%下降至 2030 年 35%，其降低之佔比則由更多之再生能源與核能發電所取代。

複循環燃氣機組，其較煤之優點為效率高、建造快、固定成本投資低且温室氣體排放少；其缺點為價格不穩定且快速需求，致對供應安全產生隱憂。燃氣機組裝置容量預期以年平均成長率 2.3%成長，其發電裝置容量之佔比從 2005 年 28%，降至 2030 年 25%，其下降裝置容量之佔比亦由再生能源與核能發電取代。

燃油機組僅在 APEC 少數產油經濟體採用，由於其燃料價格高，且考量供應安全等因素，其發電容量之佔比從 2005 年 7%降至 2030 年 6%。

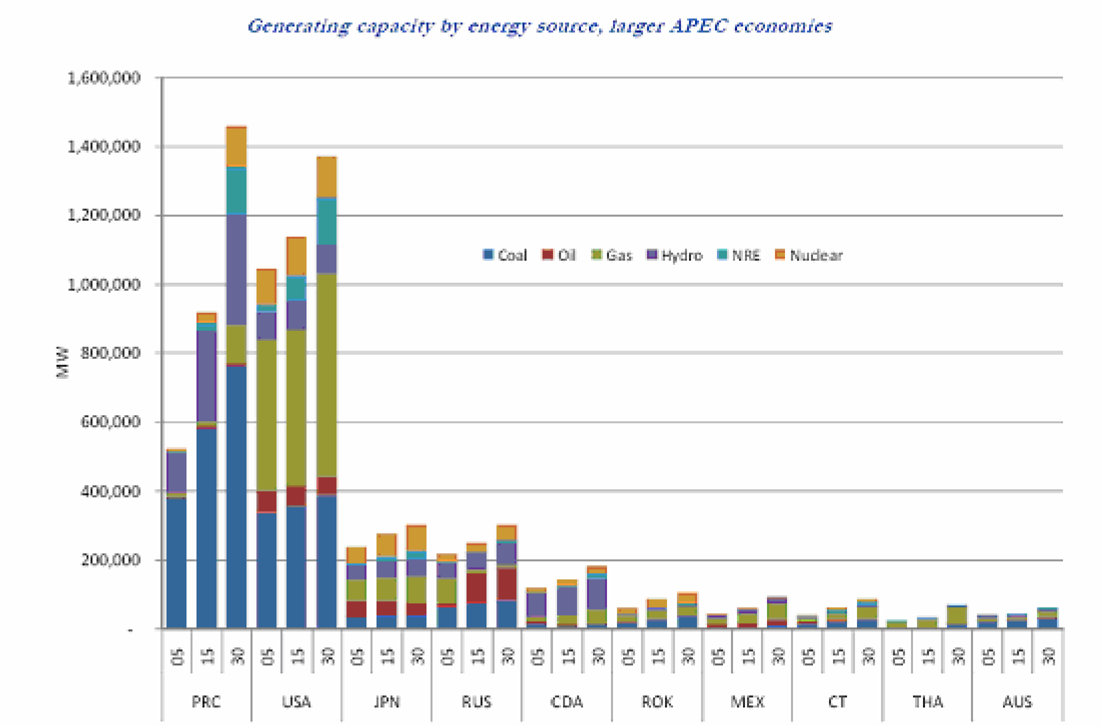
在 APEC 為解決負載快速成長，新核能機組能得到各經濟體採用，最主要原因為油與天然氣燃料價格高漲，且温室氣體排放之抑制，核能機組裝置容量佔比從 2005 年 9%提高至 2030 年 10%。

由於水力發電無燃料成本且低温室氣體排放，故水力發電為各國優先採用之發電種類，但由於都缺乏適當之建造地點，水力發電之裝置容量佔比從 2005 年至 2030 年約維持 16%，而其裝置容量年成長率約 2.6%。

APEC 各成員均加速提昇再生能源之發展，再生能源相對於其它發電種類，其以年成長率 8.4%成長，且其發電裝置容量從 2005 年 2%增加至 2030 年 8%。為降低温室氣體排放與降低成本，APEC 成員均致力於降低輸電與配電損失，提昇化石燃料發電機組效率。在基本情境分析假設，燃煤機組之效率從 2005 年 34%至 2030 年之 36%，燃氣機組由 43%至 46%，同時輸配電損失從 2005 年 6.7%降至 2030 年 5.4%。

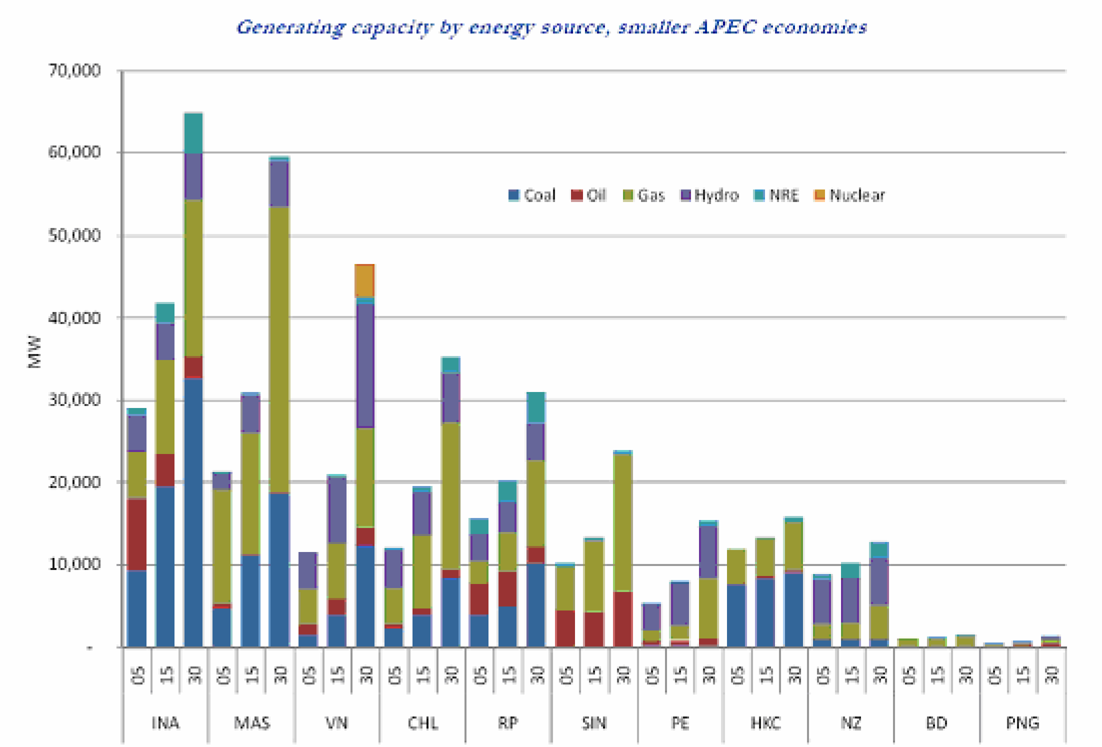
二、APEC 各經濟體發電裝置容量

在基準年 2005 年時，美國其發電裝置容量為 1047GW 為 APEC 區域最高，主要為燃氣機組佔 42%與燃煤機組 32%。其次為中國，裝置容量為 524GW，其中燃煤佔 73%與水力佔 22%。但至 2030 年時，中國發電裝置容量預計高達 1460GW 將超過美國 1370GW，詳如圖 2-3 與圖 2-4。現今中國考量能源安全與減緩氣候變遷，積極增加再生能源、天然氣與核能之利用。圖 2-5 所示為 APEC 各經濟體發電裝置容量之成長率。



Source: APERC analysis (2009)

圖 2-3　Generating capacity by energy source



Source: APERC analysis (2009)

圖 2-4　Generating capacity by energy source

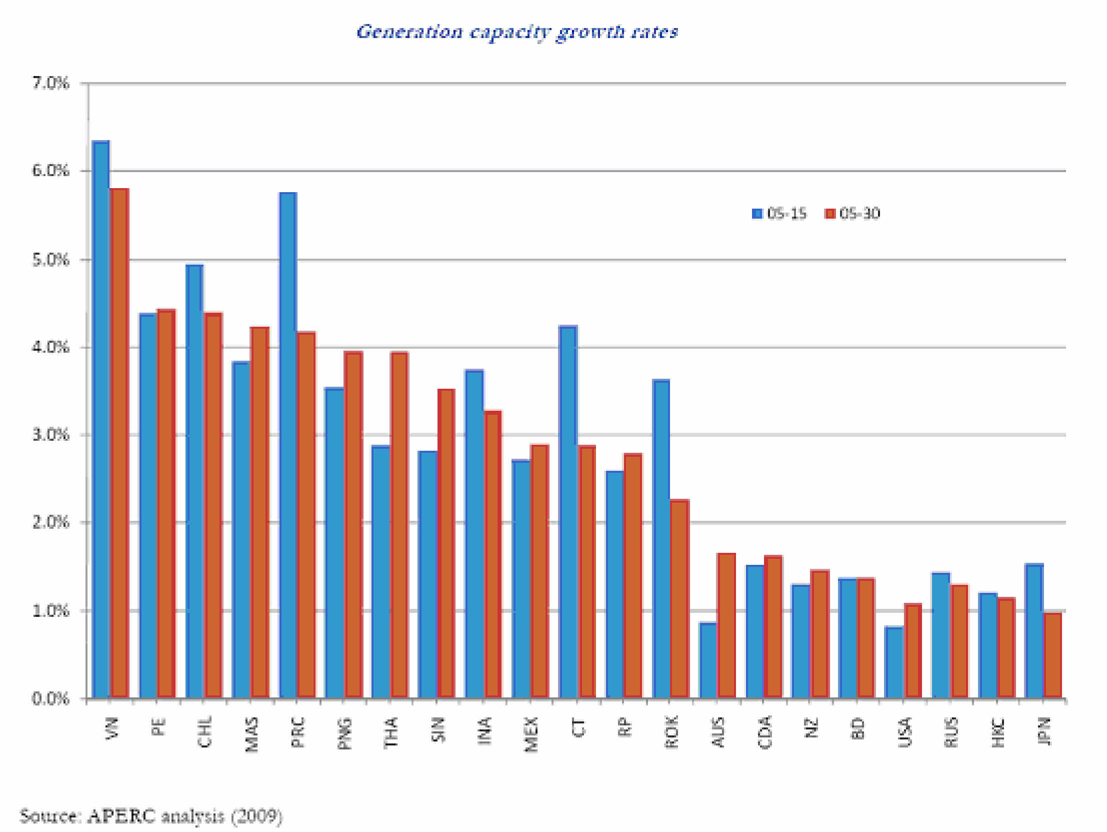


圖 2-5　Generation capacity growth rates

圖 2-6(APEC 大經濟體)與圖 2-7(APEC 小濟體)表示 2005、2015 及 2030 年各能源之電力供應。各經濟體 2005-2015 年與 2005-2030 年發電量成長率如圖 2-8 所示。

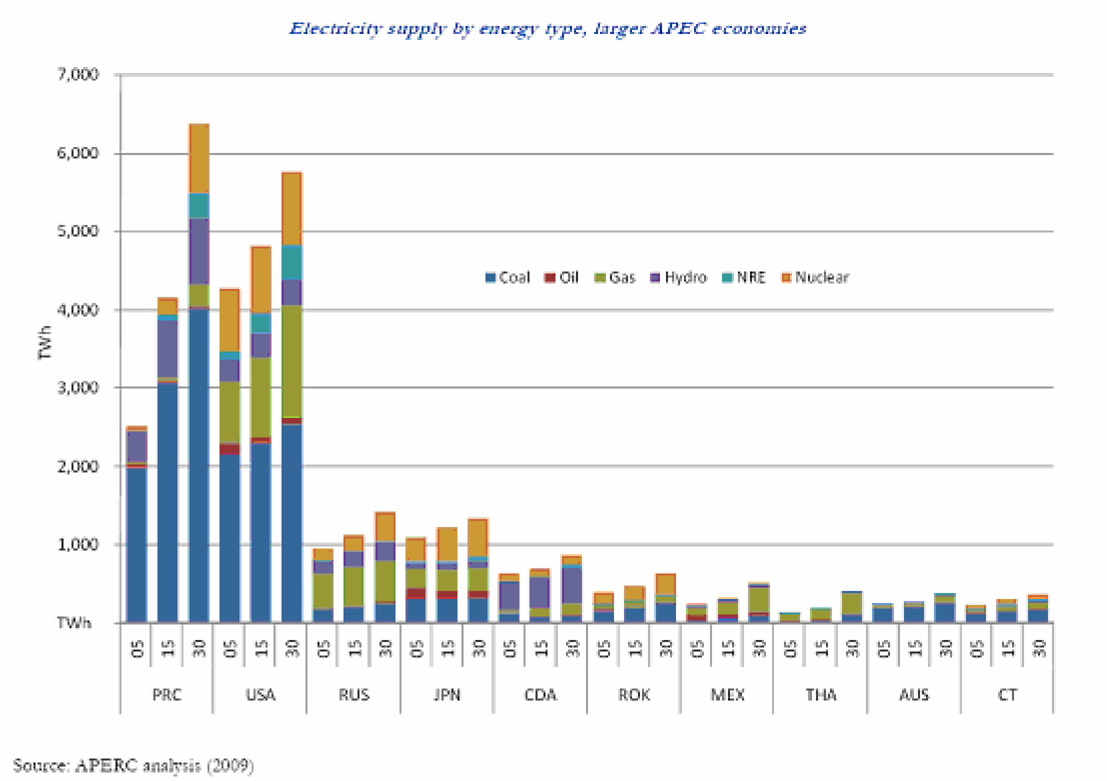


圖 2-6　Electricity supply by energy type

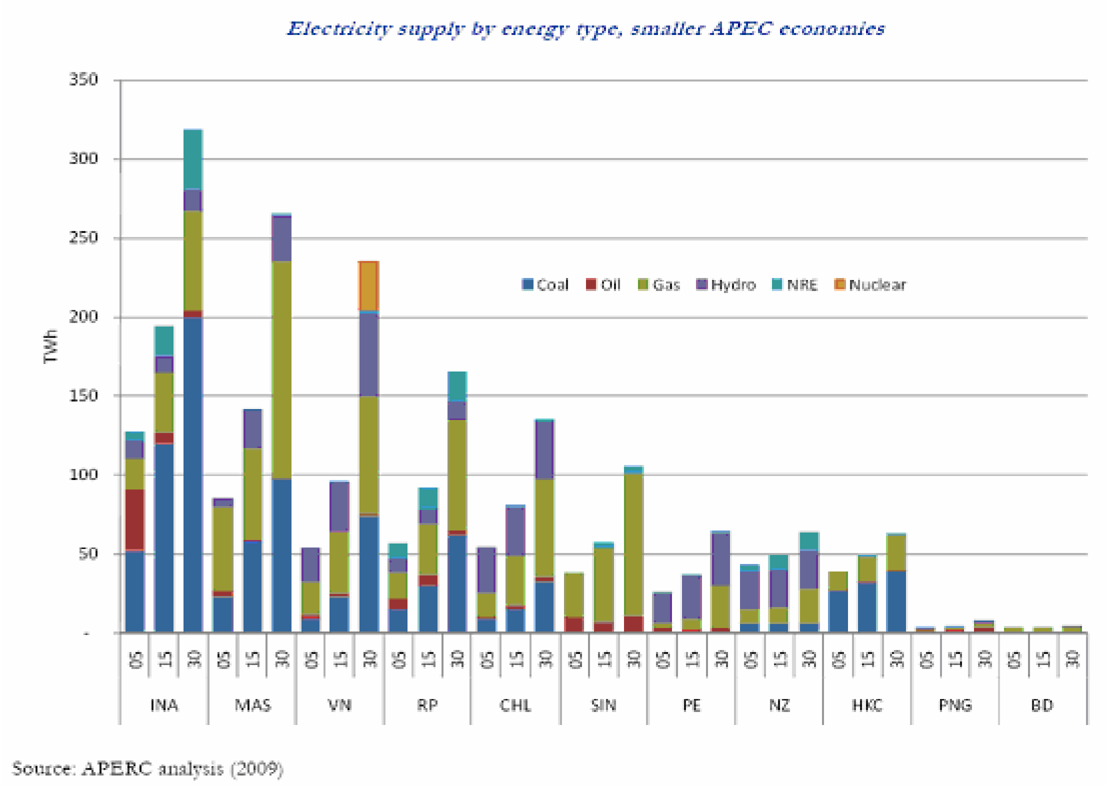


圖 2-7　Electricity supply by energy type

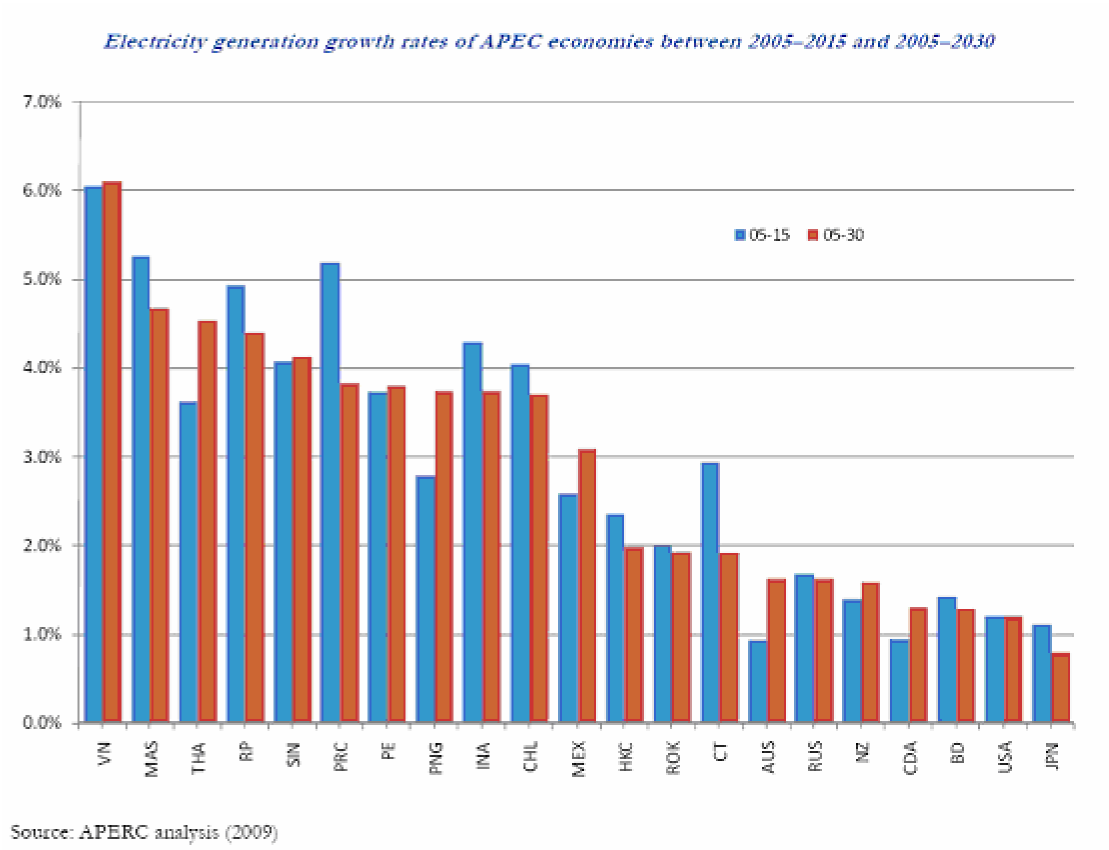


圖 2-8　Electricity generation growth rates of APEC economies between

三、電力普及率

APEC 各經濟體均傾全力讓每位居民有便利之電力使用，現儘 5 個經濟體，用電普及較低，在基準年 2005 年時，越南有 84%、菲律賓 81%、秘魯 72%、印尼 54%、新幾內亞 7%。

四、電力技術發展

將來電力技術發展有兩大目標，一是降低温室氣體之排放，二是提昇發電與輸配電之效率。為達到此兩目標，下列技術均需列入考量：

1. 高效率複循環燃氣氣組(CCGT)，其效率可望在近期內提昇至50%以上。
2. 高效率燃煤機組，如超越臨界機組使用增加鍋爐之温度，使其發電效率能達 40%以上。另外考量氣體之複循環燃煤機組

(IGCC)，有較先進技術，易於捕捉機組排放之二氧化碳。將來碳捕捉與儲存，可助燃煤機組僅排放少許之二氧化碳量。

3. 智慧電網：使用現代資訊技術，使電力系統更可靠、更有效率。智慧電網能夠藉由此快速反應，減少故障機率，使再生能源如風、太陽能等發電有更好之利用，且電力發電與儲存設備有更好之協調應用，達到低成本與高可靠度之電力系統。

五、應用於台電電源規劃

整個相關計算流程，從輸入資料、假設、計算、檢查符合相關假設後即可得到將來的發電裝置容量、溫室氣體的排放與能源平衡表圖 2-9 所示。將 APEC 能源負載與供給展望計畫中之電力部門相關計算模式應用於台電電源規劃與二氧化碳排放計算；相關計算流程從輸入台電電源開發方案如表 2-3，既有裝置容量及用戶自發電量如表 2-4，利用長期負載推估各能源別裝置容量如表 2-5，長期負載推估之供電量、需電量及廠內用電如表 2-6 所示，各機組裝置容量、容量因數熱效率如表 2-7 所示；各燃料別機組發電量佔比如表 2-8 所示。

由上述資料之輸入後經由自行開發之 EXCEL 模式獲得基準年民國 97 年與台灣未來 107 年與 117 年各發電機組(台電自有、民營電廠與汽電共生)之裝置容量如表 2-9；所需之一次能源之能源平衡表如表 2-10 及二氧化碳排放量如表 2-11。

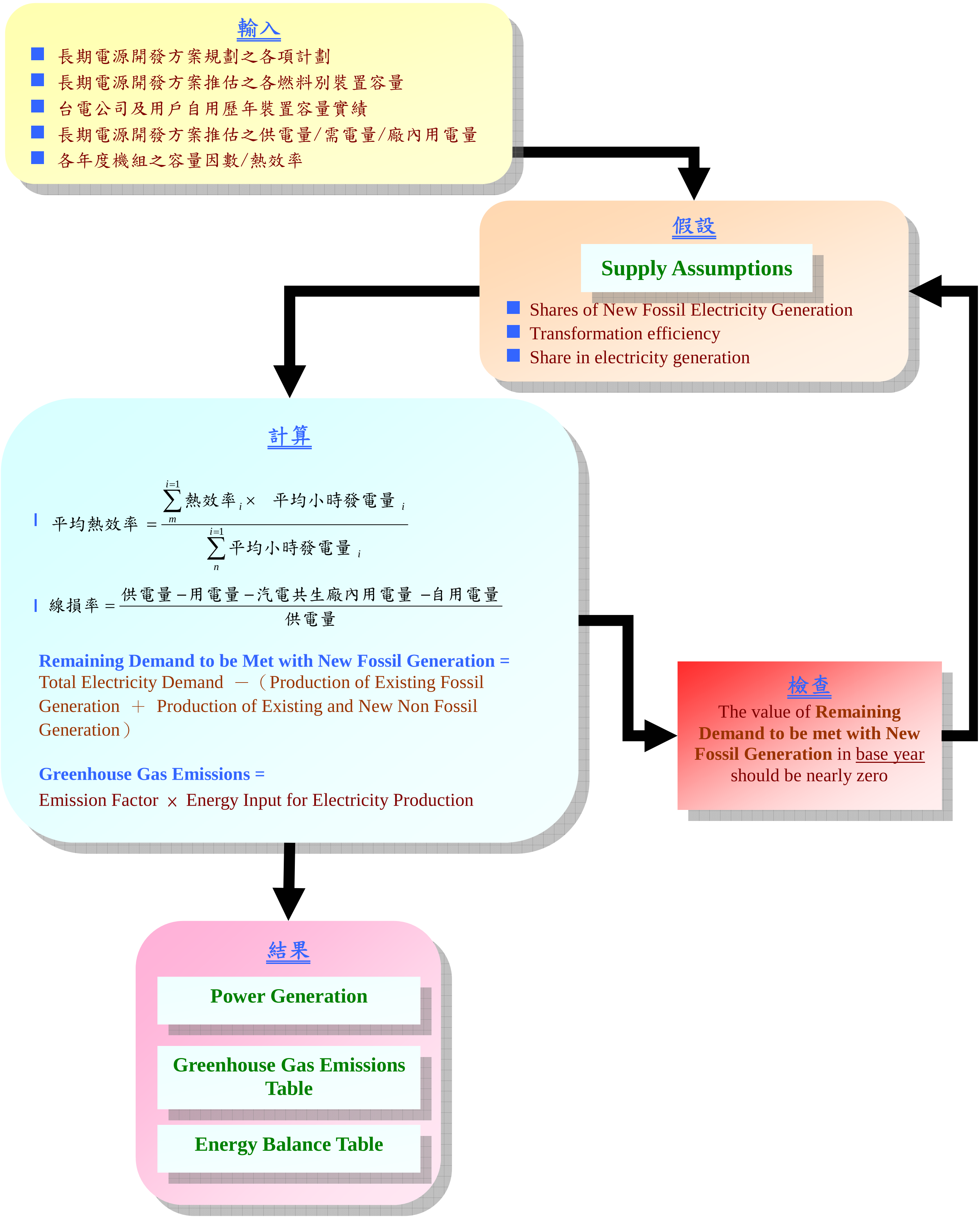


圖 2-9　電源裝置容量與二氧化碳排放計算之流程圖

表 2-3　台電電源開發方案

	A	B	C	D	E	F	G	H	I	J	K	L
1	年度	計畫名稱	電業別/能源別/燃料別	電業別	能源別	燃料別	機組名稱	裝置容量(萬瓩)	增加/減少(萬瓩)	累計增加/減少(萬瓩)		
38	99		台電自有/再生能源/風力	台電自有	再生能源	風力	風力	19.2	1.6	30.4		
39	99		台電自有/再生能源/風力	台電自有	再生能源	風力	風力	19.2	1.6	32.0		
40	99		台電自有/燃油/輕油	台電自有	燃油	輕油	馬祖	4.6	0.3	32.3		
41	99		民營電廠/再生能源/風力	民營電廠	再生能源	風力	民營風力	21.2	1.2	33.5		
42	99		台電自有/燃油/輕油	台電自有	燃油	輕油	馬祖	4.6	0.0	33.4		
43	99		台電自有/再生能源/太陽能	台電自有	再生能源	太陽能	太陽光電	0.1	0.4	33.8		
44	99		民營電廠/再生能源/其他	民營電廠	再生能源	其他	民營再生能源	0.0	2.5	36.3		
45	99		民營電廠/再生能源/其他	民營電廠	再生能源	其他	民營再生能源	0.0	77.2	113.5		
46	100		台電自有/燃油/輕油	台電自有	燃油	輕油	林口氣渦輪	30.0	-30.0	-30.0		
47	100		台電自有/燃油/輕油	台電自有	燃油	輕油	七美	0.4	0.1	-29.9		
48	100		台電自有/再生能源/風力	台電自有	再生能源	風力	風力	25.6	0.5	-29.4		
49	100		台電自有/再生能源/風力	台電自有	再生能源	風力	風力	25.6	0.5	-28.9		
50	100		台電自有/再生能源/風力	台電自有	再生能源	風力	風力	25.6	2.3	-26.6		
51	100		台電自有/燃油/輕油	台電自有	燃油	輕油	蘭嶼	0.4	-0.1	-26.7		
52	100		台電自有/燃油/輕油	台電自有	燃油	輕油	望安	0.4	0.1	-26.6		
53	100		台電自有/燃油/輕油	台電自有	燃油	輕油	蘭嶼	0.4	0.3	-26.3		
54	100		台電自有/再生能源/水力	台電自有	再生能源	水力	慣常水力	168.7	6.1	-20.2		
55	100		台電自有/燃油/輕油	台電自有	燃油	輕油	金門	9.4	-0.3	-20.5		
56	100		台電自有/燃油/輕油	台電自有	燃油	輕油	七美	0.4	0.1	-20.4		
57	100		台電自有/燃油/輕油	台電自有	燃油	輕油	望安	0.4	0.1	-20.3		
58	100		台電自有/再生能源/太陽能	台電自有	再生能源	太陽能	太陽光電	0.7	0.5	-19.8		
59	100		民營電廠/再生能源/風力	民營電廠	再生能源	風力	民營風力	22.3	4.5	-15.3		
60	100		民營電廠/再生能源/其他	民營電廠	再生能源	其他	民營再生能源	79.7	9.9	-5.4		
61	100		台電自有/核能/核能	台電自有	核能	核能	核能四#1	0.0	135.0	129.6		
62	101		台電自有/燃油/輕油	台電自有	燃油	輕油	馬祖	4.9	0.9	0.9		
63	101		台電自有/燃油/輕油	台電自有	燃油	輕油	綠島	1.0	-0.1	0.8		
64	101		台電自有/再生能源/水力	台電自有	再生能源	水力	慣常水力	174.8	4.1	4.9		
65	101		台電自有/燃油/輕油	台電自有	燃油	輕油	馬祖	4.9	-0.1	4.8		
66	101		民營電廠/再生能源/其他	民營電廠	再生能源	其他	民營再生能源	89.7	18.2	23.0		
67	101		台電自有/核能/核能	台電自有	核能	核能	核能四#2	0.0	135.0	158.0		
68	102		台電自有/燃油/輕油	台電自有	燃油	輕油	金門	9.1	-1.1	-1.1		
69	102		台電自有/燃油/輕油	台電自有	燃油	輕油	馬祖	5.7	-1.3	-2.3		
70	102		民營電廠/再生能源/其他	民營電廠	再生能源	其他	民營再生能源	107.8	20.0	17.7		
71	103		台電自有/燃油/輕油	台電自有	燃油	輕油	虎井	0.1	0.0	0.0		
72	103		台電自有/燃油/輕油	台電自有	燃油	輕油	虎井	0.1	0.1	0.0		
73	103		台電自有/燃油/輕油	台電自有	燃油	輕油	望安	0.6	0.1	0.1		
74	103		台電自有/燃油/輕油	台電自有	燃油	輕油	綠島	0.9	0.3	0.4		
75	103		台電自有/燃油/輕油	台電自有	燃油	輕油	望安	0.6	0.1	0.5		
76	103		台電自有/再生能源/風力	台電自有	再生能源	風力	風力	28.9	5.1	5.6		
77	103		民營電廠/再生能源/其他	民營電廠	再生能源	其他	民營再生能源	127.8	14.9	20.5		
78	104		台電自有/再生能源/風力	台電自有	再生能源	風力	風力	34.0	1.4	1.4		
79	104		台電自有/再生能源/太陽能	台電自有	再生能源	太陽能	太陽光電	1.1	0.1	1.5		
80	104		民營電廠/再生能源/其他	民營電廠	再生能源	其他	民營再生能源	142.8	18.5	20.0		
81	105		台電自有/再生能源/水力	台電自有	再生能源	水力	慣常水力	178.8	0.8	0.8		

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表 2-4　台電公司裝置容量及用戶自用發電容量

機組名稱		電業別	能源別	燃料別	95	96	97	98	99	100
top	台電公司統計年報實績資料-裝置容量(瓩)									
		台電自有			29843464.0	30542264.0	31013264.0			
		民營電廠			7277740.0	7289260.0	7370364.0			
		託營電廠			250000.0	250000.0	250000.0			
		用戶自用	再生能源	太陽能	1410.0	2440.0	5580.0			
		用戶自用	再生能源	風力	6140.0	6140.0	6140.0			
		汽電共生			7627446.0	7725546.0	7733346.0			
				總計	45006200.0	45815650.0	46378694.0	0.0	0.0	0.0

表 2-5　長期負載預測推估之各能源別裝置容量

機組名稱		電業別	能源別	燃料別	95	96	97	98	99	100	
top	長期負載預測資料-裝置容量(萬瓩)										
			燃煤		1807.0	1766.0	1766.0	1776.9	1783.7	1801.5	1
			燃油		465.0	477.6	480.9	488.4	488.6	458.9	
			燃氣		1173.3	1274.8	1321.8	1494.8	1520.2	1520.2	1
			核能		514.4	514.4	514.4	514.4	514.4	649.4	
			水力		260.2	260.2	260.2	260.2	260.2	260.2	
			再生能源	水力	190.9	192.1	193.8	197.6	216.8	222.9	
			再生能源	風力	9.7	18.5	24.6	40.4	97.4	107.4	
			再生能源	其他	62.5	64.1	64.2	64.3	75.9	84.0	
		用戶自用	再生能源		0.8	0.8	1.2	1.2	1.2	1.2	
		汽電共生	再生能源	其他	12.6	8.7	6.4	6.4	6.4	6.4	
		汽電共生	其他	廢熱	4.3	4.3	4.3	4.3	4.3	4.3	
				總計	4500.6	4581.5	4637.8	4848.9	4969.1	5116.4	5

表 2-6　長期負載預測推估之供電量／需電量及廠內用電量

機組名稱		電業別	能源別	燃料別	95	96	97	98	99	100	
top	供電/需電/廠內用電量										
	供電量(億度)				2222.5	2294.9	2257.9	2164.7	2214.0	2295.0	2
	用電量(億度)				2070.2	2140.3	2119.4	2024.9	2070.5	2146.8	2
	廠內用電(億度)										
		台電公司			84.9	86.6	85.3	81.5	83.3	86.4	
		汽電共生			49.5	51.8	44.9	40.2	41.4	42.5	
	自用電量(億度)				7.5	7.4	7.6	7.7	7.9	8.0	
	抽蓄用電(億度)				46.9	44.5	39.6	39.6	39.6	39.6	
	廠內用電+自用電+抽蓄用電總計(億度)				188.8	190.3	177.4	169.0	172.2	176.5	
	線路損失量(億度)				95.3	95.4	86.0	91.9	94.2	97.7	
	線路損失率(%)				4.29%	4.16%	3.81%	4.25%	4.25%	4.26%	

表 2-7　各年度機組之裝置容量／容量因數／熱效率

機組名稱		電業別	能源別	燃料別	95	96	97	98	99	100	
top	裝置容量(瓩)										
協和#1	台電自有/燃油/重油	台電自有	燃油	重油	500,000	500,000	500,000	500,000	500,000	500,000	50
協和#2	台電自有/燃油/重油	台電自有	燃油	重油	500,000	500,000	500,000	500,000	500,000	500,000	50
協和#3	台電自有/燃油/重油	台電自有	燃油	重油	500,000	500,000	500,000	500,000	500,000	500,000	50
協和#4	台電自有/燃油/重油	台電自有	燃油	重油	500,000	500,000	500,000	500,000	500,000	500,000	50
林口#1	台電自有/燃煤/煤	台電自有	燃煤	煤	300,000	300,000	300,000	300,000	300,000	300,000	30
林口#2	台電自有/燃煤/煤	台電自有	燃煤	煤	300,000	300,000	300,000	300,000	300,000	300,000	30
深澳#1	台電自有/燃煤/煤	台電自有	燃煤	煤	75,000	0	0	0	0	0	
深澳#2	台電自有/燃煤/煤	台電自有	燃煤	煤	125,000	0	0	0	0	0	
深澳#3	台電自有/燃煤/煤	台電自有	燃煤	煤	200,000	0	0	0	0	0	
台中#1	台電自有/燃煤/煤	台電自有	燃煤	煤	550,000	550,000	550,000	550,000	550,000	550,000	55
台中#2	台電自有/燃煤/煤	台電自有	燃煤	煤	550,000	550,000	550,000	550,000	550,000	550,000	55
台中#3	台電自有/燃煤/煤	台電自有	燃煤	煤	550,000	550,000	550,000	550,000	550,000	550,000	55
台中#4	台電自有/燃煤/煤	台電自有	燃煤	煤	550,000	550,000	550,000	550,000	550,000	550,000	55
台中#5	台電自有/燃煤/煤	台電自有	燃煤	煤	550,000	550,000	550,000	550,000	550,000	550,000	55
台中#6	台電自有/燃煤/煤	台電自有	燃煤	煤	550,000	550,000	550,000	550,000	550,000	550,000	55
台中#7	台電自有/燃煤/煤	台電自有	燃煤	煤	550,000	550,000	550,000	550,000	550,000	550,000	55
台中#8	台電自有/燃煤/煤	台電自有	燃煤	煤	550,000	550,000	550,000	550,000	550,000	550,000	55
台中#9	台電自有/燃煤/煤	台電自有	燃煤	煤	550,000	550,000	550,000	550,000	550,000	550,000	55
台中#10	台電自有/燃煤/煤	台電自有	燃煤	煤	550,000	550,000	550,000	550,000	550,000	550,000	55
大林#1	台電自有/燃煤/煤	台電自有	燃煤	煤	300,000	300,000	300,000	300,000	300,000	300,000	30
大林#2	台電自有/燃煤/煤	台電自有	燃煤	煤	300,000	300,000	300,000	300,000	300,000	300,000	30
大林#3	台電自有/燃油/重油	台電自有	燃油	重油	375,000	375,000	375,000	375,000	375,000	375,000	37
大林#4	台電自有/燃油/重油	台電自有	燃油	重油	375,000	375,000	375,000	375,000	375,000	375,000	37
大林#5	台電自有/燃氣/天然氣	台電自有	燃氣	天然氣	500,000	500,000	500,000	500,000	500,000	500,000	50

機組名稱		電業別	能源別	燃料別	95	96	97	98	99	100
top	容量因數(%)									
協和#1	台電自有/燃油/重油	台電自有	燃油	重油	62.41	56.05	52.37	52.37	52.37	52.37
協和#2	台電自有/燃油/重油	台電自有	燃油	重油	56.58	42.27	47.01	47.01	47.01	47.01
協和#3	台電自有/燃油/重油	台電自有	燃油	重油	50.02	60.06	43.72	43.72	43.72	43.72
協和#4	台電自有/燃油/重油	台電自有	燃油	重油	56.62	43.49	45.58	45.58	45.58	45.58
林口#1	台電自有/燃煤/煤	台電自有	燃煤	煤	79.91	58.84	73.90	73.90	73.90	73.90
林口#2	台電自有/燃煤/煤	台電自有	燃煤	煤	84.97	94.19	82.25	82.25	82.25	82.25
深澳#1	台電自有/燃煤/煤	台電自有	燃煤	煤	85.88					
深澳#2	台電自有/燃煤/煤	台電自有	燃煤	煤	92.63					
深澳#3	台電自有/燃煤/煤	台電自有	燃煤	煤	72.87					
台中#1	台電自有/燃煤/煤	台電自有	燃煤	煤	84.28	97.28	81.02	81.02	81.02	81.02
台中#2	台電自有/燃煤/煤	台電自有	燃煤	煤	90.07	87.14	90.89	90.89	90.89	90.89
台中#3	台電自有/燃煤/煤	台電自有	燃煤	煤	96.96	86.50	99.86	99.86	99.86	99.86
台中#4	台電自有/燃煤/煤	台電自有	燃煤	煤	98.75	85.81	98.74	98.74	98.74	98.74
台中#5	台電自有/燃煤/煤	台電自有	燃煤	煤	98.43	88.50	96.33	96.33	96.33	96.33
台中#6	台電自有/燃煤/煤	台電自有	燃煤	煤	94.48	91.94	94.72	94.72	94.72	94.72
台中#7	台電自有/燃煤/煤	台電自有	燃煤	煤	85.16	99.14	87.29	87.29	87.29	87.29
台中#8	台電自有/燃煤/煤	台電自有	燃煤	煤	84.97	98.01	85.38	85.38	85.38	85.38
台中#9	台電自有/燃煤/煤	台電自有	燃煤	煤	82.22	94.07	87.00	87.00	87.00	87.00
台中#10	台電自有/燃煤/煤	台電自有	燃煤	煤	55.57	73.27	97.92	97.92	97.92	97.92
大林#1	台電自有/燃煤/煤	台電自有	燃煤	煤	73.11	97.30	78.05	78.05	78.05	78.05
大林#2	台電自有/燃煤/煤	台電自有	燃煤	煤	83.78	89.56	90.23	90.23	90.23	90.23
大林#3	台電自有/燃油/重油	台電自有	燃油	重油	37.68	35.40	29.14	29.14	29.14	29.14
大林#4	台電自有/燃油/重油	台電自有	燃油	重油	49.15	34.05	33.55	33.55	33.55	33.55

機組名稱		電業別	能源別	燃料別	95	96	97	98	99	100
top	熱效率(%)									
協和#1	台電自有/燃油/重油	台電自有	燃油	重油	35.33	35.03	34.89	34.89	34.89	34.89
協和#2	台電自有/燃油/重油	台電自有	燃油	重油	34.03	34.47	33.96	33.96	33.96	33.96
協和#3	台電自有/燃油/重油	台電自有	燃油	重油	34.81	34.70	33.88	33.88	33.88	33.88
協和#4	台電自有/燃油/重油	台電自有	燃油	重油	34.68	34.54	33.98	33.98	33.98	33.98
林口#1	台電自有/燃煤/煤	台電自有	燃煤	煤	32.47	32.35	32.63	32.63	32.63	32.63
林口#2	台電自有/燃煤/煤	台電自有	燃煤	煤	32.09	31.70	32.15	32.15	32.15	32.15
深澳#1	台電自有/燃煤/煤	台電自有	燃煤	煤	31.08					
深澳#2	台電自有/燃煤/煤	台電自有	燃煤	煤	33.25					
深澳#3	台電自有/燃煤/煤	台電自有	燃煤	煤	33.44					
台中#1	台電自有/燃煤/煤	台電自有	燃煤	煤	35.88	35.87	35.90	35.90	35.90	35.90
台中#2	台電自有/燃煤/煤	台電自有	燃煤	煤	35.88	35.84	35.90	35.90	35.90	35.90
台中#3	台電自有/燃煤/煤	台電自有	燃煤	煤	35.87	35.88	35.92	35.92	35.92	35.92
台中#4	台電自有/燃煤/煤	台電自有	燃煤	煤	35.89	35.88	35.87	35.87	35.87	35.87
台中#5	台電自有/燃煤/煤	台電自有	燃煤	煤	36.14	36.14	36.15	36.15	36.15	36.15
台中#6	台電自有/燃煤/煤	台電自有	燃煤	煤	36.17	36.17	36.17	36.17	36.17	36.17
台中#7	台電自有/燃煤/煤	台電自有	燃煤	煤	36.09	36.13	36.16	36.16	36.16	36.16
台中#8	台電自有/燃煤/煤	台電自有	燃煤	煤	36.12	36.18	36.21	36.21	36.21	36.21
台中#9	台電自有/燃煤/煤	台電自有	燃煤	煤	35.93	35.93	35.71	35.71	35.71	35.71
台中#10	台電自有/燃煤/煤	台電自有	燃煤	煤	33.36	35.35	35.83	35.83	35.83	35.83
大林#1	台電自有/燃煤/煤	台電自有	燃煤	煤	35.34	35.09	35.55	35.55	35.55	35.55
大林#2	台電自有/燃煤/煤	台電自有	燃煤	煤	35.32	35.04	35.48	35.48	35.48	35.48
大林#3	台電自有/燃油/重油	台電自有	燃油	重油	33.18	33.16	32.38	32.38	32.38	32.38
大林#4	台電自有/燃油/重油	台電自有	燃油	重油	33.59	32.82	33.03	33.03	33.03	33.03
大林#5	台電自有/燃氣/天然氣	台電自有	燃氣	天然氣	29.03	28.31	29.37	29.37	29.37	29.37
大林#6	台電自有/燃氣/天然氣	台電自有	燃氣	天然氣	32.29	31.45	31.36	31.36	31.36	31.36

表 2-8　各燃料別機組發電量估比

Name of Economy		TW			Balance Version Date:		2009/11/3	
Base Year		97						
	units	82	87	92	97	107	117	
Existing Fossil Generating Capacity								
Coal	MW	0	0	0	17660	21963	32678	
Oil	MW	0	0	0	4809	3824	2419.6	
Natural Gas	MW	0	0	0	13218	16818	26182	
		0.0	0.0	0.0	35687.0	42605.0	61279.6	
Existing and Planned Non-Fossil Capacity						0	0	
Nuclear	MW	0	0	0	5144	7208	2700	
Hydro	MW	0	0	0	4539.874	4694.474	4825.474	
Geothermal	MW	0	0	0	0	0	0	
Wind	MW	0	0	0	252.1	628	1264.2	
Solar	MW	0	0	0	5.58	20.58	30.58	
Other	MW	0	0	0	750.14	3299.64	6009.34	
	GW	0.0	0.0	0.0	46378.7	58455.7	76109.2	
Shares of New Fossil Electricity Production								
Coal	%				91.9%	85.0%	85.0%	
Oil	%				6.0%	6.0%	2.0%	
Natural Gas	%				2.1%	9.0%	13.0%	
					100.0%	100.0%	100.0%	
Assumed Generator Capacity Factors								
Coal	%	0.0%	0.0%	0.0%	82.1%	86.6%	89.8%	
Oil	%	0.0%	0.0%	0.0%	37.0%	42.1%	44.3%	
Natural Gas	%	0.0%	0.0%	0.0%	34.7%	29.8%	26.2%	
Nuclear	%	0.0%	0.0%	0.0%	90.4%	91.8%	90.4%	
Hydro	%	0.0%	0.0%	0.0%	31.0%	31.8%	32.4%	
Geothermal	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Wind	%	0.0%	0.0%	0.0%	29.3%	29.0%	26.3%	
Solar	%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
Other	%	0.0%	0.0%	0.0%	26.8%	26.2%	26.1%	
Transformation efficiency								
		average				*new plant only*		
Coal	%	0.0%	0.0%	0.0%	35.6%	36.5%	37.8%	
Oil	%	0.0%	0.0%	0.0%	33.6%	33.7%	33.6%	
Natural Gas	%	0.0%	0.0%	0.0%	40.6%	41.7%	43.1%	
				average				
Nuclear	%	33.3%	33.3%	33.3%	33.3%	33.3%	33.3%	
Hydro	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
Geothermal	%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	
NRE	%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	
Share in electricity generation		100%	100%	100%				
Coal	%	54.6%	71.3%	78.5%				
Oil	%	25.8%	7.9%	3.4%				
Natural Gas	%	0.2%	0.4%	0.4%				
Nuclear	%	0.0%	0.0%	1.2%				
Hydro	%	19.4%	20.4%	16.4%				
Geothermal	%	0.0%	0.0%	0.0%				
Wind	%	0.0%	0.0%	0.0%				
Solar	%	0.0%	0.0%	0.0%				
Other	%	0.0%	0.0%	0.0%				
Residual-Check	%	0.0%	0.0%	0.0%				
Transmission and distribution losses								
	%	0.0%	0.0%	0.0%	3.8%	4.3%	4.3%	
		0.00%	0.00%	0.00%	3.81%	4.26%	4.25%	(org)
Heat production efficiency								
	percent				80.0%	87.0%	88.0%	
Share in heat production								
Coal	%				69.0%	90.0%	85.0%	
Oil	%				20.0%	2.0%	1.0%	
Natural Gas	%				4.5%	7.5%	13.0%	
Nuclear	%				0.0%	0.0%	0.0%	
Hydro	%				0.0%	0.0%	0.0%	
Geothermal	%				0.0%	0.0%	0.0%	
Wind	%				0.0%	0.0%	0.0%	
Solar	%				0.0%	0.0%	0.0%	
Other	%				0.8%	0.5%	1.0%	
Residual-Check	%				5.7%	0.0%	0.0%	

units		87	92	97	107	117
Share in electricity generation						
台電自有	%	85.0%	85.0%			
民營電廠	%	10.0%	10.0%			
汽電共生	%	5.0%	5.0%			
		100.0%	100.0%			
台電自有	%	95.0%	95.0%			
民營電廠	%	0.0%	0.0%			
汽電共生	%	5.0%	5.0%			
		100.0%	100.0%			
台電自有	%	85.0%	85.0%			
民營電廠	%	10.0%	10.0%			
汽電共生	%	5.0%	5.0%			
		100.0%	100.0%			
Shares of New Fossil Electricity Production						
台電自有	%			85.0%	85.0%	85.0%
民營電廠	%			10.0%	10.0%	10.0%
汽電共生	%			5.0%	5.0%	5.0%
				100.0%	100.0%	100.0%
台電自有	%			95.0%	95.0%	95.0%
民營電廠	%			0.0%	0.0%	0.0%
汽電共生	%			5.0%	5.0%	5.0%
				100.0%	100.0%	100.0%
台電自有	%			85.0%	85.0%	85.0%
民營電廠	%			10.0%	10.0%	10.0%
汽電共生	%			5.0%	5.0%	5.0%
				100.0%	100.0%	100.0%

表 2-9　長期電源裝置容量

	Mtoe	82	87	92	97	107	117
Production of Existing Fossil Generation							
台電自有							
Coal	GWh	0	0	0	69060	85773	169840
Oil	GWh	0	0	0	11077	9024	4315
Natural Gas	GWh	0	0	0	32819	35689	51785
民營電廠							
Coal	GWh	0	0	0	24304	24304	24304
Oil	GWh	0	0	0	0	0	0
Natural Gas	GWh	0	0	0	7363	8238	8238
汽電共生							
Coal	GWh	0	0	0	33668	56457	62790
Oil	GWh	0	0	0	4502	5072	5073
Natural Gas	GWh	0	0	0	38	31	31
Remaining Demand to Be Met with New Fossil Generation							
台電自有							
Coal	GWh				0	87	2655
Oil	GWh				0	7	70
Natural Gas	GWh				0	9	406
民營電廠							
Coal	GWh				0	10	312
Oil	GWh				0	0	0
Natural Gas	GWh				0	1	48
汽電共生							
Coal	GWh				0	5	156
Oil	GWh				0	0	4
Natural Gas	GWh				0	1	24
Total Electricity Production - Mtoe							
台電自有							
Coal	Mtoe	0.00	0.00	0.00	9.28	12.18	19.01
Oil	Mtoe	0.00	0.00	0.00	1.27	1.15	0.77
Natural Gas	Mtoe	0.00	0.00	0.00	2.94	3.21	4.42
民營電廠							
Coal	Mtoe	0.00	0.00	0.00	1.09	1.43	2.24
Oil	Mtoe	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	Mtoe	0.00	0.00	0.00	0.35	0.38	0.52
汽電共生							
Coal	Mtoe	0.00	0.00	0.00	0.55	0.72	1.12
Oil	Mtoe	0.00	0.00	0.00	0.07	0.06	0.04
Natural Gas	Mtoe	0.00	0.00	0.00	0.17	0.19	0.26
Energy input for electricity production -GWh							
台電自有							
Coal	GWh	0.00	0.00	0.00	303159.18	397667.37	620194.41
Oil	GWh	0.00	0.00	0.00	44037.96	39864.33	26744.32
Natural Gas	GWh	0.00	0.00	0.00	84259.71	92114.25	126756.09
民營電廠							
Coal	GWh	0.00	0.00	0.00	35665.79	46784.40	72964.05
Oil	GWh	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	GWh	0.00	0.00	0.00	9912.91	10836.97	14912.48
汽電共生							
Coal	GWh	0.00	0.00	0.00	17832.89	23392.20	36482.02
Oil	GWh	0.00	0.00	0.00	2317.79	2098.12	1407.60
Natural Gas	GWh	0.00	0.00	0.00	4956.45	5418.49	7456.24
Energy input for electricity production -Mtoe							
台電自有							
Coal	Mtoe	0.0	0.0	0.0	26.1	34.2	53.3
Oil	Mtoe	0.0	0.0	0.0	3.8	3.4	2.3
Natural Gas	Mtoe	0.0	0.0	0.0	7.2	7.9	10.9
民營電廠							
Coal	Mtoe	0.0	0.0	0.0	3.1	4.0	6.3
Oil	Mtoe	0.0	0.0	0.0	0.0	0.0	0.0
Natural Gas	Mtoe	0.0	0.0	0.0	0.9	0.9	1.3
汽電共生							
Coal	Mtoe	0.0	0.0	0.0	1.5	2.0	3.1
Oil	Mtoe	0.0	0.0	0.0	0.2	0.2	0.1
Natural Gas	Mtoe	0.0	0.0	0.0	0.4	0.5	0.6
Needed new fossil generation capacity							
台電自有							
Coal	MW				0.00	11.47	337.68
Oil	MW				0.00	1.86	18.00
Natural Gas	MW				0.00	3.52	177.04
民營電廠							
Coal	MW				0.00	1.35	39.73
Oil	MW				0.00	0.00	0.00
Natural Gas	MW				0.00	0.41	20.83
汽電共生							
Coal	MW				0.00	0.67	19.86
Oil	MW				0.00	0.10	0.95
Natural Gas	MW				0.00	0.21	10.41
Needed new fossil generation capacity							
台電自有							
Coal	MW				0.00	11.47	337.68
Oil	MW				0.00	1.86	18.00
Natural Gas	MW				0.00	3.52	177.04
民營電廠							
Coal	MW				0.00	1.35	39.73
Oil	MW				0.00	0.00	0.00
Natural Gas	MW				0.00	0.41	20.83
汽電共生							
Coal	MW				0.00	0.67	19.86
Oil	MW				0.00	0.10	0.95
Natural Gas	MW				0.00	0.21	10.41

表 2-10　能源平衡表

Energy balance table

Member Economy TW

Year:97

Units: Mtoe	Coal a	Crude Oil	Petrol. Prod. b	Gas c	Hydro	Nuclear	NRE d	Electricity	Heat	Total
Production	0.0	0.0		0.0	1.1	10.5	0.2			11.8
Imports	30.7	0.0	4.0	8.5			0.0	0.0		43.2
Exports e	0.0	0.0	0.0	0.0				0.0		0.0
Total energy supply	30.7	0.0	4.0	8.5	1.1	10.5	0.2	0.0	0.0	55.0
Power and heat generation	(30.7)		(4.0)	(8.5)	(1.1)	(10.5)	(0.2)	20.5	0.0	(34.5)
Own Use & Losses g	0.0		0.0	0.0				(0.7)	0.0	(0.7)
Total final energy demand								18.2		18.2

Notes:

a Coal refers to raw coal and coal products. b Such as gasoline, diesel, LPG, naphtha, fuel oil, etc. c Includes natural gas and town gas.

d Includes geothermal, wind, solar, tidal and biomass.e Includes exports, stock changes and international marine bunkers.

f Includes auxiliary fuel use. g Own use and transmission & distribution losses h Includes agriculture and construction sectors.

Energy balance table

Member Economy TW

Year:107

Units: Mtoe	Coal a	Crude Oil	Petrol. Prod. b	Gas c	Hydro	Nuclear	NRE d	Electricity	Heat	Total
Production	0.0	0.0		0.0	1.1	15.0	0.8			16.9
Imports	40.2	0.0	3.6	9.3			0.0	0.0		53.2
Exports e	0.0	0.0	0.0	0.0				0.0		0.0
Total energy supply	40.2	0.0	3.6	9.3	1.1	15.0	0.8	0.0	0.0	70.0
Power and heat generation	(40.2)		(3.6)	(9.3)	(1.1)	(15.0)	(0.8)	26.2	0.0	(43.8)
Own Use & Losses g	0.0		0.0	0.0				(1.1)	0.0	(1.1)
Total final energy demand								23.4		23.4

Notes:

a Coal refers to raw coal and coal products. b Such as gasoline, diesel, LPG, naphtha, fuel oil, etc. c Includes natural gas and town gas.

d Includes geothermal, wind, solar, tidal and biomass.e Includes exports, stock changes and international marine bunkers.

f Includes auxiliary fuel use. g Own use and transmission & distribution losses h Includes agriculture and construction sectors.

Energy balance table

Member Economy TW

Year:117

Units: Mtoe	Coal a	Crude Oil	Petrol. Prod. b	Gas c	Hydro	Nuclear	NRE d	Electricity	Heat	Total
Production	0.0	0.0		0.0	1.2	5.5	1.4			8.1
Imports	62.7	0.0	2.4	12.8			0.0	0.0		78.0
Exports e	0.0	0.0	0.0	0.0				0.0		0.0
Total energy supply	62.7	0.0	2.4	12.8	1.2	5.5	1.4	0.0	0.0	86.1
Power and heat generation	(62.7)		(2.4)	(12.8)	(1.2)	(5.5)	(1.4)	32.8	0.0	(53.3)
Own Use & Losses g	0.0		0.0	0.0				(1.3)	0.0	(1.3)
Total final energy demand								29.4		

Notes:

a Coal refers to raw coal and coal products. b Such as gasoline, diesel, LPG, naphtha, fuel oil, etc. c Includes natural gas and town gas.

d Includes geothermal, wind, solar, tidal and biomass.e Includes exports, stock changes and international marine bunkers.

f Includes auxiliary fuel use. g Own use and transmission & distribution losses h Includes agriculture and construction sectors.

表 2-11　二氧化碳排放

Greenhouse gas emissions table

Member Economy　TW

Year:97

Units: $MtCO_{2e}$	Coal [a]	Oil	Petrol. Prod. [b]	Gas [c]	Total	
Tranformation to Power & Heat	122.7	NA	12.4	19.6	154.6	8.5 t-co2/toe
台電自有	104.3	NA	11.7	16.7	132.7	
民營電廠	12.3	NA	0.0	2.0	14.2	
汽電共生	6.1	NA	0.6	1.0	7.7	
Total emissions						2.8 t-co2/toe

Notes:

a *Coal refers to raw coal and coal products.* ***b*** *Such as gasoline, diesel, LPG, naphtha, fuel oil, etc.* ***c*** *Includes natural gas and town gas.*

d *Includes geothermal, wind, solar, tidal and biomass.* ***e*** *Includes energy use by non-heat/electricity tranformation industries (e.g. refininers, LNG plants, etc…).*

Greenhouse gas emissions table

Member Economy　TW

Year:107

Units: $MtCO_{2e}$	Coal [a]	Oil	Petrol. Prod. [b]	Gas [c]	Total	
Tranformation to Power & Heat	160.9	NA	11.2	21.4	193.5	8.3 t-co2/toe
台電自有	136.8	NA	10.6	18.2	165.6	
民營電廠	16.1	NA	0.0	2.1	18.2	
汽電共生	8.0	NA	0.6	1.1	9.7	
Total emissions						2.8 t-co2/toe

Notes:

a *Coal refers to raw coal and coal products.* ***b*** *Such as gasoline, diesel, LPG, naphtha, fuel oil, etc.* ***c*** *Includes natural gas and town gas.*

d *Includes geothermal, wind, solar, tidal and biomass.* ***e*** *Includes energy use by non-heat/electricity tranformation industries (e.g. refininers, LNG plants, etc…).*

Greenhouse gas emissions table

Member Economy　TW

Year:117

Units: $MtCO_{2e}$	Coal [a]	Oil	Petrol. Prod. [b]	Gas [c]	Total	
Tranformation to Power & Heat	251.0	NA	7.5	29.5	287.9	9.8 t-co2/toe
台電自有	213.3	NA	7.1	25.1	245.5	
民營電廠	25.1	NA	0.0	2.9	28.0	
汽電共生	12.5	NA	0.4	1.5	14.4	
Total emissions						3.3 t-co2/toe

Notes:

a *Coal refers to raw coal and coal products.* ***b*** *Such as gasoline, diesel, LPG, naphtha, fuel oil, etc.* ***c*** *Includes natural gas and town gas.*

d *Includes geothermal, wind, solar, tidal and biomass.* ***e*** *Includes energy use by non-heat/electricity tranformation industries (e.g. refininers, LNG plants, etc…).*

第三章 瞭解中國能源政策-各區域之能源效率 (Understanding Energy in China-Geographies of Energy Efficiency) (2008~2009 計畫)

一、計畫內容摘要

1. 中國中央和地方的能效政策

長期以來中國政府一直致力於節約能源資源、提高能源效率的工作。為了保障能源安全，推動可持續經濟發展，以及減少因高速經濟成長對環境可能產生的破壞，節能工作視為中國能源發展重要戰略。自 2004 年頒佈《節能中長期規劃》以來，中國採取了一系列行動，以使中國未來能夠發展出一套低能耗的發展模式。“十一五國民經濟和社會發展規劃綱要”為中國節約資源和環境保護發展提供了堅實的政策基礎。不僅中國的領導階層與全世界的觀察家們都期待中國中央層面的節能政策是否能真正幫助減少其工業迅速發展對能源的需求。以往的研究，包括亞太能源研究中心之中國專案的一期報告明確了在目前經濟情況下中國能源政策執行時遭遇的各種挑戰，如經濟的快速發展、工業化和城市化、市場化改革和全球化等等都是其中的因素。對政策執行的研究，全力瞭解中央層面的能效政策是如何被各個行業、地區和企業所執行。在中國政策的成功執行已經給能源節約戰略能否最終成功提供借鑒，這種預測將對全球能源展望產生深遠的影響。中國政府確定將使人均國民生產總值在 2020 年期間達到 2000 年的四倍，努力提高人民的生活水準的目標。同時，能源需求總量將伴隨著的增加，必須對能源的快速發展進行適時、適地和適式的宏觀調控。雖然在一定程度上能夠提供所需的能源，但是隨之付出的環境方

面的代價會破壞業已改善的生活水準，因此，在“十一五”期間減低能源密度 20% 成了一個強制性的指標。

2. 定義中國能效的“Geographies”

中國能源政策中相當重要的變化在地區層面表現為，中央把降低能源密度的總體指標在地區層面進行分解、落實；地區把降低能源密度的指標與地區整體經濟社會發展結合起來，並按照中央政策要求執行政策或者使國家條令附有法律效應。到目前為止，事實證明中國所有地區採取了相應措施來實現它們各自的節能目標，許多地區的節能成績也在幫助推動“十一五”期間 20%這個整體目標的最終實現。儘管如此，有些地區沒有完成其預定的年度節能目標，而且許多中央層面的節能措施還沒有能夠在各地獲得有效的實施。與節能目標有關的各種資料表明了中國在節能方面已經取得的成就。節能成效所引起的各種變化一直在被評估中，這是各級政府實施的目標責任制的關鍵點。事實上，各種由中央和地方政府頒佈的條例和法令表明評分的結果在使行政命令、獎勵和公眾獎勵變成真正地激勵節能努力的各項行動是十分有效的。中國近幾年進行的一系列機構調整目的是為了加強能源政策獲得更有效執行。中國國家發展和改革委員會承擔起了最主要的“十一五”節能政策的執行工作。節能目標需要在各個能源部門獲得更多和更深的執行，也就迫使各個政府主管部門進行更多的協調與配合。中國特有的自上而下的行政機構設置使得政策及有關政策執行的各項指令較易在地區層面上獲得傳遞。中國疆域遼闊差異性相對較大，在能效和節能措施方面尤為如此。各個地區的能源密度有很大不同；在同一個行業，效率最高的和落後的企業之間差異也很大。中國在節能努力的過程中考慮到了這些差異性，行業設定了能效的基準，以該行業中最高能效為標準來指導改進整個行業的效率。對於地方政府而言，其執行政策的靈活性比較大，可以採用各種不同的措施來實現其節能目標。即各地存在著很大的差異性。因此，各項法令與

措施必須因地制宜。

3. 發電業從擴張到產業升級火電廠熱耗率和輸配電損失是電力部門效率高低的關鍵指標

中國擁有超過 6,000 個火電機組，超過四分之三的機組容量小於 100 百萬瓦。這些小火電機組效率遠低於 600 百萬瓦以上之大型機組，裝置大容量之發電機組，中國一直是居於世界的領先地位。目前政策之一是藉由關閉小型和老舊之機組以提升電力部門之整體效率。雖然這項政策往往不受當地小電廠持有者的歡迎，但在 2007 年，還是成功地關閉了 23.4GW 的小型火電廠，使整體火電機組平均熱耗率由每千瓦時 356 克標準煤耗降至 345 克。

持續淘汰效率低之小火電廠可進一步提高火電機組的效率。近年來增加了在輸配電系統的設備投資，這將整合整個電力工業的發電能力，也可提高電網的穩定性和降低系統線路損失。國家發電公司與電網公司通力合作以積極改善電力供應側效率的同時，政府也鼓勵地方政府或企業集團發展熱電聯產系統，北京高碑店熱電聯產具有高的運轉效率。

4. 打造世界級的鋼鐵業

到目前為止，中國的鋼鐵行業就其生產總量位列世界第一，它占了中國終端能源總需求的將近 20%。該行業以遍佈全中國、整合性較差以及擁有較多低能效的小廠為特徵，但也擁有超過 3000 萬噸先進的生產力。作為中國經濟改革過程的一部分，政府減少了對該行業的行政干預。鋼鐵生產商們越變得獨立，它們的低效率也越顯現出來。克服這些低效率的過程以加強能源密度的改進，一直到 2002 年。現在政府利用其與該行業的緊密關聯通過更加大幅度的行業重組和推動先進的高能效技術的使用來提高能效。通過與地方和行業簽訂目標責任書，中國已經成功地關閉了超過了 4600 萬噸的落後鋼鐵生產能力。新建生產能力其規模、能效水準、生產過程和生產設備必須符合

政府的要求。除此以外，有超過 250 個鋼鐵企業參加了千家企業節能活動，該活動要求這些企業在地方政府的監督下達到特定的降低能源密度的目標。政府雖然對技術規格和節能目標的設定十分清楚，但是財政支持是節能工作中很薄弱的環節。企業兼併和吸收國外資金可以為能效的提高提供一定的財力支援，同時政府的資金支援能夠促進提高能效技術的廣泛發展。

5. 多種方法提升製造業能效

中國的製造業在推動中國降低能源密度上起著雙重的作用。首先，它們幫助推動提高產品能效。其次，它們通過提高設備的能源效率以提高其產品的附加值來降低企業自身的能源密度。中國沿海的製造中心，特別是中國在沿海地區的經濟特區是製造業能效提高最佳地區。雖然這些地區私營企業比較多，但是政府與行業的合作依然十分密切。同時，製造商們在政府各種措施的不斷推動下致力於把節能產品帶到市場上。能源價格逐漸從政府管控中鬆綁也使得製造商們有更多機會來提高它們的能效。沿海地區節能成效能夠被普及到中國內地較落後的地區。

6. 面向綠色生活的住宅和商業部門

雖然住宅和商業部門在中國能源消費中占的比重沒有工業部門那麼大，但是這部分增長得很快。這個部門的能源效益提高潛力很大，政府很多年以前已經開始著手此項工作。最近幾年的政策給住宅和商業部門設定了更高的減少能源消耗的目標，特別是在建築領域，即擴大了建築節能所涉及的範圍並對所用產品提出了性能標準和標識的要求。政策的執行和對執行效果的監督對減緩住宅和商業部門的能源消耗的增長趨勢十分重要。目前實施節能行動激勵廠家把高能效產品提供給住宅和商業部門的消費者，也對不能配合的廠家依據實《中國節能法》的修改案的法律懲罰。“十一五”期間，地方政府正在加強監督和政策執行。但是新的建築面積的迅速增加，家電的普及

給節能政策的執行帶來的困難，另一方面顯示了節能的重要性。

7. 公共機構節能成效

中國有一個地方有著很大的節能潛力，那就是政府機構節能。政府機構擁有超過 1 億平方米的建築總面積，提供辦公和工作人員住宿使用。這些建築的能源消耗量大大超過相同建築在歐洲和日本的能源消耗量。在國務院機關事務管理局的領導下，從 2001 年開始進行政府機構節能行動以在政府機構普及節能的知識以及逐步制訂和執行節能的各項措施。這些措施包括對建築能耗的監控、對建築的翻修、加強對所屬車輛油耗的管理以及政府採購節能產品。國務院機關事務管理局通過統計資料證實節能行動最終使公共機構建築用電從 2005 年的每平方米 81.3 度電降低到了 2008 年的 73.1 度電。

中國採取了各種不同的政策執行策略以滿足其有較大差異性的各地能效的提高的要求。不斷地通過監控進行評估獲得對其制訂的政策的回饋並根據回饋進行政策的調整和改進政策的目標。

二、電力部門擴充與升級

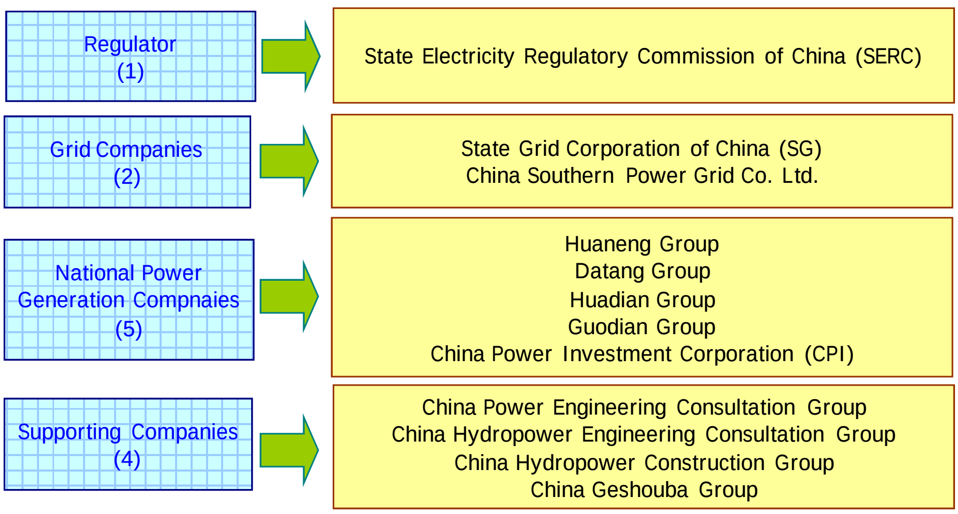
1. 中國電力工業之發展

為了因應電力負成長與缺電問題，自從 2003 年起，中國電力部門即加強發電容量之擴充，當缺電問題解決後，電力部門之能源效率與環境改善則列入重要之項目，不僅著力於發電側效率之改善，更對於輸電傳輸加強改善。

中國電力部門在 2002 年改革供給面，將電廠與電網分開運作。本章即就電力供應面之政策，能源效率提加以說明。

在 2002 年電力部門之改革如圖 4-1 所示，中國國家發改委（the National Development and Reform Commission，NDRC）為電力部門之主要管制單位。而國家電力管制局（the State Electricity Regulatory Commission）負電力部門商業之運作，包括電費之制定。目前，有兩

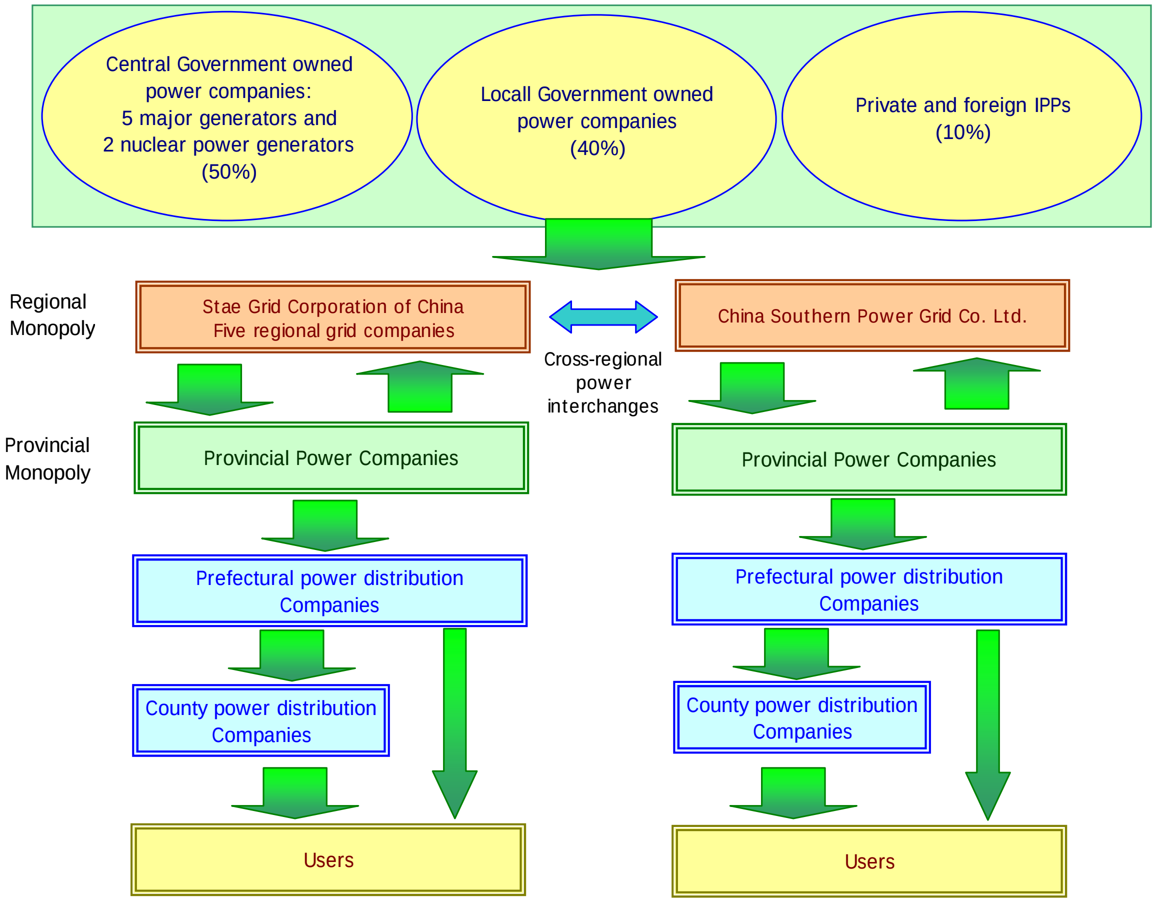
個主要電網公司，中國國網公司（State Grid Corporation of China）包括華北（北京、湖北、山西、山東）發電裝置容量達 129.2GW；東北（東蒙古、遼寧、吉林與黑龍江），發電裝置容量 55.8GW，華東（上海、江蘇、浙江、安徽、和福建）發電裝置容量 164.6GW；華中（江西、河南、湖北、湖南、重慶、四川）發電裝置容量 154.3GW；西北（陝西、甘肅、青海、遼夏、新疆）發電裝置容量 47.1GW，中國南方電網（廣東、廣西、海南、貴州、雲南）發電裝置容量 128GW，與中國南方電網公（China Southern Power Grid Co. Ltd.），發電部分包括五個國家級發電公司、地區發電公司和獨立發電業等。



Source: China Power Industry Association, China Power Industry Development Annual Report 2005

圖 3-1 Composition of China's Restructured Electricity Sector

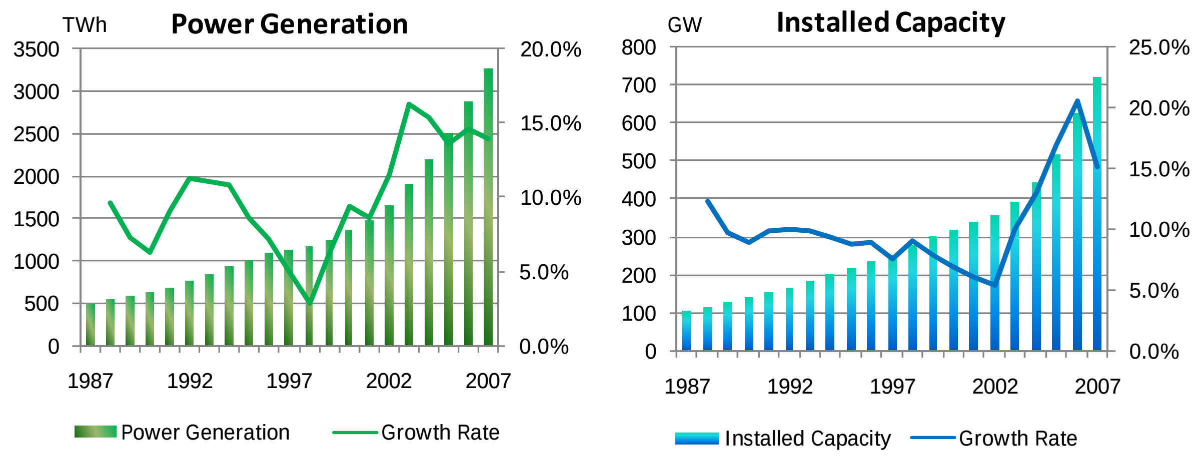
圖 4-2 為電力傳輸之流程圖，圖中在發電側，中央政府擁有 5 大發電公司與核能電廠約占總容量 50%，地方政府 40%，私人與 IPP 占 10%。



Source: State Electricity Regulatory Commission

圖 3-2　Flow of Electricity

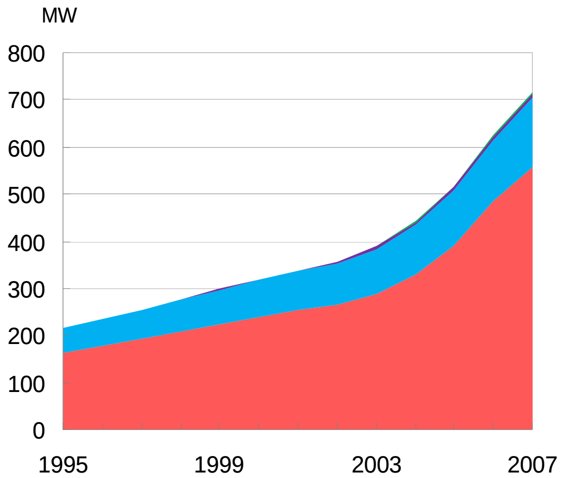
過去兩個世紀，中國電力發電裝置容量成長迅速，如圖 4-3 所示，發電量成長在 1998 年僅 3%，到 2003 年成長率達到高峰為 16%。而年裝置容量從 2002 年成長率 5%到 2006 年 21%。



Source: China Electric Power Yearbook 2008

圖 3-3　Power Generation China, 1987~2007

在 1990 年區間，能源價格相對低點，燃煤和水力機組為中國最主要發電來源，如圖 4-4 所示。隨著經濟成長與用電量激增，除了增設燃煤機組外，更開發三峽水力發電於 2003 年開始運轉；在過去兩個世紀火力發電為主體約占 75%，其次為水力 21~25%，核能占 1 %。中國在 2003 年至 2004 年間電力短缺，中國改變核能發的政策，2007 年核能裝置容量僅 8,850MW，將來大力發展核能發電。



	Installed Capacity 2007		Capacity Increase 1995 to 2007	
	GW	%	GW	%
Thermal	556	77	393	78
Hydro	148	21	96	19
Nuclear	9	1	7	1
Others	5	1	5	1
Total	718	100	501	100

Source: IEA (1987~2004), China Electric Power Yearbook (2005 ~ 2008)

圖 3-4　Installed Capacity by Energy Source: 1995~2007

2. 改善能源效率之政策（2006~2010）

在中國第十一之五年計畫，其最重要之政策即是改善電力部門之能源效率，首先須先淘汰效率低之小型火力機組，改以高效率、高容量之機組取代，目前已發展商轉超超臨界燃煤機組 600MW，其效率已達 44%以上，其次為輸電線路之強化，減少輸電之損失等，茲將電力部門改善能源效率能源安全和節能之政策摘要如下：

- 發展先進發電設備，如靠近煤場大容量發電廠之設置，大水力發電廠，大容量燃氣之複循環機組，節水的發電廠與核能發電。
- 發展大容量高效率之電力發電技術，如裝置容量至少達 600MW 之超臨界與超超臨界火力機組。
- 限制建造傳統中容量或小容量之機組（300MW 以下）加入在高壓之輸電網上。
- 發展高容量、長距離、電力輸電技術和更新電網之運轉技術。
- 在北方需熱氣之中大型城市發展汽電共生之發電裝置，提昇能源使用效率。

3. 電力傳輸的改善

中國電力部門最大負擔即是一次能源無對稱之分布與電力中心市場。為此;中國正積極建造由西至東三大主要長距離幹線之電力傳輸計畫,藉此連接西部之電源供給至東部之負載中心。目前此三大幹線總輸電容量已達 47.5GW。

這些建造之幹線,其最大容量 DC 500KV 和交流輸電線從雲南連接至廣東之 800KV 輸電線其總長度約 1438KM,連接山西、河南至湖北 1000KV 之輸電線其總長度約 654KM。這些由西至東之輸電線建造,也可帶動中、西部地區之經濟發展。

未來電力部門效率之提昇與節能,除了發展超超臨界 600MW 之機組提昇至 1000MW 容量機組,超高壓之輸電線路建造,地區配電網路之建設外,更須加強負載系統管理(Demand System Management)與發展非化石料之電源,如核能與再生能源等。這些政策除中央主導外,尚須地方政府之全力配合,始能達到事半功倍之效。

第四章　智慧電網（Smart Grid）

一、日本

日本著重於發展太陽能以減低 CO2 之排放。為達此目的，日本已著手裝置智慧電表與自動讀表系統，以利控制電力供給之可靠與保證其供電品質，目前日本風力裝置容量 2009 年為 2.1GW、PV 為 2.4GW，將來大量推廣太陽能至 2020 年，PV 預計裝置容量須達 28GW，2030 年達 53GW，為 2005 年之 40 倍，其中，60%裝置於住宅區域，其餘 40%非住宅區，如工業、商業等區域，詳如圖 4-1，表 4-1 所示為日本計畫之摘要表，其從發電端、輸電端、配電端及應用，此表各項計畫日本計畫均參與其中。此計畫摘要表依已執行與規劃兩項分別呈現。

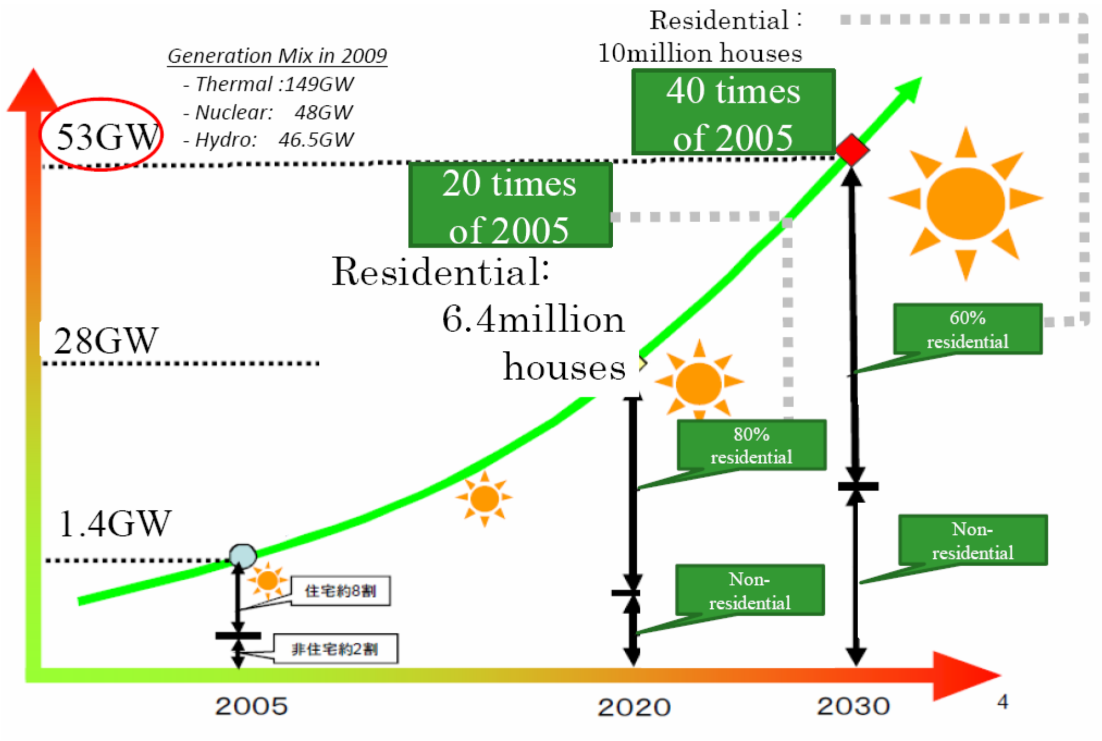
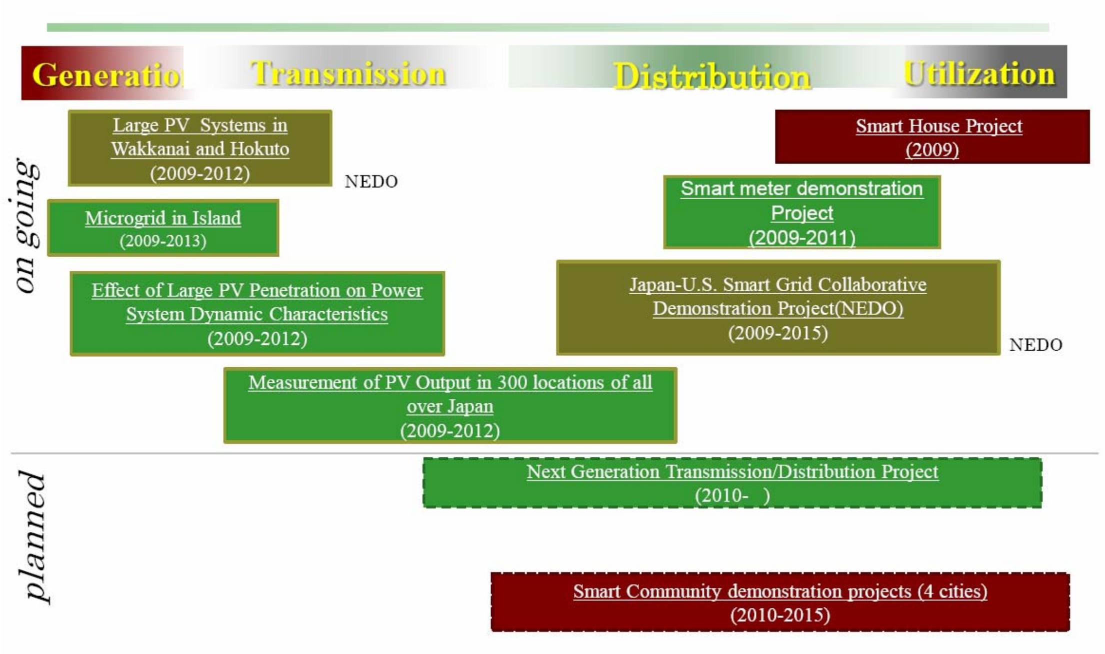


圖 4-1　Perspective of PV Integration

表 4-1　Summary of SmartGrid / Microgrid Projects (Japanese government evolved)



二、韓國

韓國智慧電網由智慧區域、智慧再生能源、智慧交通網三個平台結合智慧之電力市場與智慧電力網，形成如圖 4-2。其發展目標分短期與長期；短期目標為 2012 年，完成主要運轉技術配置，配電自動化與鋪設主要之通訊網路。長期目標為 2020 年，完成 WAMS，系統能自動 Self-healing。配電能源資源建設與先進通訊網路如圖 4-3 所示。

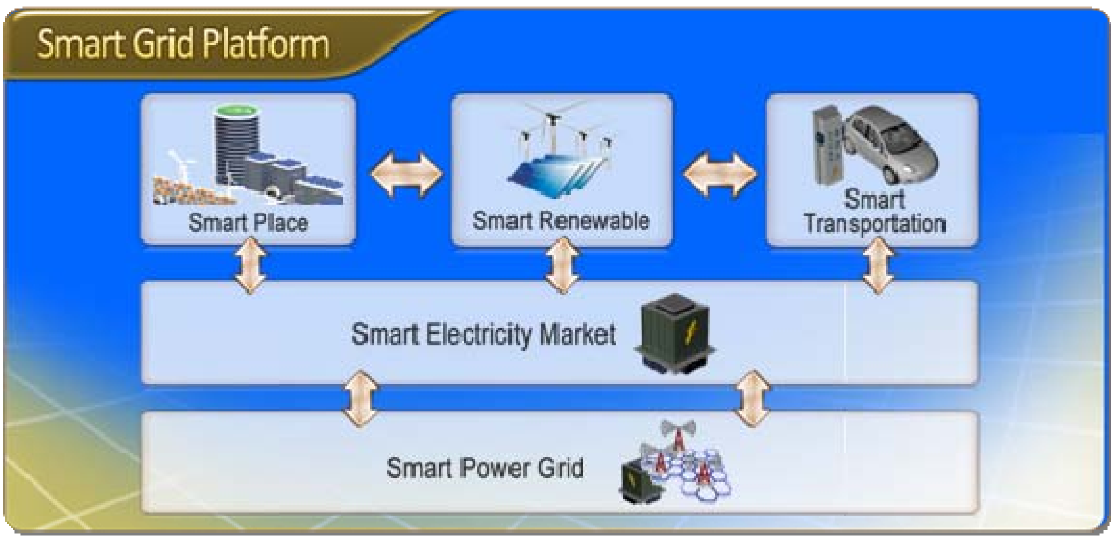


圖 4-2　Smart Grid Platform

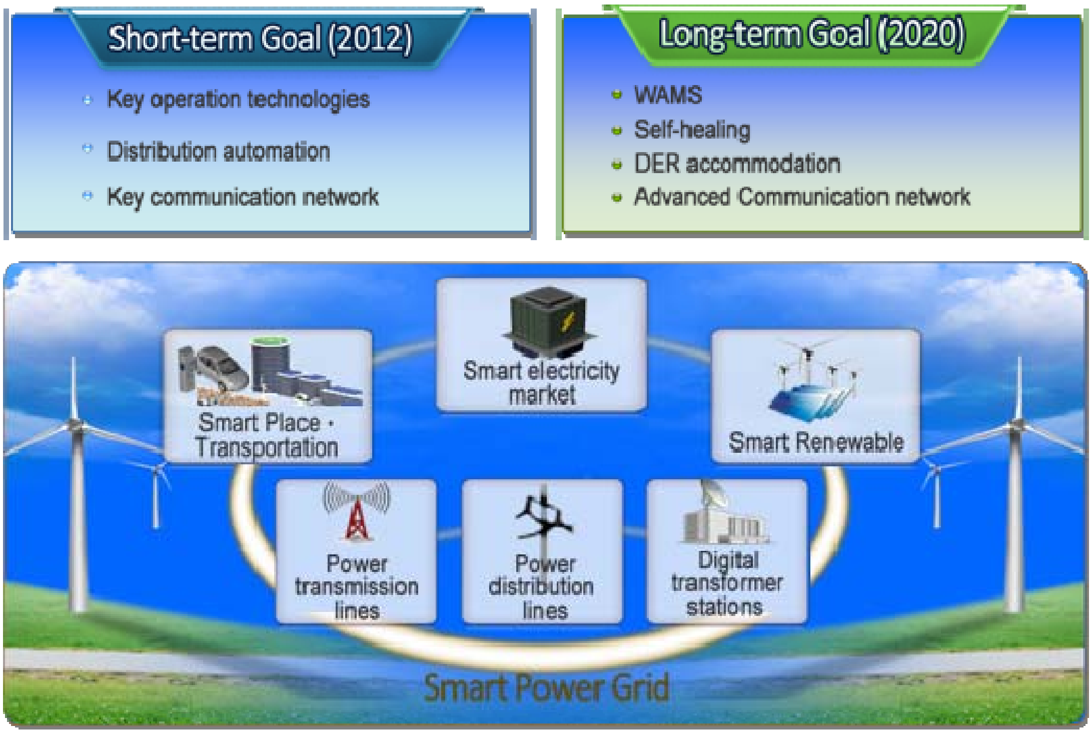


圖 4-3　Smart Power Grid

■ 智慧用戶：

至 2012 年透過 AMI 即時資訊交換與動態之電能價格，至 2020 年時，所有用戶均加入此系統，透過 AMI 可自動零售交易，如圖 4-4 所示。

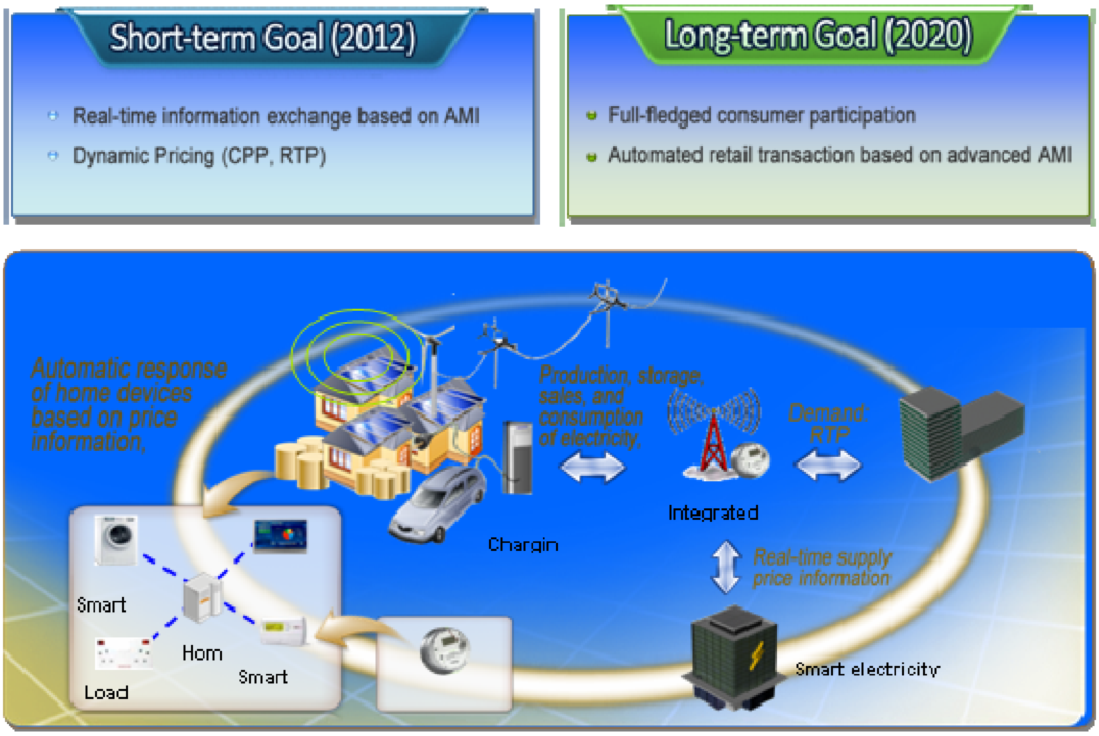


圖 4-4　Smart Consumer

■　**智慧再生能源：**

至 2012 年完成整合微電網，商業化之儲能產品，至 2020 年完成所有配電能源資源建設與微電網與大型之儲能系統如圖 4-5 所示。

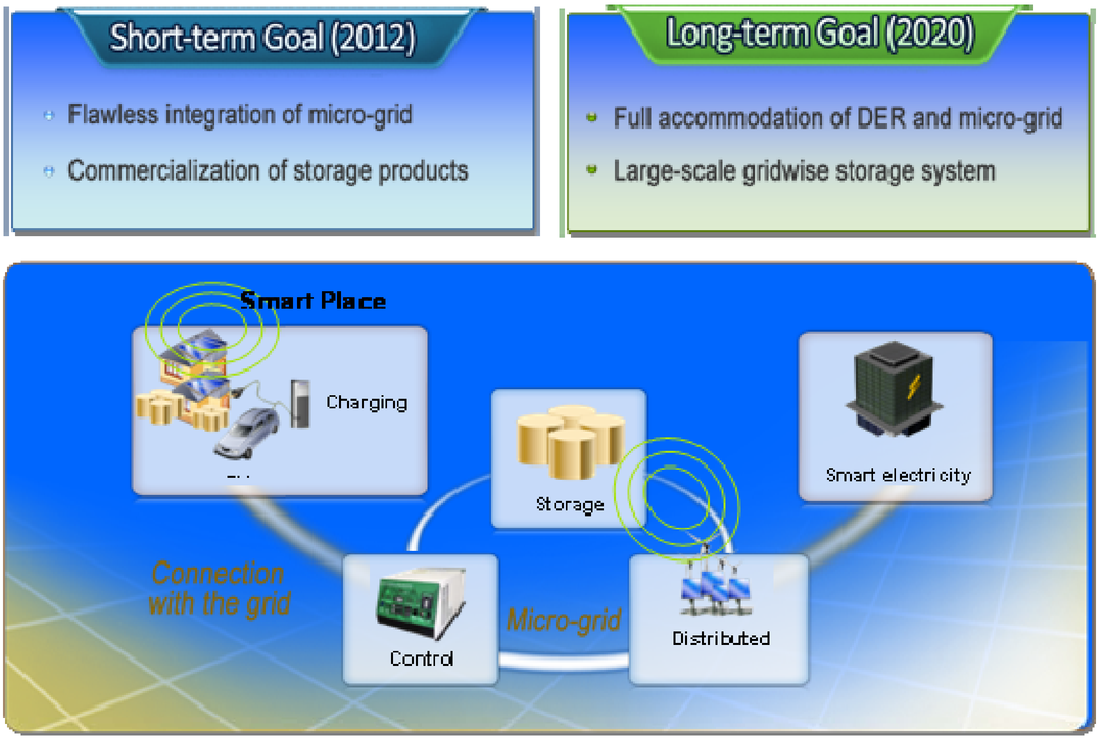


圖 4-5 Smart Renewables

■ **智慧交通：**

至 2012 年完成區域 EV 充電設施與達成 EV 之運轉，至 2020 年完成全國 EV 充電設施與方便簡便充電系統如圖 4-6 所示。

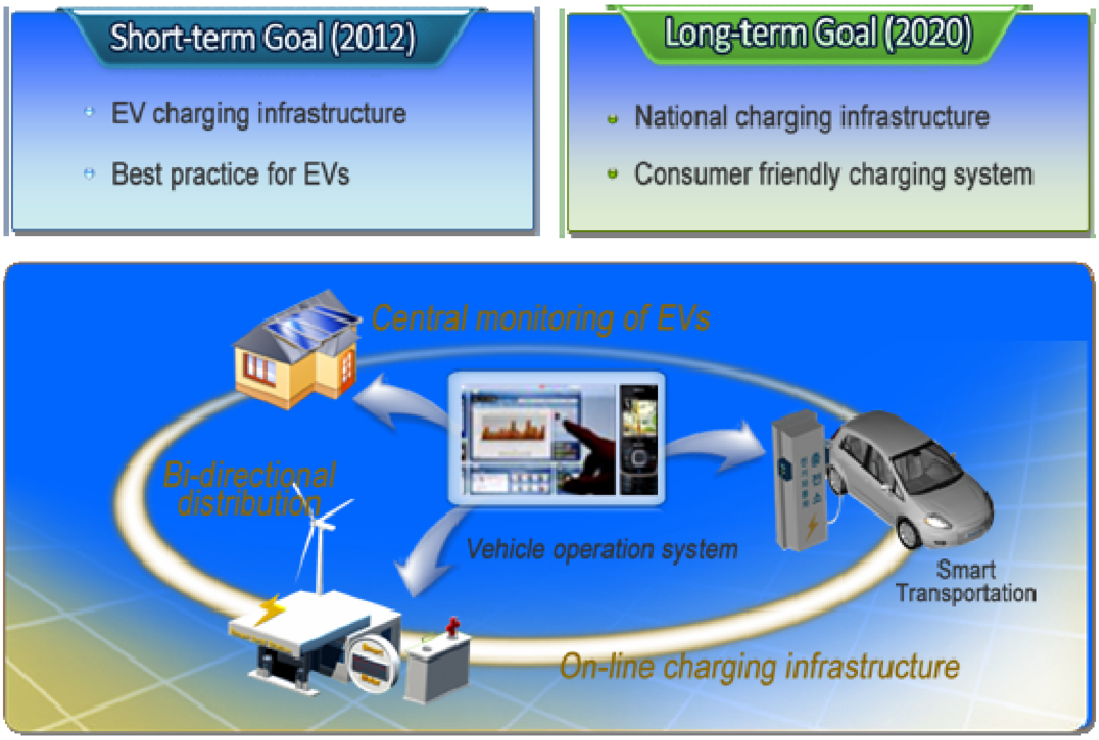


圖 4-6　Smart Transportation

■ **智慧電力市場：**

至 2012 年完成量販(wholesale)電力市場下之電力零售交易及簡易明白動態電力價格。至 2020 年完成全國零售之電力市場，融合不同性質工業用戶加入並期待完成亞洲最快之網路系統如圖 4-7 所示。

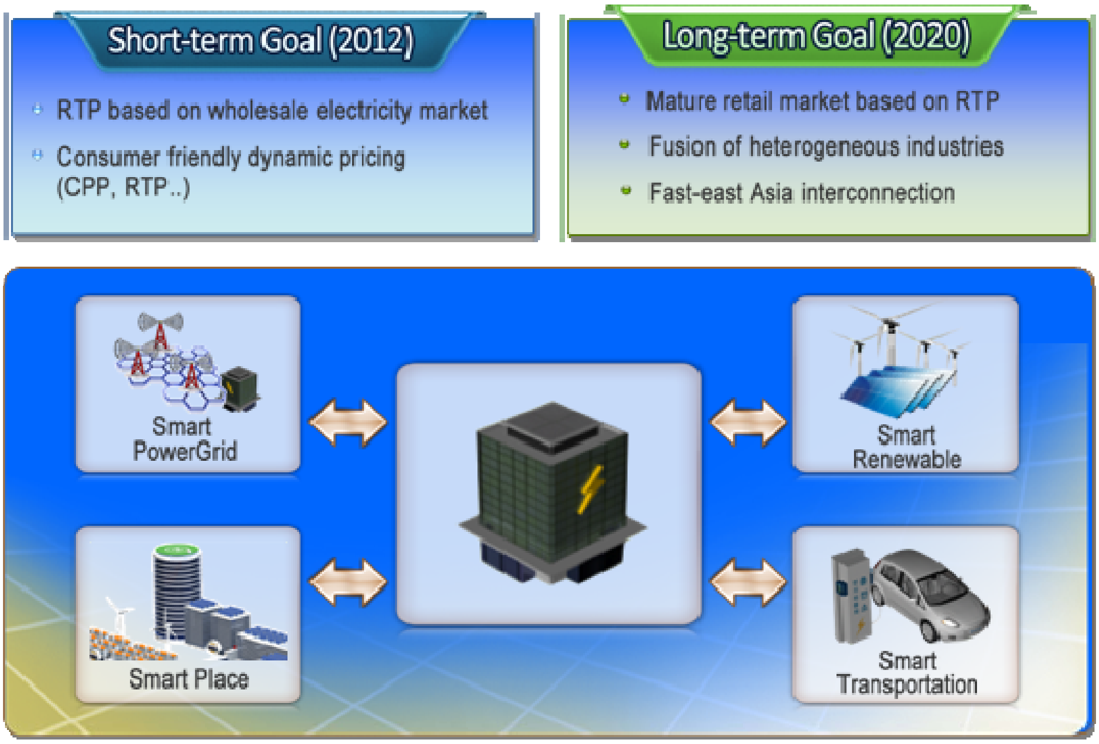


圖 4-7　Smart Electricity Market

第五章　結論與建議

1. 燃煤機組裝置容量減少，最主要取決於政府政策與逐漸上升之碳價，屆時碳價達到適當之高點時，CCS 即為商業選項之一。
2. 政府為抑低二氧化碳排放量，鼓勵燃氣發電量於 2025 年須達全發電量 25%，屆時燃氣發量必再創新高，天然氣用量提高後，對於天然氣採購日形困難。
3. 超超臨界和氣化複循環燃煤機組，其技術上之突破，將來勢必為重要發電來源。
4. 再生能源電源推廣端賴其發電成本與儲能系統之搭配；將來再生能源發電除提高其發電效率外，減少對系統之衝擊，如能克服，則再生能源對整體發電占比勢必攀升。
5. 日本福島 311 核能事件後，再生能源（風力與太陽能）更受各國之重視與發展，台電除配合政府政策發展風力與太陽能外，為加強電能安全與效率，為達此目的，智慧電網為不可或缺的一環。
6. 高效率複循環燃氣氣組(CCGT)，其效率可望在近期內提昇至 50%以上。
7. 高效率燃煤機組，如超越臨界機組使用增加鍋爐之溫度，使其發電效率能達 40%以上。另外考量氣體之複循環燃煤機組(IGCC)，有較先進技術，易於捕捉機組排放之二氧化碳。將來碳捕捉與儲存，可助燃煤機組僅排放少許之二氧化碳量。
8. 智慧電網：使用現代資訊技術，使電力系統更可靠、更有效率。智慧電網能夠藉由此快速反應，減少故障機率，使再生能源如風、太陽能等發電有更好之利用，且電力發電與儲存設備有更好之協調應用，達到低成本與高可靠度之電力系統。智慧電網發展除利用 AMI 達到節能減碳之功用，對我國發展再生能源產業與資訊產業必帶來新的商機。

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[3] APERC website http://www.ieej.or.jp/APERC

附錄：APERC 研究期間負責完成計畫項目並撰寫報告摘錄如下

CHINA

- *Rapid economic growth will drive an average annual growth rate of 2.4 percent in China's final energy demand over the outlook period.*
- *The total primary energy supply is projected to grow at 2.6 percent annually over the period; this includes average annual growth rates of 1.9 percent for coal, 3.1 percent for oil and about 7.7 percent for natural gas.*
- *China's oil import dependency will increase from 38 percent in 2005 to 72 percent in 2030.*
- *Nuclear energy production is expected to grow 11.9 percent between 2005 and 2030; this increase will be key to China reducing CO_2 emissions over the outlook period.*
- *Renewable energy is projected to grow significantly: 16.5 percent between 2005 and 2030.*

ECONOMY

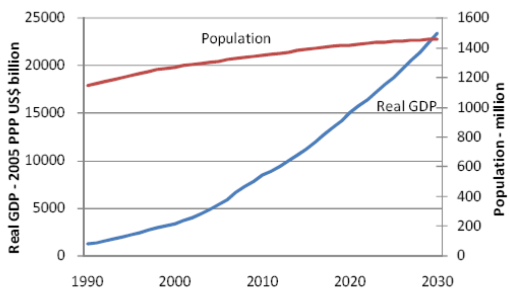
China's land area covers 9,596,961 square kilometres, making it the fourth largest economy in size in the world, after Russia, Canada, and the US. It features a range of landscape types, including mountains, deserts and river basins. The economy's population growth will be restrained during the outlook period, growing 0.4 percent per year compared with an average annual growth of 1.4 percent in the three decades from 1975. The total population is expected to increase to about 1.45 billion by 2030 – 20 percent of the world population.

China is the third largest economy in the world after the US and Japan with a nominal GDP of US$4.4 trillion in 2008. It has sustained high rates of economic growth since the early 1990s; the annual growth rates for 1991–2007 range between 7.6 and 14.2 percent.[57] However, in the late 1990s, growth slowed slightly, and energy consumption also levelled off during 1997–2000. Since 2001, as GDP growth sped up again, along with rates of industrialization, urbanization and motorization, China's energy consumption has grown rapidly.[58] The Chinese economy is expected to grow robustly over the outlook period, at an average annual rate of 6.1 percent – this is the fastest rate projected for all APEC economies.

In particular, China's oil demand increased in response to rising car ownership and industrial development, so that by 2005 it accounted for 19 percent of the economy's total energy demand.

Recent growth in China's energy demand has mainly been driven by rapid growth in industry; in 2006, industry as a whole accounted for 43.8 percent of final energy consumption.[59] While there is some investment in light manufacturing, the main area of growth has been in a comeback of heavy industry since 2001.[60] Within this sector, energy use is dominated by smelting of ferrous metals (29 percent of all industrial energy used in 2006), followed by non-metal mineral industry (21 percent).[61]

Figure PRC1: GDP and population



Source: APERC analysis (2009)

The transportation sector accounted for around 10.5 percent of final energy consumption in 2006; this increased at 9.1 percent annually from 2000 to 2005. This growth in demand is mainly driven by road transportation, which consumes 66.7 percent of this sector's energy use.[62] Passenger vehicle numbers, including civil and private, have grown at an average annual rate of 24 percent from 2000 to 2007.[63] While China is making significant investments in public transportation, including high-speed rail and urban mass transit rail systems, private vehicle ownership is still expected to rise sharply.[64]

The 'other' sector, which is mainly residential and commercial use, accounted for 37 percent of the economy's final energy demand in 2006. Residential

57 IMF (2009).
58 NBS (2008), Energy/6-2.
59 IEA (2008A), II.92.
60 APERC (2008), p 115.
61 IEA (2008A), II.92.
62 Ibid.
63 NBS (2008), Transport/15-26, 15-27.
64 IEA (2007), pp 378–379.

energy use dominates (75.8 percent of this sector's energy use in 2006), followed by agriculture and commercial, at about 10 percent each.[65]

Most of the rural areas in China now have electricity supply; the 2005 electrification figure was 99.4 percent of households.[66] Growth in residential energy demand, however, is mainly due to increasing urbanization. The urban population, concentrated in the Bohai Bay Rim, the Yangtze River Delta and the Pearl River Delta, has grown annually at 3.1 percent from 2000 to 2005, while the rural population has experienced negative population growth.[67] These increases in urbanization and the move toward nuclear families translate into a higher quality of life, and also to increases in total energy demand, as urban residents tend to be more dependent on electricity and commercial fuels than the rural population.[68]

Across the whole of China, heating and cooling is one of the top five residential uses of energy. However, the actual level of demand ranges widely across the economy's varying geography; for instance, in Guanzhou heating and cooling consumes 32 percent of household energy use, while in Shenyang it can be as low as 1 percent of total electric demand.[69]

ENERGY RESOURCES

China is rich in energy resources, particularly coal. In 2006, China was the largest producer and consumer of coal in the world, as well as the fifth largest producer, and second largest consumer, of oil. However, after a long history of being a net oil exporter, China became a net oil importer in 1993. According to recent estimates, China has recoverable coal reserves of some 114.5 billion tonnes, enough to last 44 years at 2007 demand levels; proven oil reserves of 2,100 million tonnes, which will last 5.6 years at 2008 demand levels; and proven natural gas reserves of 2,460 bcm, equivalent to 30 years demand at 2008 levels.[70] In addition, China is endowed with 400 GW of hydroelectric generation potential, more than any other economy in the world (2007 installed hydro capacity was 148 GW). There is also potential wind-based generation of 1000 GW, including 750 GW offshore and 250 GW shore-based.[71] Most of the economy's existing electricity generation is coal fired, with coal accounting for 79 percent of electricity production in 2005.

Much of the growth in domestic energy demand for crude oil is being met by imports. The expansion of domestic crude oil production and refinery capacity has not been sufficient to match the rapid increase in demand for diesel and gasoline. China's increased take from the global oil market has had significant impact internationally, tightening the overall balance between demand and supply. Chinese oil companies are also trying to boost overseas investment levels in order to ensure stable supplies.

In 2007, China's total investment in renewable energy was ranked second in the world at US$12 billion, after Germany, which invested US$14 billion.[72] Additions of 2.1 GW installed capacity increased the wind power total installed capacity to 4.2 GW in 2007.[73] In addition, China has been speeding up installation of solar photovoltaic power generation: in early 2007 the installed capacity was 20 MWp, which had risen to 200 MWp at the end of that year. China produced 1088 MWp of solar cells in 2007, exceeding production rates in Japan (920 MWp) and Europe (1062 MWp).[74]

ENERGY POLICIES

In a context of rising demand and constrained supply, China has made energy security the top priority in its energy policy objectives. The economy's "11th five-year plan" sets out a programme for the enhancement of energy security, with strong emphasis on energy efficiency. By 2010, China aims to improve energy intensity by 20 percent, compared with 2005 levels. A number of measures have been implemented to this end, including modernization of energy industries, with the closure of small coalmines, electricity plants, refineries, and iron-and-steel production plants; and the introduction of efficient technologies throughout the energy supply chain, from production and transportation through to consumption.[75]

In recognition of its vulnerability to international market changes, China has been trying to increase the security of its oil supply through intensifying its upstream investment activities in Kazakhstan, Venezuela, Sudan, Iraq, Iran and Peru. It also started developing a second cross-border oil pipeline project between China and Kazakhstan in 2008.[76]

65 IEA (2008A), II.92.
66 IEA (2006), p 570.
67 UN (2007).
68 APERC (2008), p 115–128.
69 APERC (2008), p 121.
70 2007 coal consumption from NBS (2008), p 246; all proved reserves and consumption other than coal from BP (2009).
71 Wu (2007).
72 The Climate Group (2008).
73 CEPY (2008), p 732.
74 IPPGC (2009).
75 NDRC (2007).
76 CIIC (2009).

The government has been steadily implementing energy sector reforms. Gains have been made in the management of energy, and law around energy saving has been noticeably strengthened. The new government elected by the 11th National People's Congress in 2008, has established a high-level coordinating body with the aim of strengthening decision-making in the energy area: the National Energy Committee is in charge of drawing up the economy's overall energy strategy, and deliberating on energy security issues.

One rapidly developing area is the use of combined heat and power (CHP) cogeneration. In northern China where demand for heat is great during winter, CHP offers good gains in energy efficiency, while also reducing air pollution and increasing overall power supply to communities – so allowing an increase in quality of life in a cold climate. Since energy reform policies were introduced in the 1970s, the installed capacity of heat and power cogeneration has grown quickly: from 10 GW in 1990, to 29.9 GW in 2000, and 69.8 GW in 2005 (annual average growth rates of 11.6 percent during 1990–2000, and 18.5 percent during 2001–2005). This expansion is seen to have made a considerable contribution to the economy and social development of China.[77]

The overall policy goals set by China for development of an efficient power sector are:[78]

- promoting the construction of highly efficient large-scale power plants, such as supercritical and extra supercritical coal-fired generation
- restricting the construction of small- and medium-sized conventional coal plants (300 MW and below) and closing inefficient small thermal power plants (China closed plants with total capacity of 23.36 GW in 2007)[79]
- promoting the construction of highly efficient combined heat and power plants to supply district heating in medium-sized and large cities
- promoting the construction of safely designed nuclear power plants.[80]

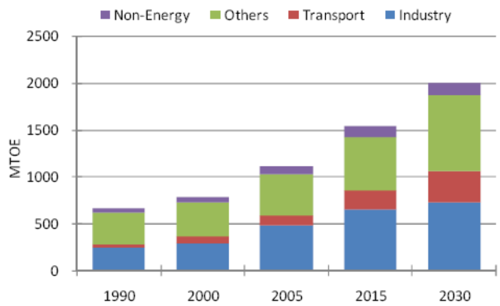
In 2008, the Chinese Ministry of Finance made a major budget allocation for energy saving and renewable energy, and it is expected this ministry's role in energy conservation promotion will increase greatly. Options being considered include: setting up a special fund to increase investment in energy conservation; adjusting the tax system to encourage energy conservation and promote the rational development and utilization of energy; improving government procurement policies to encourage government agencies to take the lead in energy saving; improving rates for use of resources and environment so that prices reflect real costs; and establishing a fund to support use of new renewable energy sources, to gradually reduce dependence on conventional sources of energy.[81]

OUTLOOK

FINAL ENERGY DEMAND

Over the forecast period, China's final energy demand is projected to grow at 2.4 percent per year, which is much slower than the average annual growth of 4.2 percent between 1985 and 2005. The 'other' sector will take up the largest share in 2030, at 40 percent, followed by the industry sector (36 percent) and transport (17 percent).

Figure PRC2: Final energy demand



Source: APERC analysis (2009)

Industry

China's industrial energy demand is projected to grow at an average annual rate of 1.7 percent until 2030; this is slower than its average annual growth of 2.6 percent between 1985 and 2005. More than two-thirds of the energy required in the industrial sector will be used by heavy industry, such as the processing of chemicals, metals, non-metallic minerals, mining and quarrying. Coal has been the major source of energy in China's industrial sector, although other energy sources such as oil and electricity have nibbled at its share. Over the forecast period, coal's share of the total industrial energy demand is expected to decline, reaching 46 percent by 2030, down from 59 percent in 2005. Coal is mainly used in the production of crude steel, cement, and chemicals.

77 CTJ (2008).
78 NDRC-STD (2006).
79 CPIA (2008).
80 NDRC (2007).
81 APERC (2009), p 56.

The share of the total industrial energy demand met by petroleum products is projected to decrease to 6 percent in 2030, down from 8 percent in 2005. The industrial demand for natural gas is projected to grow quickly, at 6.1 percent per year, compared with 3.5 percent average annual growth between 1985 and 2005. Despite the relatively fast increase in demand, the natural gas share of the total industrial energy demand will reach only 7 percent in 2030, up from 3 percent in 2005.

The industrial demand for electricity is projected to grow the fastest, at an average annual rate of 2.8 percent over the outlook period. It is expected to follow coal as this sector's dominant energy source by 2030, accounting for 32 percent of China's industrial energy demand. Manufacturing is the major industrial electricity user.

Transport

Chinese transportation energy demand is expected to grow by 4.4 percent annually over the outlook period. Gasoline, the main fuel for passenger vehicles, will see a 4.0 percent increase over the period, while diesel use for trucks and farm vehicles is expected to grow by 4.5 percent. Continued income growth will boost levels of passenger vehicle ownership.

Other

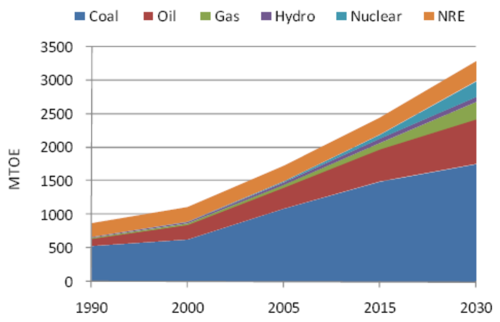
Energy demand in the 'other' sector, which includes residential, commercial, agricultural, and construction demand, is expected to grow at an average annual rate of 2.5 percent over the outlook period. Electricity and biomass are expected to continue to dominate the energy mix in this sector; electricity's share rises from 12 percent in 2005 to 26 percent in 2030, while biomass drops from 52 percent to 28 percent. This shift in the energy mix is based on increased urbanization and rising living standards.

PRIMARY ENERGY SUPPLY

China's total primary energy supply is projected to grow at an average annual rate of 2.6 percent – a slower pace than between 1985 and 2005, when the average annual growth was 2.9 percent.

Among the fossil fuels, natural gas will grow at the fastest pace (7.7 percent per year), followed by oil (3.1 percent) and coal (1.9 percent). Nuclear energy is expected to play a key role in reducing China's CO_2 emissions; it has a projected growth of 11.9 percent over the period, while new renewable energy has a projected growth of about 1.0 percent.

Figure PRC3: Primary energy supply



Source: APERC analysis (2009)

Coal demand will be largely driven by the electricity sector, which accounted for more than 50 percent of the total demand for this fuel in 2007.[82] China will continue to rely on coal to meet the rising demand for electricity, as the most cost-effective option it has; this is in the context of significant coal reserves and the expectation that China is likely to remain a net exporter of coal. The economy is projected to double its installed capacity of coal-fired electricity generation, from 381 GW in 2005 to 762 GW in 2030.

Growth in the industry and transportation sectors will boost demand for oil, with industry (including non-energy oil production) consuming 25 percent and transport using 52 percent of the total oil demand in 2030. As China's efforts to increase its oil supply will not match this rising demand, the economy's net oil import dependency is projected to increase from 38 percent in 2005 to 72 percent in 2030.

The natural gas share of the total primary energy supply will increase from 2 percent in 2005, to 4 percent in 2015, and 8 percent in 2030. China faces considerable difficulties importing and distributing natural gas, which has slowed its uptake of the fuel. Two major pipelines have begun operation or are under construction in the first decade of the twentieth century. The first West–East Gas Pipeline began operation in 2004. It brings natural gas from Kazakhstan to more than 70 cities and 3,000 large and medium-sized enterprises, supporting annual sales of 42 bcm; it is also the main gas source for the Bohai Sea, and Yangtze River Delta economic circles. Construction began in 2008 on the second West–East Gas Pipeline, which will run from Horgos in Xinjiang (where it connects to the Central Asia Gas Pipeline, bringing supply from Kazakhstan, Turkmenistan, and Uzbekistan), southeast to

82 NBS (2008).

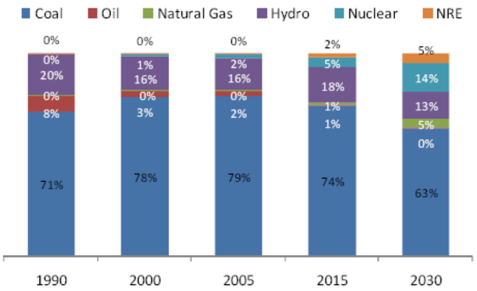
Guangzhou, and east to Shanghai. This 9,139 kilometre line will pass through 14 provinces and municipalities.[83] This second pipeline will deliver 30 bcm annually, a supply level expected to meet demand for 30 years.[84]

ELECTRICITY

Electricity demand in China will increase by 3.8 percent per year over the outlook period – this is more than twice as fast as it was increasing in the period to 2005. The economy's total electricity demand is expected to surpass that of the US sometime around 2025.

Throughout the outlook period, coal will maintain its dominant share in the electricity generation mix; it is projected to provide around 63 percent of generation in 2030. Generation based on natural gas will provide about 5 percent of the total generation mix. In coastal areas, gas-fired generation will replace coal-fired generation, as a result of reforms aimed at reducing emissions. Installed nuclear capacity is projected to increase substantially from 7 GW in 2005 to 70 GW in 2020, and further to 120 GW in 2030; however, the total nuclear share in the electricity generation mix will reach only 14 percent by 2030. Hydro will see a major expansion with the opening of the Three Gorges Dam project in 2009. By 2030, hydro capacity is expected to have reached 320 GW, up from 117 GW in 2005, and renewables-based capacity to reach 139 GW (mostly from wind), up from 3 GW in 2005.

Figure PRC4: Electricity generation mix



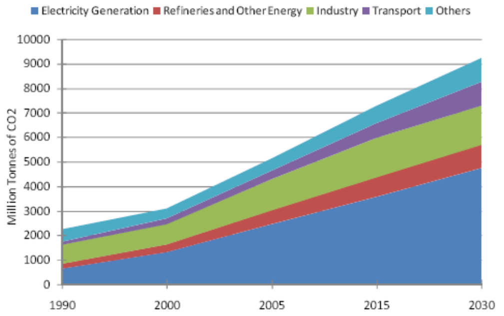
Source: APERC analysis (2009)

CO_2 EMISSIONS

Over the outlook period China's total CO_2 emissions are projected to increase from 5,131 million tonnes of CO_2 in 2005 to 9,225 million tonnes in 2030. Of the 2030 emissions, 51 percent will come from the electricity sector (about 4,741 million tonnes) and 17 percent from industry (1,600 million tonnes).

The decomposition analysis shown in the table below suggests that the growth in China's CO_2 emissions from fuel combustion will primarily be due to economic growth, moderated significantly by decreasing energy intensity. The decline in China's CO_2 intensity of energy by 0.3 percent during the outlook period is based on the commissioning of large capacity nuclear power plants and development of renewable energy resources.

Figure PRC5: CO_2 emissions by sector



Source: APERC analysis (2009)

Table PRC1: Analysis of reasons for change in CO_2 emissions from fuel combustion

(Average Annual Percent Change)

	1990-2005	2005-2015	2015-2030	2005-2030
Change in CO_2 Intensity of Energy	0.9%	-0.1%	-0.5%	-0.3%
Change in Energy Intensity of GDP	-4.9%	-3.7%	-2.8%	-3.2%
Change in GDP	10.1%	7.7%	5.0%	6.1%
Total Change	5.7%	3.6%	1.5%	2.3%

Source: APERC Analysis (2009)

CHALLENGES AND IMPLICATIONS

China is richly endowed with energy resources such as coal, oil, and hydro. However, the development of these energy sources is not sufficient to meet the economy's growing demand. On the electricity front, there is a need to create a regulatory framework that is attractive for investors, perhaps by means of rewarding investors who build more efficient and environmentally friendly plants.

China's new policy initiatives to promote energy efficiency are expected to reduce the economy's energy intensity significantly; however, the projected increases in living standards and continued economic growth, along with China's high reliance on coal, mean greenhouse gas emissions are still expected to climb significantly. With its large population and rapid economic growth, minimizing the significant environmental impact from the rapid projected

[83] CIIC (2008).

[84] CIIC (2009).

growth should be a top priority for the Chinese government, for without proper measures for fighting greenhouse gas emissions and pollution, China's economic development can create significant burden (on its citizens and the planet).

In terms of energy imports, net import dependency of oil is projected to increase from 38 percent in 2005 to 72 percent in 2030. The increasing energy imports, combined with depleting domestic resources, have raised concerns over energy supply security. While China is aggressively strengthening its relationships with resource-exporting countries, it must continue its effort if it wishes to avoid possible supply shocks and impediments to its high economic growth. Even without significant supply shocks, such high dependency on oil may impede economic growth due to unstable energy prices in China.

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HONG KONG, CHINA

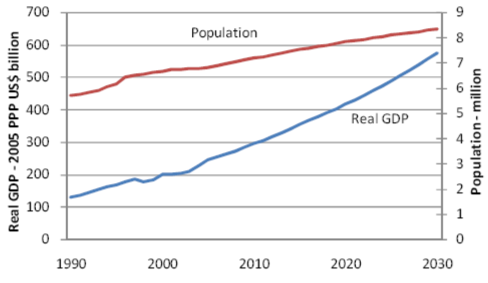
- *Hong Kong, China's primary energy supply is projected to grow at an average annual rate of 1 percent over the outlook period. Most of the increased demand is for oil for international air transport and local transport; in 2030 oil occupies a 40 percent share of the total primary energy supply.*
- *Hong Kong, China is expected to be increasingly dependent on imported energy from mainland China, with import levels doubling between 2005 and 2030.*
- *CO_2 emissions from fuel combustion are projected to reach 54 million tonnes of CO_2 by 2030, which is approximately a 28 percent increase on 2005 levels.*

ECONOMY

Hong Kong, China, is one of the special administrative regions of the People's Republic of China. It borders Guangdong to the north and is surrounded by the South China Sea to the east, west and south. Hong Kong, China is an international financial centre, and has a highly developed capitalist economy.

Hong Kong, China has been transforming itself into an almost entirely services-based economy. Its GDP is expected to grow at an average annual rate of 3.5 percent over the outlook period; this is a slowing down compared to average annual growth of 5.1 percent between 1985 and 2005. Besides the economy's traditional strengths in financial, logistics, property, tourism and services industries, Hong Kong, China's projected growth is based on an increase in knowledge-based and services industries, including fitness and beauty, theme parks, business consulting, and environmental industries. By 2030, it is expected that the services sector will contribute more than 95 percent of GDP. The population is expected to grow slowly at an average annual rate of 0.8 percent over the outlook period, reaching more than 8 million people in 2030.

Figure HKC1: GDP and population



Source: APERC analysis (2009)

Hong Kong, China's economy has a firm foundation in its strong financial services sector. It is expected to continue to shift towards higher-value-added services and a knowledge-based economy. To stay competitive and attain sustainable growth, Hong Kong, China needs to restructure and reposition itself to face the challenges posed by globalization and closer integration with mainland China. The Mainland and Hong Kong Closer Economic Partnership Arrangement (CEPA) is an example of the opportunities the economy has under the 'One Country, Two Systems' relationship with mainland China.[85] The trade in goods liberalization of CEPA means that all products of Hong Kong, China origin enjoy tariff-free access to mainland China – on application by local manufacturers, and as long as the CEPA rules of origin are satisfied. And from January 2008, service suppliers in Hong Kong, China enjoy preferential treatment in 38 service areas in mainland China.

The government's strategy is to move up the value chain by: speeding up structural transformation to a high-value, knowledge-based, and skill-intensive economy; pursuing reforms in education and population policy to achieve the talent pool required; and leveraging on the immense business opportunities available in mainland China. There are four economic sectors where Hong Kong, China has a competitive advantage over mainland China: trade and logistics, tourism, financial services, and professional services and other producer services.

While road transport is highly visible in the city, the Hong Kong MTR rail system is also a significant part of the transportation sector, carrying about 3.5 million passengers every weekday in 2008, and its ridership has increased at about 5.8 percent annually from 2000 to 2008.[86] As a regional aviation hub as well as the gateway to the Pearl River Delta (PRD) area of mainland China, Hong Kong international airport has

[85] HKTID (2009).

[86] MTRC (2009).

significant throughput – it served around 80 airlines and 48.6 million passengers in 2008.[87] Hong Kong, China's energy use for international aviation is significant – petroleum products for international aviation accounted for about 76 percent of energy use in the whole transportation sector in 2006.[88] In the future, mainland China's increasing participation in global economic activities is expected to speed up the growth of passenger air travel between Hong Kong, China and mainland China. Globalization of economic activities has also increased the freight volume of air transport.

Energy use in Hong Kong, China's 'other' sector is heavily dominated by commercial and public services, which consume about 70 percent of all energy used in this sector (while the residential subsector consumes 29 percent).[89] Due to its tropical climate, air conditioning is a significant part of residential energy use, accounting for about 20 percent of residential demand in 2006. Relatively slow growth in residential energy use (an average annual increase of 1.72 percent from 1996 to 2006) appears to reflect market saturation. Similarly, growth in air conditioning use in the commercial sector has also grown only moderately, at an average annual rate of 2 percent over the same period.[90]

ENERGY RESOURCES

The absence of a domestic energy source has made Hong Kong, China a net importer of oil products (mostly from Singapore); it also imports natural gas – in 2007, 100 percent of this came from mainland China. Privately owned electric and gas utilities service the economy's daily requirements.

Towngas and liquefied petroleum gas (LPG) are the two main types of fuel gas used throughout Hong Kong, China. Towngas is distributed by the Hong Kong and China Gas Company Limited. It is manufactured at plants in Tai Po and Ma Tau Kok, using both naphtha and natural gas (from October 2006) as the feedstock. LPG is supplied by oil companies and imported into Hong Kong, China through the five terminals on Tsing Yi Island.[91]

In 2008 the total installed electricity generating capacity serving Hong Kong, China was 12,644 MW, including capacity in Guangdong contracted to utilities in Hong Kong, China. All locally generated electricity is thermal fired. Electricity is supplied by CLP Power Hong Kong Limited (CLP Power) and The Hongkong Electric Company Limited (HEC). CLP Power supplies electricity from its Black Point (2,500 MW), Castle Peak (4,108 MW) and Penny's Bay (300 MW) power stations. Natural gas is the main fuel at Black Point, and coal the main fuel at Castle Peak. The natural gas is imported from the Yacheng 13-1 gas field off Hainan Island in southern China, via a 780-kilometre high-pressure submarine pipeline. CLP Power is contracted to purchase about 70 percent of the electricity generated at the two 984 MW pressurized water reactors at the Guangdong Nuclear Power Station at Daya Bay to help meet the long-term demand for electricity in its supply area. It also has the right to use 50 percent of the 1,200 MW capacity of Phase 1 of the Guangzhou Pumped Storage Power Station at Conghua.[92]

Electricity for HEC is supplied from the coal- and gas-fired Lamma Power Station, which has a total installed capacity of 3,736 MW. Natural gas used at this station is mainly imported through submarine pipeline from Dapeng LNG terminal in Guangdong, China. At the Lamma site, HEC also operates the first commercial wind turbine in Hong Kong, which began operation in February 2006 as a pilot project. The rated capacity of the wind turbine is 800kW.[93]

ENERGY POLICIES

The Government of the Hong Kong Special Administrative Region (SAR) pursues two key energy policy objectives. The first is to ensure that the energy needs of the community are met safely, efficiently, and at reasonable prices. The second is to minimize the environmental impact of energy production and consumption, and promote the efficient use and conservation of energy.

In keeping with the free market economic policy of Hong Kong, China, the government intervenes only when necessary to safeguard the interests of consumers, ensure public safety, and protect the environment. The government works with the power, oil and gas companies to maintain strategic reserves of coal, diesel and naphtha. It monitors the performance of the power companies

87 HKIA (2009).
88 IEA (2008) II–127.
89 Ibid, II–127.
90 HKEEO (2008).
91 APERC (2009), p 60.
92 Ibid, p 59.
93 HEC (2009).

through the Scheme of Control Agreements, most recently revised in 2008, to encourage energy efficiency, quality services, and renewable energy use.[94]

To help monitor the energy situation, Hong Kong, China has developed an energy end-use database. The database provides useful insight into the energy supply and demand situation, including energy consumption patterns and trends, and energy use characteristics of the individual sectors and subsectors. A basic data set is publicly available on the internet.[95]

In its latest 2008–2009 Policy Address, the government indicates it will continue to support environmental protection and promote sustainable development by taking vigorous measures to improve air quality.[96] For example, the Hong Kong, China government has reached a consensus with the Guangdong Provincial Government on jointly transforming the pan-Pearl River Delta (PRD) region into a 'green and quality living area' based on the principles of promoting environmental protection and sustainable development. To achieve this goal, Hong Kong, China and Guangdong will work together in the areas of post-2010 emission reduction arrangements, the optimization of the energy mix for electricity generation, the development and wider use of renewable energy, vehicle emissions reductions, enhanced conservation, and scientific research, as well as raising public awareness.

On 28 August 2008 a Memorandum of Understanding was signed between the Hong Kong SAR Government and National Energy Bureau of China. This ensures a long-term and stable supply of nuclear electricity, and the supply of natural gas from three different sources, namely offshore gas, piped gas, and liquefied natural gas (LNG), to be supplied through an LNG terminal to be built, as a joint venture, on a neighbouring mainland site.[97] At present, 28 percent of electricity generated by plants in Hong Kong, China is gas fired. The government enacted the legislation on the Mandatory Energy Efficiency Labelling Scheme in May 2008, which will enforce labelling of home appliances to ensure that appliances have met the government's specified requirements.[98] The government is also a leader in energy efficiency building codes, and has provided guidelines since July 2008 that include direction for reporting and reducing greenhouse gas emissions from buildings.[99]

Electricity supply in Hong Kong, China has been provided by two independent, vertically integrated power companies, each providing generation, transmission, distribution and retailing of electricity in two geographically separate areas. Natural gas will be the main energy source for electricity generation in the future. To improve air quality and address the challenges posed by global warming, the government of Hong Kong, China has said it will actively explore ways to gradually increase the use of 'cleaner' energy by, for example, increasing the proportion of natural gas for local electricity generation to 50 percent.[100] However, Hong Kong, China can import much more electricity from mainland China. This projection, therefore, estimates there will be limited new power plant development and that the gas-fired share of local electricity generation will remain at 35 percent in 2030.

Hong Kong, China's government has set a target of 1–2 percent of its total electricity supply to be based on renewable energy sources by 2012. Hong Kong, China does not have much wind farm potential, so most of these increases are expected to come from solar energy.[101]

Other action to promote energy efficiency and conservation, and to make substantial reductions in carbon dioxide emissions, includes the government's plans to implement a district cooling system at the Kai Tak Development – this will supply chilled water to buildings in the new development area for centralized air-conditioning.[102]

In the transportation area, almost all diesel taxis have now been replaced by LPG models. In August 2002, the government launched a voluntary incentive scheme to encourage owners of existing diesel public and private light buses to replace their vehicles with LPG- or electricity-driven models. Up to the end of December 2007, there were over 2,700 LPG light buses in operation, representing more than 40 percent of all public/private light buses in Hong Kong. The government has also taken a leading role in the use of green vehicles, and introduced petrol-electric hybrid vehicles in government fleets in 2005. The government

94 HKG, HECL and HEHL (2008).
95 http://www.emsd.gov.hk
96 HKG (2008A).
97 NEA of PRC and HKSAR (2008).
98 HKG (2008B).
99 HKEPD(2008).
100 APERC (2009), p 61.
101 Leung and Hui (2004).
102 EMSD (2009).

continues to identify possible ways to encourage vehicle owners to use cleaner alternative energy sources.[103]

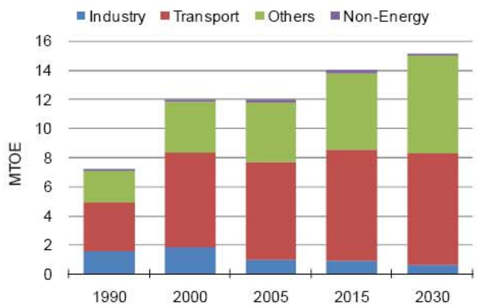
OUTLOOK

FINAL ENERGY DEMAND

In 2005, the total final energy demand in Hong Kong, China reached 12 Mtoe. The transport sector accounted for the largest share at 54 percent, followed by the 'other' sector (34 percent), which is mainly residential and commercial use, and the industrial sector (8 percent). The dominance of transport means the most important end-use energy source was petroleum, accounting for 66 percent of energy use. Electricity and others made up 29 percent of end-use consumption, while gas accounted for only 5 percent.

Over the outlook period, final energy demand is projected to grow at an average annual rate of 0.9 percent, which is low compared with the average annual rate of 5.2 percent between 1985 and 2005. In 2030, the transport sector is expected to still hold the largest share, at 51 percent, followed by the 'other' sector (44 percent), and industry (5 percent).

Figure HKC2: Final energy demand



Source: APERC analysis (2009)

Industry

Energy demand in the industrial sector is projected to decline at an average annual rate of 1.7 percent until 2030; this is a drop from the average annual growth of 1 percent between 1985 and 2005. This decrease can perhaps be accounted for by the relocation to mainland China of many industries, especially energy- and labour-intensive ones. Petroleum products are the dominant energy source in Hong Kong, China's industrial production processes, and this consumption is projected to decline at 2.7 percent per year. Diesel accounts for almost all industrial oil consumption in the economy.

Transport

Transport energy demand is projected to rise slightly, from 6.7 Mtoe in 2005 to 7.7 Mtoe in 2030. Much of the growth will come from demand for jet kerosene for international air transport – representing more than 70 percent of the increase in transportation energy demand over the outlook period. The rest of the increase in the projected transportation energy demand will come from local road transport, which uses mainly oil.

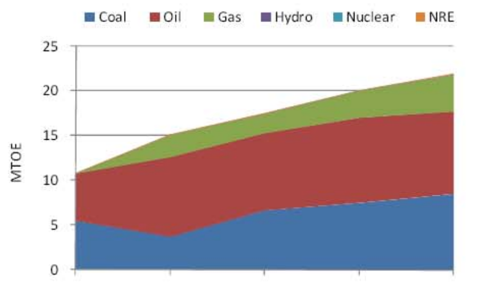
Other

Energy demand in the 'other' sector, which includes residential, commercial, agricultural, and construction demand, is primarily driven by the requirements for space cooling, water heating and cooking. Over the outlook period, the 'other' sector energy demand is expected to grow at an average annual rate of 1.9 percent; this is consistent with projected income growth and improving living standards in Hong Kong, China. Electricity will make up the largest share of the total 'other' sector energy consumption in 2030, accounting for 84 percent.

PRIMARY ENERGY SUPPLY

Hong Kong, China has no domestic energy reserves or petroleum refineries and therefore imports all of its primary energy needs. The total primary energy demand is projected to grow at an annual rate of 1 percent during the outlook period. The strong demand growth in transport means oil will continue to dominate the total primary energy supply, even though its share will decline from 48 percent in 2005 to 40 percent in 2030. Natural gas will increase its share, increasing from 12 percent in 2005 to 18 percent by 2030, at the fastest average annual rate of 2.6 percent. Coal will maintain its 37 percent share in 2030.

Figure HKC3: Primary energy supply



Source: APERC analysis (2009)

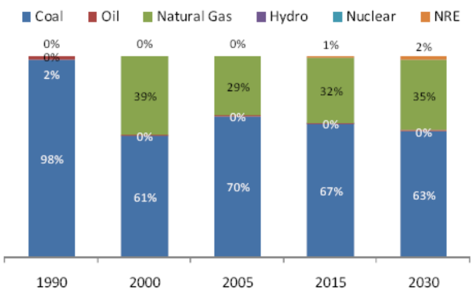
[103] APERC (2009), p 63.

ELECTRICITY

Hong Kong, China's electricity demand is projected to increase at an average annual rate of 2 percent, reaching 5.9 Mtoe in 2030. The economy's commitment to reducing GHG emissions means that additions to the total installed capacity are expected to be natural gas fired, rather than coal fired, and coal's share of the total electricity generation is expected to fall from 70 percent in 2005 to 63 percent in 2030.

Because of strong public opposition to nuclear power, and limited land for construction of a plant, nuclear power is not a viable option for Hong Kong, China over the outlook period. However, the importing of electricity from the Guangdong Daya Bay Nuclear Power Station will continue – this plant supplies around 22 percent of electricity demand in Hong Kong, China. When the power supply agreement with Daya Bay expires in 2013, Hong Kong, China will need to continue sourcing electricity supply from mainland China. Government policies aimed at slowing climate change have set a target for electricity generation from renewable sources: 1–2 percent of the total electricity supply is to be renewables based by 2012. Our projection is that the economy will achieve 1 percent electricity supply from renewable sources by 2015 and 2 percent in 2030.

Figure HKC4: Electricity generation mix



Note: this graph excludes imported electricity from China.

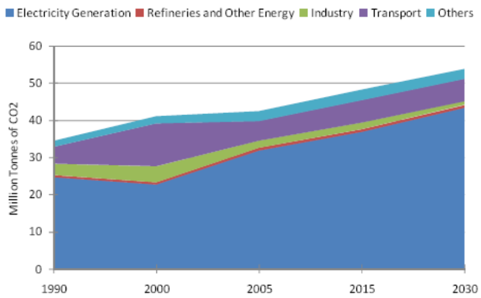
Source: APERC analysis (2009)

CO_2 EMISSIONS

Over the outlook period, Hong Kong, China's total CO_2 emissions from fuel combustion are projected to reach 54 million tonnes of CO_2, which is 29 percent higher than in 2005 and 59 percent higher than the 1990 level emissions.

The electricity generation sector is expected to account for the largest share, at 80 percent of total CO_2 emissions or 43.3 million tonnes of CO_2, followed by the transportation sector (11 percent, or 6.1 million tonnes of CO_2). The transport figures exclude emission from international aviation.

Figure HKC5: CO_2 emissions by sector



Source: APERC analysis (2009)

The decomposition analysis shown in this table indicates that the increases in Hong Kong, China's CO_2 emissions are mainly driven by GDP growth. However, significant and steady reduction in energy intensity is expected to offset much of the increase stemming from economic growth.

Table HKC1: Analysis of reasons for change in CO_2 emissions from fuel combustion

(Average Annual Percent Change)

	1990-2005	2005-2015	2015-2030	2005-2030
Change in CO_2 Intensity of Energy	-2.1%	-0.2%	0.1%	0.0%
Change in Energy Intensity of GDP	-6.6%	-2.8%	-2.5%	-2.6%
Change in GDP	10.9%	4.4%	3.3%	3.7%
Total Change	1.4%	1.3%	0.7%	1.0%

Source: APERC analysis (2009)

CHALLENGES AND IMPLICATIONS

Overall, the economy of Hong Kong, China is expected to continue to grow healthily. However, such growth will be heavily dependent on its energy security, as Hong Kong, China depends on imports for most of its energy supply.

With its lack of capacity to refine oil or build many new power plants, the economy is heavily dependent on imported oil and electricity, especially to supply the large energy demands from international aviation and from the residential and commercial sectors. It is critical that Hong Kong, China improves its energy security, in particular to protect itself from fluctuations in the energy market. While the lack of indigenous resources means little can be done to improve security of supply of fossil fuels, electricity security could be greatly improved by ensuring the continuation of the contract with Guangdong Daya Bay Nuclear Power Station, which expires in 2013. Although

Hong Kong, China is almost entirely dependent on imported energy, the fact that much of this energy is imported from mainland China, with which it has close political and economic ties, should help to reduce security of supply risks.

In terms of reducing GHG emissions, the shift away from coal to gas for electricity generation will make a significant difference. However, the increasing energy demand, especially for electricity, will pose a challenge for reducing actual emissions totals. The economy could help reduce its GHG emissions by shifting to more imported electricity from nuclear or renewable energy sources, or by further increasing its energy efficiency at home. Government policies to increase vehicle fuel efficiency and implement district cooling schemes should be continued, to further reduce overall environmental impacts.

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CHINESE TAIPEI

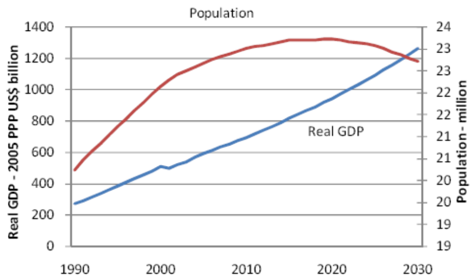
- *Chinese Taipei's primary energy supply is projected to grow at an average annual rate of 1.6 percent over the outlook period; this is due mainly to growth in the industry and transport sectors.*
- *Chinese Taipei will change its energy mix to reduce its CO_2 emissions, by increasing imports of natural gas and developing renewable energy sources.*
- *The Renewable Energy Development Act has been introduced to speed up the development of clean energy. The share of renewable energy is expected to rise from 1 percent of total electricity generation in 2005 to 7 percent in 2030.*
- *Government policy now includes consideration of nuclear power as a non-carbon energy option, with the aim of improving the economy's energy supply diversity.*

ECONOMY

Chinese Taipei is located in the middle of a chain of islands stretching from Japan in the north to the Philippines in the south. Its position, just 160 kilometres off the south-eastern coast of China, makes it a natural gateway to East Asia.

The economy is made up of the islands of Taiwan, Penghu, Kinmen, Matsu, and several islets, with a total area of about 36,188 square kilometres. Only one quarter of the land is arable – in those areas the subtropical climate permits multi-cropping of rice and the growing of fruit and vegetables all year round.

Figure CT1: GDP and population



Source: APERC analysis (2009)

The population of Chinese Taipei is expected to increase at the slow average annual rate of 0.007 percent, from 22.65 million in 2005 to 22.69 million in 2030.

Chinese Taipei's GDP is projected to grow at an average annual rate of 3.1 percent over the outlook period, reaching US$1,261 billion in 2030; this compares to GDP average annual growth of 9 percent from 1990 to 2005.

The rapid economic development of the past decade has resulted in substantial changes to the economic structure of Chinese Taipei, with the emphasis moving from industrial production to the services sector. In 2007, 71.1 percent of domestic production was in the service sector, with industry accounting for 27.5 percent and the agriculture sector 1.5 percent. In 1990, services made up 54.6 percent and industry 41.2 percent of production.[236] Chinese Taipei's main industries are electronics, petrochemicals, and metals and mechanical. Within the manufacturing sector itself there has also been structural change, from energy-intensive industries to industries that are non-energy intensive. The non-energy-intensive industries also make up the largest share of exports; information technology, for instance, accounts for about 46 percent of the economy's total exports in 2007.[237]

Chinese Taipei imports almost all its crude oil for refining requirements. The economy's total refining capacity has reached 1.23 million barrels per day, which exceeds the domestic demand. This makes Chinese Taipei a net exporter of petroleum products; in 2007 these totalled about 16.7 Mtoe.[238]

In terms of overall energy use, industry accounts for most of the economy's energy consumption (51.8 percent in 2007), followed by transportation at 13.1 percent and residential use at 11.2 percent.[239] Energy use in the industry sector is dominated by chemical and petrochemical processing (35 percent in 2006), while iron and steel used 22 percent.[240]

Chinese Taipei has developed a comprehensive road transport system including two freeways that run north to south across the island of Taiwan. Transport sector energy consumption totalled 15 Mtoe in 2006 – most of

236 BOE (2008A), p 116.
237 IDB (2008), Statistics.
238 BOE (2008B).
239 BOE (2008A), p 38.
240 IEA (2008), p II95.

this was used within road transportation (about 12 Mtoe or 80 percent), with international aviation using 2.6 Mtoe (17 percent).[241] Chinese Taipei has been striving to reduce its automobile dependency (in 2007 there were 5.7 million passenger cars in the economy)[242] and to encourage the use of public transport. These include a high-speed rail system, which runs 345.18 kilometres from Taipei to Kaoshung, and a 74.4 kilometre mass rapid transit system around Taipei city. There are plans for construction of further mass rapid transit systems in urban centres including Taipei, Taichung and Kaoshung. The policies encouraging a shift to public transport have been successful in Taipei city, with the daily ridership increasing at an average annual rate of 6.5 percent from 2000 to 2007; the Taipei Metro served, on average, 1.14 million passengers daily in 2007.[243]

In the 'other' sector, which includes residential, commercial, agriculture, and construction energy use, residential energy consumption in 2006 was 5.6 Mtoe (33.6 percent) and commercial 3.6 Mtoe (28.3 percent).[244] As the majority of the population is concentrated in major cities, electricity is the main source of energy for almost all homes; the electricity demand has grown at an average annual rate of 5.9 percent from 1990 to 2007.[245] Air conditioning in the summer season is a major source of residential electricity demand.

ENERGY RESOURCES

Chinese Taipei has very limited domestic energy resources. It relies on imports for most of its energy requirements and is a net importer of fossil energy – in 2007 its import dependency was 99.3 percent. Oil formed the biggest part of this primary supply, at 51.1 percent (coming mainly from Saudi Arabia, Kuwait and Iran), coal made up 32.1 percent (mainly from Australia, Indonesia and China), while imported LNG occupied 8.1 percent (coming mainly from Indonesia and Malaysia). Indigenous resources provided very small percentages of the economy's primary supply: natural gas 0.3 percent, hydro power 0.3 percent, geothermal, solar and wind power 0.1 percent combined. [246]

At the time of writing this review, there were three nuclear power plants in Chinese Taipei, each with two units, creating a total installed capacity of 5144 MW. A fourth nuclear power plant (also with two units) is currently under construction; it is scheduled to begin operation in 2010 and 2011, adding 1350 MW of capacity per unit.[247]

Taiwan's total electricity generation in 2007 was 243 TWh. This is mainly dependent on fossil fuels; their 78.2 percent share is made up of coal (53.6 percent), LNG (18.4 percent), and oil (6.2 percent). Nuclear generation accounted for 16.7 percent of total electricity generation in 2007, and renewable electricity 1.7 percent.[248]

The government's aim is to have a total electricity supply which provides a reserve capacity of 15–20 percent based on peak demand levels. Because of environmental issues and complex official approval processes, new power plants being constructed by Taiwan Power Company (TPC) fell behind schedule, which kept the total electricity below reserve capacity between 1990 and 2004. Reserve capacity remained under 8 percent between 1990 and 1996. In order to stabilize the power supply, TPC contracted with independent power producers (IPP) through a round of bidding when the reserve capacity was below 16 percent. Power produced by IPPs is sold to TPC through TPC's transmission lines. The reserve capacity has been more than 16 percent since 2004. The Ministry of Economic Affairs has announced it will open a fifth round of bidding to IPPs if the reserve capacity falls below 16 percent in the future.[249]

ENERGY POLICIES

Chinese Taipei's Energy Commission, which was established in 1979 under the Ministry of Economic Affairs (MOEA), became the Bureau of Energy in 2004. The Bureau is responsible for formulating and implementing the economy's energy policy. Recent policy development includes the establishment of a suite of energy-related legislation, covering renewable energy development, petroleum administration, natural gas business, and electricity. The aim is to create a better energy business environment.

The fundamental goal of the Chinese Taipei Energy Policy is to promote energy security, supported by secure imports of oil, natural gas and coal as well as the development of domestic energy

241 IEA (2008), p II95.
242 BOE (2008A), p 122.
243 TRTC (2008), p 25.
244 IEA (2008), p II95.
245 BOE (2008A), p 83.
246 BOE (2008A), p 12.
247 TPC (2008).
248 BOE (2008A), p 81.
249 BOE (2006).

resources including nuclear, fossil fuels, and new renewable energy sources.

On 5 June 2008, the Ministry of Economic Affairs released the *Framework of Taiwan's Sustainable Energy Policy*. This presents a "win-win-win" solution for energy, the environment and the economy. [250] The framework addresses the constraints that Chinese Taipei faces in terms of its insufficient natural resources and limited environmental carrying capacity. It states that sustainable energy policies should support the efficient use of the economy's limited energy resources, the development of clean energy, and the security of energy supply. The framework establishes these goals:

- reductions in energy intensity from 2005 levels – by 20 percent by 2015 and by 50 percent by 2025;
- Chinese Taipei's new government changed the economy's nuclear policy in 2008 from a "non-nuclear homeland policy" to allow reconsideration of nuclear power as a non-carbon energy option;
- reductions in total CO_2 emissions, so that total emissions return to the 2008 level between 2016 and 2020, and are further reduced to the 2000 level by 2025; at the same time, the share of low carbon energy in electricity generation systems will be increased from the current 40 percent to 55 percent by 2025;
- secured and stable energy supply, achieved by building a secure energy supply system to meet economic development goals, namely 6 percent average annual GDP growth rate from 2008 to 2012, and $US30,000 per capita income by 2015.

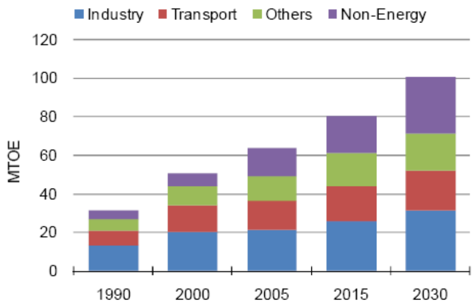
In order to reach these goals, Chinese Taipei has set these energy conservation targets and strategies: 1) industry sector: raise boiler efficiency, expand cogeneration, and increase share of high-value-added industries; 2) power sector: replace coal-fired and gas-fired power plants with high-efficiency generating units and reduce line losses by improving power dispatch and transmission facilities; 3) transportation sector: raise the fuel efficiency standard for private vehicles by 25 percent (on 2005 levels) by 2025, and raise appliance efficiency standards by 10 percent to 70 percent in 2011; 4) residential and commercial sectors: completely eliminate incandescent lights and replace with LED lighting by 2025 to increase energy efficiency and reduce total power consumption.[251]

OUTLOOK

FINAL ENERGY DEMAND

Chinese Taipei's total final energy demand is projected to grow at an average annual rate of 1.9 percent over the outlook period, increasing from 63.4 Mtoe in 2005 to 100.4 Mtoe by 2030. The industrial sector will account for the largest share of total 2030 demand (31 percent), followed by non-energy (29 percent), transport (21 percent) and the 'other' sector (19 percent). Demand for electricity is projected to increase at an average annual rate of 1.9 percent.

Figure CT2: Final energy demand



Source: APERC analysis (2009)

Industry

Energy demand in the industry sector is projected to grow at an average annual rate of 1.6 percent, lower than the average annual growth of 5.5 percent between 1987 and 2007. This reduction in demand growth is due to the structural shift in the industry sector, from energy-intensive to non-energy-intensive industries, as well as improvements in energy efficiency. Currently the dominance of petrochemical industry makes the Chinese Taipei industrial sector highly energy intensive. This energy intensity will reduce, as will the rate of increase in the sector's energy demand, as the electronics and IT industries are expected to grow more quickly than the petrochemical industry.

The share of coal in the industrial energy mix is expected to increase slowly at an average annual rate of 2.1 percent; this compares to 5.5 percent growth between 1987 and 2007. This is a result of a slowdown in crude steel production. At the same

[250] BOE (2008c).

[251] Ibid.

time the industrial use of natural gas is projected to grow at an average annual rate of 2 percent during the outlook period.

Transport

Chinese Taipei's transport energy consumption has grown in parallel with its economic development, improvement in living standards, and upgrades in transportation infrastructure. All transport sub-sectors exhibited substantial average annual growth of 5.2 percent between 1987 and 2007. The transport energy demand is projected to grow further over the outlook period, at an average annual rate of about 1.3 percent. Exports of high-value-added manufacturing products, and increase of direct air travel between Chinese Taipei and mainland China, is expected to spur growth in the air transport energy demand. To accommodate the predicted rise in air transport, Chinese Taipei is considering the construction of a new airport close to the centre of Taipei, and expansion of the freight handling capacity at Kaohsiung airport.

Chinese Taipei's population is expected to peak sometime in 2020. Over the outlook period, mass transit rail-systems are expected to gradually replace buses and passenger vehicles for city travel, just as the high-speed railways continue to replace the passenger vehicles for inter-city travel. As a result, gasoline demand is expected to grow only at an average annual rate of 0.6 percent between 2005 and 2030. By contrast, the diesel demand for freight trucks is expected to grow at an annual average rate of 1.9 percent; this is due to the growth in production of high-value-added manufactured goods, and the expansion of petrochemical industries, which favour trucks as the main mode of transport.

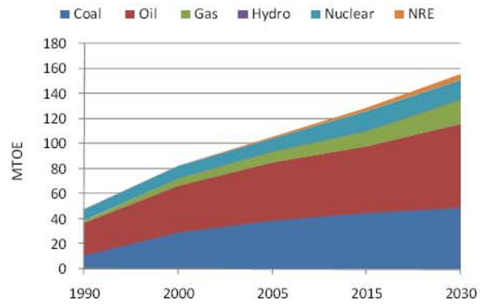
Other

Energy demand in the 'other' sector, which includes residential, commercial, agricultural, and construction demand, is primarily driven by income growth and the improvement in living standards. The energy demand of Chinese Taipei's 'other' sector is expected to grow at an average annual rate of 1.6 percent over the outlook period. Electricity is expected to continue to dominate the energy mix, accounting for 74.1 percent of 'other' sector energy consumption.

PRIMARY ENERGY SUPPLY

The share of new renewable energy (NRE) sources (which include biomass, biofuels, wind, solar, geothermal, and small hydro) in Chinese Taipei's primary energy mix is projected to increase significantly from 1.0 percent in 2005 to 2.9 percent in 2030. To speed up the development of 'clean energy', the Renewable Energy Development Act was enacted in June 2009. This new legislation focuses on encouraging new renewables-based generation that is connected to the main grid, through fixed feed-in tariffs – this is where TPC purchases power from renewable power generators on contracts involving preferential rates and grid-connecting obligations. The overall aim is to secure the market for electricity generated from renewable energy.

Figure CT3: Primary energy supply



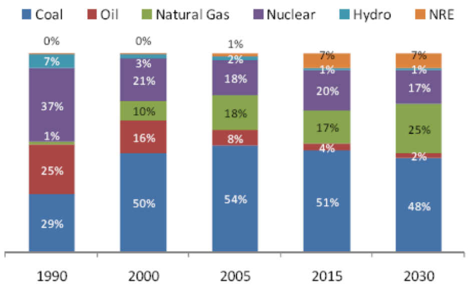
Source: APERC analysis (2009)

ELECTRICITY

By 2030, Chinese Taipei's total installed capacity is expected to reach 88.4 GW. The majority of this will be thermal (76.5 percent); this is made up of coal (48 percent of the total generation), natural gas (25 percent) and oil (2 percent). Other generation at the end of the outlook period will be from nuclear (17 percent), NRE (7 percent), and hydro (1 percent).

Chinese Taipei's total electricity generation is projected to increase from 223 TWh in 2005 to 359 TWh in 2030, growing at an average annual rate of 1.9 percent. Efforts to reduce the economy's CO_2 intensity of energy will mean the share of coal will decrease from 54 percent in 2005 to 48 percent in 2030 – it is being replaced by increased generation from natural gas and NRE sources. The natural gas share will increase significantly from 18 percent in 2005 to 25 percent in 2030. Some oil-fired electricity generation will also be replaced by natural gas, with oil's share projected to decrease from 8 percent in 2005 to 2 percent in 2030. Nuclear's share is expected to remain static throughout the outlook period. The share of electricity generation supplied by hydro is projected to be the smallest, decreasing from 2 percent in 2005 to 1 percent in 2030; this is due to perceived negative impacts on the environment. At the same time, as a result of government policy to promote the development of renewable energy sources (mainly from wind power), the NRE share will increase from 1 percent in 2005 to 7 percent in 2030.

Figure CT4: Electricity generation mix



Source: APERC analysis (2009)

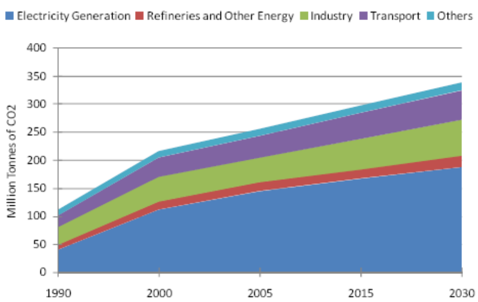
CO_2 EMISSIONS

Over the outlook period Chinese Taipei's total CO_2 emissions from fuel combustion are projected to reach 338 million tonnes of CO_2, which is 32 percent higher than in 2005 and 302 percent higher than the 1990 level.

The electricity generation sector is expected to account for the largest share, at 55 percent of total CO_2 emissions or 187 million tonnes of CO_2, followed by the industry sector at 19 percent (64 million tonnes of CO_2) and the transportation sector at 15 percent (52 million tonnes of CO_2).

The decomposition analysis shown in the following table indicates the increases in CO_2 emission are mainly driven by GDP growth. However, the significant reduction in the economy's energy intensity is expected to offset much of the increase resulting from economic growth.

Figure CT5: CO_2 emissions by sector



Source: APERC analysis (2009)

Table CT1: Analysis of reasons for change in CO_2 emissions from fuel combustion

(Average Annual Percent Change)

	1990-2005	2005-2015	2015-2030	2005-2030
Change in CO_2 Intensity of Energy	0.3%	-0.5%	-0.4%	-0.4%
Change in Energy Intensity of GDP	-3.2%	-1.7%	-1.6%	-1.7%
Change in GDP	8.9%	3.8%	3.0%	3.3%
Total Change	5.7%	1.5%	0.9%	1.1%

Source: APERC analysis (2009)

CHALLENGES AND IMPLICATIONS

Chinese Taipei is expected to remain an energy importer over the outlook period, due to its lack of indigenous energy sources. The economy will continue to import almost all of its oil requirements. To minimize the impact of any oil supply disruptions, Chinese Taipei maintains an oil stockpile of no less than 60 days' supply.[252] The economy has also tried to diversify its energy supply mix by switching from oil to natural gas, coal and renewable energy. In addition, it has started to secure international joint venture agreements to acquire captive supply sources.

Chinese Taipei's new government changed the economy's nuclear policy in 2008 from a "non-nuclear homeland policy" to allow reconsideration of nuclear power as a non-carbon energy option. This projection shows that if nuclear energy's share of electricity generation remains static, and the NRE share remains small, that Chinese Taipei's greenhouse gas (GHG) emissions will increase by one third by 2030 compared with 2005 emissions. Even though the share of renewables is expected to increase from 1 percent in 2005 to 7 percent in 2030, electricity production from fossil fuels will still increase. It would be a rational response to add further nuclear units on the existing nuclear power generation sites; this could be in addition to improving the energy efficiency on both the supply and demand sides of electricity provision.

To decouple energy consumption and GDP growth, the service sector needs to be promoted and expanded and the industry sector needs to move to a less energy-intensive structure. For example, promoting knowledge-based industries such as the Green Silicon Island, high-value-added and low-energy-intensive scientific industry parks, could be one way to foster a less energy-intensive economy.

With limited domestic energy resources, the security of Chinese Taipei's energy supply is central to its energy policy goals of meeting a growing energy demand while reducing CO_2 emissions. The economy will have to look to

[252] BOE (2009), Article 24.

alternative energy sources, in particular replacing coal with natural gas and renewable energy. Chinese Taipei has already moved to promote renewable energy with the 2009 introduction of the Renewable Energy Development Act, which uses fixed feed-in tariffs and grid-connecting obligations to encourage NRE-based generation.

The establishment of international stockpiling through regional cooperation could be an important way of stabilizing domestic energy supply, as could the acquisition of equity in international energy resource developments by the national oil company.

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4 ELECTRICITY

HISTORICAL TREND

APEC's electricity demand has grown robustly between 1990 and 2005 at an average annual rate of 3.4 percent per year, from 5716.9 TWh in 1990 to 9385.2 TWh in 2005. Rapid growth was observed in Viet Nam (14.3 percent), followed by China (9.9 percent), Malaysia (9.8 percent) and Indonesia (9.6 percent), as shown in Table 4.1.

In 1990, developed economies such as Australia, Canada, Japan and the US accounted for 70 percent of the APEC region's total electricity consumption, with the US alone consuming 47 percent. However, in 2005, the total share consumed by these economies decreased to 58 percent; this was due mainly to China's increasing electricity demand as a result of its rapid economic growth. China's share has increased from 8 percent in 1990 to 21 percent in 2005, as calculated from Table 4.1.

Table 4.1: APEC's electricity demand (TWh)

Economy	1990	2005	2030	1990-2005 (%)	2005-2030 (%)
Australia	129.2	206.5	310.7	3.2%	1.6%
Brunei Darussalam	1.0	3.1	4.2	7.7%	1.2%
Canada	418.1	512.2	688.9	1.4%	1.2%
Chile	15.4	48.1	121.6	7.9%	3.8%
China	481.8	1994.9	5196.8	9.9%	3.9%
Hong Kong, China	23.8	40.1	69.0	3.5%	2.2%
Indonesia	27.1	107.1	275.8	9.6%	3.9%
Japan	749.7	976.7	1202.1	1.8%	0.8%
Korea	94.4	357.7	575.3	9.3%	1.9%
Malaysia	19.9	80.8	245.1	9.8%	4.5%
Mexico	100.2	184.2	425.5	4.1%	3.4%
New Zealand	27.8	38.1	56.3	2.1%	1.6%
Papua New Guinea	1.7	2.8	7.5	3.6%	4.0%
Peru	11.8	22.7	59.2	4.5%	3.9%
Philippines	20.9	45.3	136.5	5.3%	4.5%
Russia	826.8	650.1	1000.9	-1.6%	1.7%
Singapore	12.6	32.4	91.4	6.5%	4.2%
Chinese Taipei	76.0	199.0	319.1	6.6%	1.9%
Thailand	38.4	121.3	401.1	8.0%	4.9%
United States	2634.0	3716.3	5023.0	2.3%	1.2%
Viet Nam	6.2	46.1	232.1	14.3%	6.7%
APEC	5716.9	9385.2	16442.1	3.4%	2.3%

Source: APERC analysis (2009)

OUTLOOK RESULTS

ELECTRICITY DEMAND

Electricity demand is expected to continue to grow between 2005 and 2030, at a rate of 2.3 percent per year. By region, North America, especially the US, is projected to contribute most significantly to demand for electricity. Electricity demand in the US is projected to reach 5,023 TWh in 2030 or about 30.5 percent of APEC's total electricity demand in 2030. However, China's expected high economic growth will mean its electricity demand will surpass all other APEC economies' by the end of the outlook period. In 2030 it is expected to reach 5,197 TWh or 31.6 percent of APEC's total electricity demand in 2030, as shown in Table 4.1.

Table 4.2 shows the share of electricity in projected total final energy demand (TFED) for each APEC member economy. Electricity share in TFED is expected to increase for all economies during the outlook period, with the exception of Brunei Darussalam. This economy's share of electricity in its TFED is projected to decrease steadily over the outlook period, from 32 percent in 2005 to 20 percent in 2030. This anomalous result for Brunei Darussalam's electricity demand is mainly due to the fact that the economy has extensive gas resources, and domestic gas use is being encouraged, and is expected to meet most of the growth in energy demand.

Table 4.2: APEC electricity as percentage of TFED

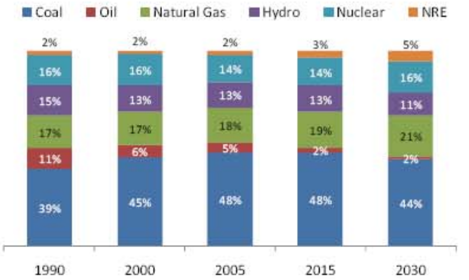
Economy	1990	2005	2030
Australia	19	23	24
Brunei Darussalam	20	32	20
Canada	22	22	23
Chile	12	19	20
China	6	15	22
Hong Kong, China	29	29	39
Indonesia	3	7	10
Japan	21	24	30
Korea	12	21	23
Malaysia	12	17	23
Mexico	10	15	22
New Zealand	25	25	25
Papua New Guinea	23	24	32
Peru	12	17	26
Philippines	12	15	26
Russia	11	13	16
Singapore	16	18	29
Chinese Taipei	21	27	27
Thailand	11	15	24
United States	17	20	25
Viet Nam	2	9	19
APEC	14	18	23

Source: APERC analysis (2009)

ELECTRICITY SUPPLY

Electricity supply across the APEC region is expected to grow at an average annual rate of 2.2 percent between 2005 and 2030. Figure 4.1 shows the historical and future APEC electricity generation mix in percentage terms. (See Chapter 2 for a discussion of projected electricity supply in absolute quantities.)

Figure 4.1: APEC electricity generation mix (1990–2030)



Source: APERC analysis (2009)

Electricity generating capacity

To meet the projected increase in total electricity supply, total generating capacity in the APEC region is projected to roughly double over the outlook period, from 2,286 GW in 2005 to 4,361 GW in 2030. As new generating capacity is added, the supply mix is expected to change, driven by a number of factors, including fuel costs, local environmental regulations, capital availability, acceptability of nuclear generation, and concerns about the price risks for LNG. Figure 4.2 shows the projected electricity generating capacity by energy type.

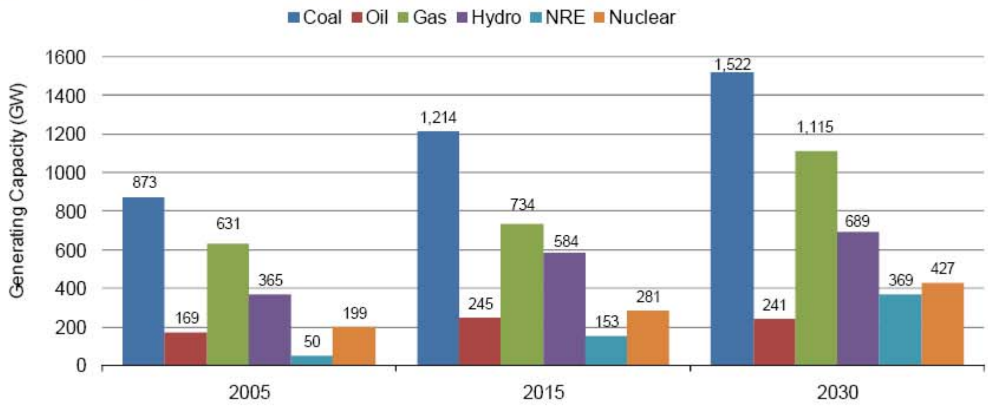
Over the outlook period, oil and LNG prices are expected to continue to increase while the price for coal is expected to remain stable and relatively low, as it is an energy resource with abundant deposits worldwide. For these reasons, coal is likely to remain the dominant energy source for electricity generation in the APEC region. Coal, however, generates more greenhouse gases than any other fossil fuel. Even under business-as-usual assumptions, concerns about climate change may limit the growth of coal-fired generating capacity.

Coal-fired generating capacity is expected to grow at an average annual rate of 2.3 percent, while the share of generating capacity that is coal fired will decrease slightly, from 38 percent in 2005 to 35 percent in 2030. The decrease in share is mainly due to the more rapid increases expected for renewable and nuclear generation capacity.

Natural-gas-fired combined-cycle gas turbines (CCGT) are very efficient at converting gas to electricity, have little local environmental impact, can be built quickly, have fairly low initial capital cost, and have less greenhouse gas emissions than coal. Despite these significant advantages, limitations on local gas supplies and the risks of volatile prices for imported LNG are expected to prevent dramatic increases in the penetration of natural gas in many APEC economies.

Natural-gas-fired generating capacity is expected to grow at an average annual rate of 2.3 percent, and the share of generating capacity that is natural gas fired will decrease slightly, from 28 percent in 2005 to 25 percent in 2030. Again, this decrease in share is mainly due to the more rapid increases expected for renewable and nuclear generation capacity.

Figure 4.2: APEC projected electricity generating capacity



Source: APERC analysis (2009)

Oil-fired electricity generation is expected to maintain a strong presence only in areas where no other fuels are readily available – this is due primarily to high costs and security of supply risks. Oil-fired generating capacity is expected to grow at an average annual rate of 1.4 percent, and the share of generating capacity that is oil fired will decrease from 7 percent in 2005 to 6 percent in 2030.

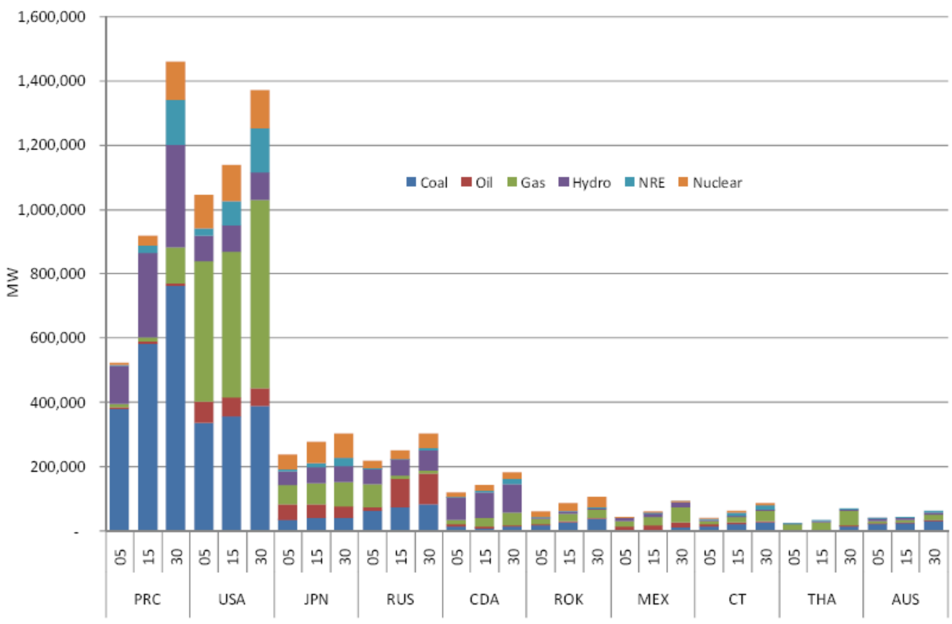
The development of new nuclear electricity generating capacity is projected to gain momentum; again this is due to price risks associated with oil and LNG and concerns about greenhouse gas emissions. Asian APEC member economies, in particular, are expected to start revitalizing their nuclear programmes to meet rising electricity demand. Nuclear generating capacity is expected to grow at an average annual rate of 3.1 percent, and the nuclear share of generating capacity will increase from 9 percent in 2005 to 10 percent in 2030.

Although hydro is an attractive option, as it has no fuel costs and low greenhouse gas emissions (see Chapter 5), its further development will be hindered in many economies by a lack of suitable sites. Hydro generating capacity is expected to grow at an average annual rate of 2.6 percent, and the hydro share of generating capacity will remain constant at 16 percent between 2005 and 2030.

A number of initiatives are expected to be taken by APEC member economies to promote the development of new renewable energy sources (NRE) – that is renewable energy other than hydro – even under our business-as-usual assumptions. Therefore, the installed capacity of NRE is projected to increase at the fastest rate of any generation energy source, 8.4 percent per year. However, the NRE share of generating capacity will increase from 2 percent in 2005 to only 8 percent in 2030.

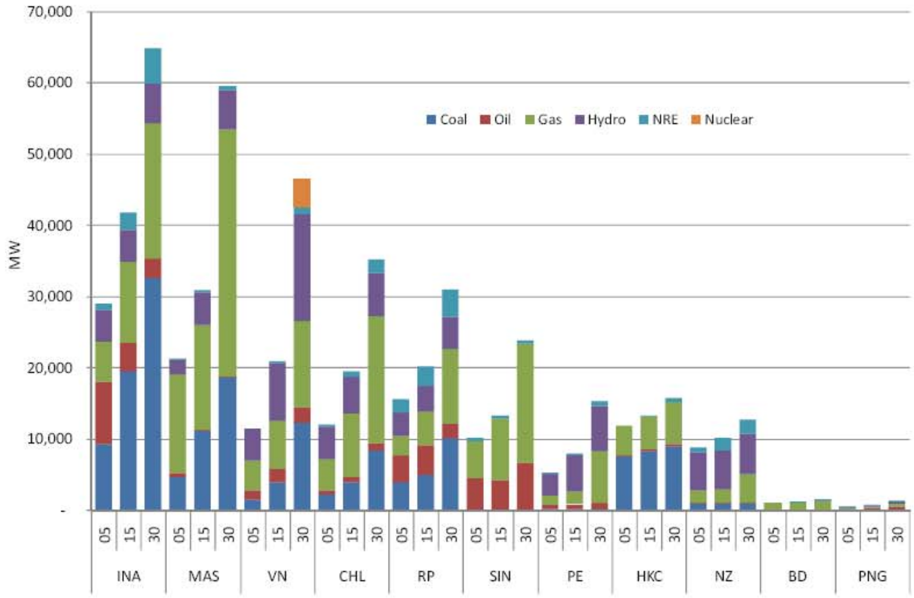
In order to reduce greenhouse gas emissions and control costs, APEC economies are expected to focus on reducing transmission and distribution loss, as well as increasing the efficiency of electricity generation from fossil fuels. Our business-as-usual projections indicate that average coal generation efficiency will increase from 34 percent in 2005 to 36 percent in 2030 and average gas generation efficiency will increase from 43 percent to 46 percent. Similarly, we expect that transmission and distribution losses will be reduced from 6.7 percent in 2005 to 5.4 percent in 2030.

Figure 4.3: Generating capacity by energy source, larger APEC economies



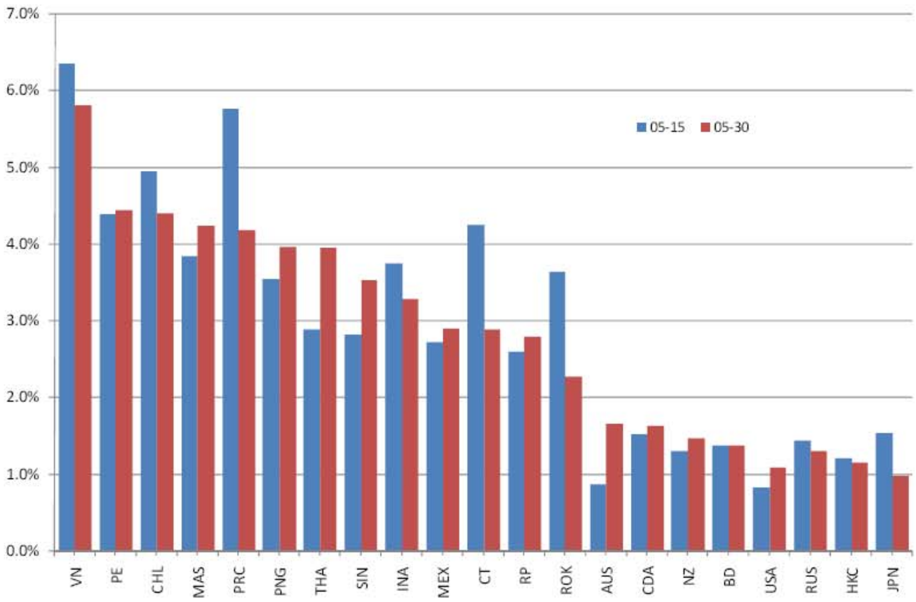
Source: APERC analysis (2009)

Figure 4.4: Generating capacity by energy source, smaller APEC economies



Source: APERC analysis (2009)

Figure 4.5: Generation capacity growth rates



Source: APERC analysis (2009)

Generating capacity by economy

In 2005, the largest installed generation capacity was in the US. Its total capacity, of over 1,047 GW, was dominated by gas (42 percent) and coal (32 percent). China's 2005 installed capacity was the second highest, at 524 GW, of which coal was 73 percent and hydro was 22 percent. However, in 2030, China's installed capacity is expected to exceed that of the US, reaching 1,460 GW compared to the US's 1,370 GW. After these two economies, Japan and Russia will have the next largest installed capacities, in both 2005 and 2030.

Figures 4.3 and 4.4 (on previous pages) show the installed generation capacities by energy source and economy. Note the two graphs have different scales on the vertical axes.

It is notable that China, recognizing the importance of securing energy for its economy and the imperative of mitigating climate change, is expected to increase its utilization of renewable energy, natural gas, and nuclear.

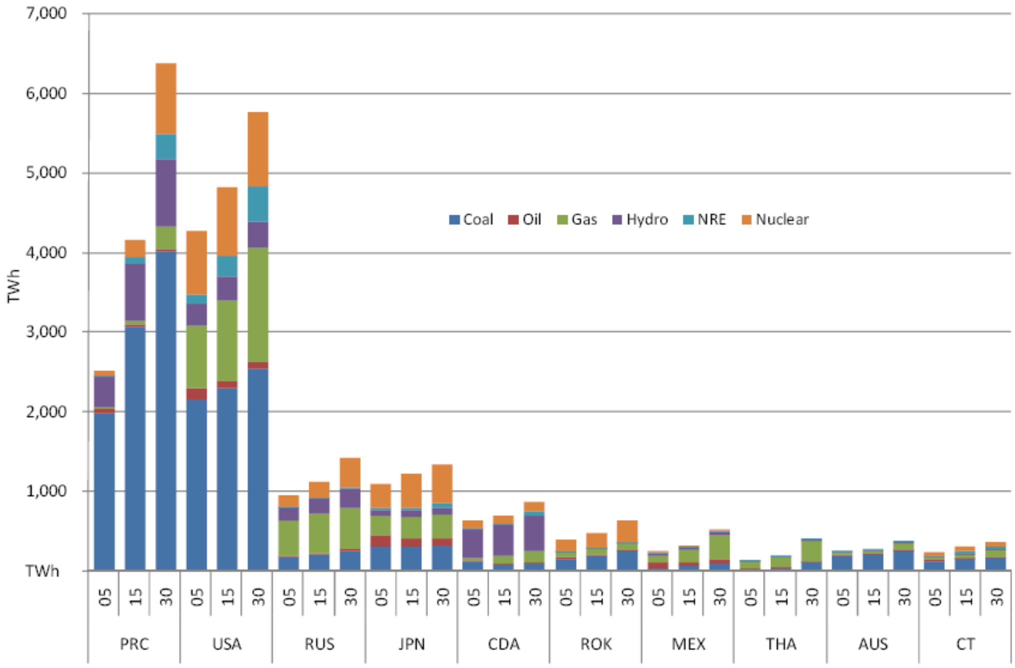
Figure 4.5 (on previous page) shows the growth rates for generating capacity across all APEC economies.

Electricity generation mix and growth rate

Figures 4.6 and 4.7 (following) show the electricity supply by energy type by economy. Again, note that the vertical axes of the two graphs have different scales. The results are very much in line with the graphs of generating capacity by economy presented in Figures 4.3 and 4.4 above.

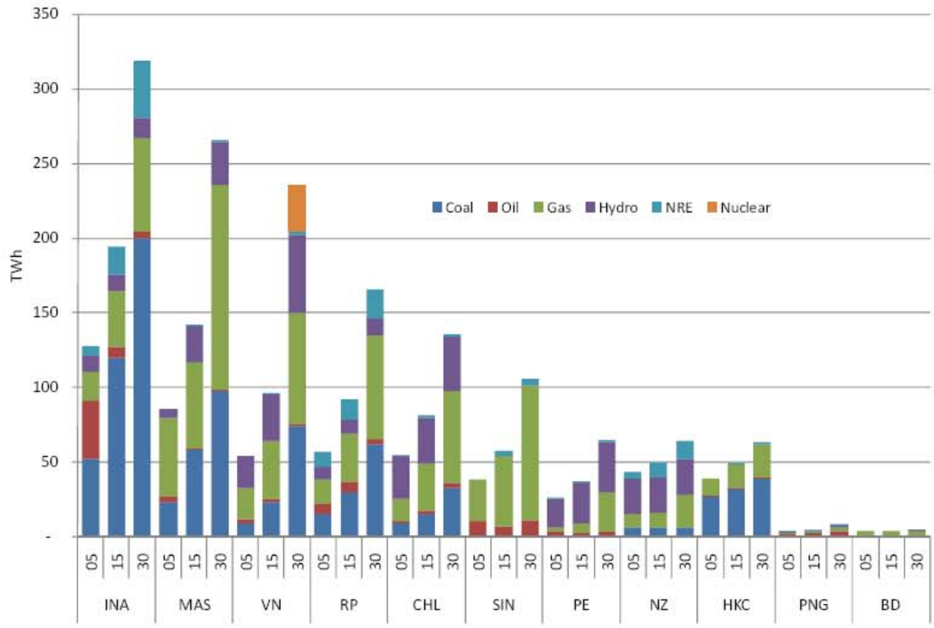
Figure 4.8 (following) shows the electricity supply growth rates for the APEC economies. Again, the results are in line with the graph of generating capacity in Figure 4.5 above.

Figure 4.6: Electricity supply by energy type, larger APEC economies



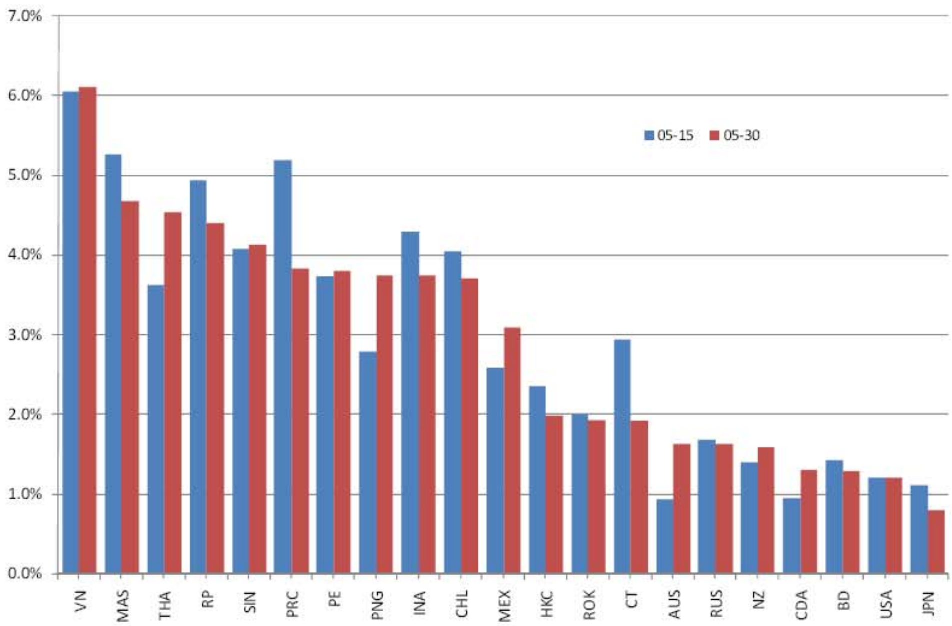
Source: APERC analysis (2009)

Figure 4.7: Electricity supply by energy type, smaller APEC economies



Source: APERC analysis (2009)

Figure 4.8: Electricity generation growth rates of APEC economies between 2005–2015 and 2005–2030



Source: APERC analysis (2009)

ACCESS TO ELECTRICITY

The APEC economies are striving to provide access to electricity for all their people, and they have made impressive progress toward achieving this critical development milestone. China's achievement in providing 99 percent of their population with access to electricity by 2006 is especially impressive. Only five APEC economies still had access rates less than 98 percent in 2005: Viet Nam (84 percent), the Philippines (81 percent), Peru (72 percent), Indonesia (54 percent),[85] and Papua New Guinea (estimated at 7 percent)[86]. These economies are moving aggressively to provide increased access, and we expect nearly universal access by 2030.

ELECTRICITY TECHNOLOGY DEVELOPMENT

There are two main goals for future electricity technology development: to reduce greenhouse gas emissions, and to increase generation, transmission, and distribution efficiency. In order to achieve these two goals, a number of highly efficient and/or low emission technologies are commercially available or in development. Some of these are discussed elsewhere in this volume, including solar photovoltaics (see box "Why the potential of solar photovoltaics may be underestimated" in Chapter 1 and the Chapter 5 section on renewable energy), hydro, wind, geothermal, biomass (all in the Chapter 5 section on renewable energy), and nuclear (Chapter 5 section on nuclear).

In addition, the following technologies should be mentioned:

1. High-efficiency natural gas electricity generation, such as combined-cycle gas turbines (CCGT), the efficiency of which can be increased above 50 percent.[87]
2. High-efficiency coal-fired electricity generation, such as ultra supercritical coal (USC) power plants, which use increased boiler temperature to increase its efficiency above 40 percent.[88] Another coal generation technology to consider is integrated gasification combined cycle (IGCC),[89] which turns coal into a synthetic gas for cleaner burning, resulting in increased efficiency and reduced greenhouse gas emissions. IGCC technology has the additional advantage of allowing the easy capture of CO_2, thus facilitating carbon capture and storage (CCS). CCS would allow the burning of coal with minimal CO_2 emissions.
3. Smart grids: using modern information technology, it should be possible to re-engineer the electric power grid for greater reliability, higher efficiency, and reduced emissions. Such a smart grid might be able to save consumers money by signalling certain consumer devices, such as electric vehicle battery chargers, when to turn on and off. With more control over electricity demand, the smart grid would also be better able to utilize intermittent renewables, such as wind. The smart grid would be able to more quickly sense, and respond to, developing problems, thus reducing the risk of outages. And the smart grid would be in a better position to optimize the use of electricity generation and storage facilities at any given time for lowest cost and highest reliability.[90]

85 IEA (2006), pp 565–572.
86 World Bank (2007).

87 NEDO (2006), p 42.
88 Greenfacts (2008), p 1.
89 NEDO (2006), p 42.
90 DOE (2008).

Electricity trade in the APEC region

The APEC region encompasses a diverse set of economies in terms of energy demand and supply patterns (some economies are operating near capacity, while others have surplus capacity), demand growth potential, and natural resource endowment. These differences provide an opportunity for greater electricity trade that can result in benefits such as reduced costs of electricity supply and improved electricity availability. A detailed discussion of the benefits of electricity interconnection in APEC can be found in APERC (2000) and APERC (2004).

There are a number of ways in which electricity can be traded; the arrangements are generally determined by the volume of trade and the level of integration required between trading partners. Trading arrangements can range from simple two-way bilateral trades to complex trades involving multiple parties and economies.[91]

The simplest arrangement is cross-border electricity exchanges between neighbouring economies. This is often used to take advantage of conveniently timed surpluses/deficits in electricity supply. Sometimes trade occurs via a transit economy that may or may not be involved in the transaction. These agreements can expand beyond small trades as the relationships between utilities and governments develop.[92] A number of APEC economies are engaged in bilateral electricity trade with both APEC and non-APEC member economies. These include links between the United States – Mexico; United States – Canada, Thailand – Laos, Thailand – Malaysia, Malaysia – Singapore, China – Thailand, China – Viet Nam, China – Hong Kong, China, and Russia (in this last case a number of neighbouring economies).

The relative simplicity of these arrangements and the benefits that can accrue to participating parties will encourage increased cross-border electricity exchange in the APEC region over the outlook period. There are a number of plans either under construction or being considered that are scheduled to be completed during the outlook period. For example, there have been many studies conducted to assess the viability of increased electricity interconnection in northeast Asia (Japan, China, Korea and Russia).[93]

System harmonization between economies is a more advanced trading arrangement. It involves the establishment of a common operating environment through the synchronization of member electricity systems and harmonization of financial, legal, political, social and environmental frameworks. This creates a single market with common procedures and standards for arranging electricity sales, day-to-day operations, dispute settlement, maintenance, system expansion, and governance. A feature of this arrangement is that the independent systems are managed by a single market operator and governed by a common body. This trading arrangement can bring greater benefits than cross-border exchange, but requires a coordinated approach by participating economies, which can take years to achieve.[94]

To achieve system harmonization within a set of economies as economically, culturally and socially diverse as APEC would be extremely challenging. However, there are plans to harmonize the electricity grid by APEC members of ASEAN (Brunei Darussalam, Singapore, Malaysia, Philippines, Indonesia, Thailand and Viet Nam). The ASEAN Power Grid energy plan 2010–2015 aims to encourage "interconnections of 15 identified projects, first on cross-border bilateral terms, then gradually expand to sub-regional basis and, finally to a totally integrated Southeast Asian power grid system".[95] There are four projects in operation, three projects that are under construction, and an additional eight projects scheduled to start within the first half of the outlook period.[96] The ASEAN power grid has been endorsed by the governments of the participating economies and proposals for the grid have been extensively analyzed. It is unlikely that full integration will be achieved during the outlook period.

Table 4.3: ASEAN power grid projects

Connection	Expected completion
Under construction	
Thailand - Lao PDR	
Roi Et - Nam Theun 2	2009
Udon Tani - Nabong	2011
Lao PDR - Viet Nam	2010
Lao PDR - Cambodia	2011
Projects at a less advanced stage	
Sarawak - Peninsular Malaysia	2015
Peninsular Malaysia - Sumatra	2012
Batam - Bintam - Singapore	2015
Sarawak - West Kalimantan	2012
Philippines - Sabah	2015
Sarawak - Sabah - Brunei	2015
Thailand - Myanmar	2014
East Kalimanton - Sabah	na

Source: ASEAN (2009)

91 World Bank (2008) p 52–55.
92 Ibid, p 53.
93 APERC (2004), p 9.
94 World Bank (2009), p 70.
95 ASEAN (2009), p 12.
96 Ibid, p 14.

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POWER SECTOR EXPANSION MAKES WAY FOR UPGRADES

To cope with the rapid growth of electricity demand that has caused frequent power shortages since 2003, China's electricity sector has focused on expanding its generation capacity. It has succeeded in this at an unprecedented speed. As power shortages have diminished, the electricity sector has made efficiency and environment improvement its top priority. At present, the policy to improve the efficiency of the power generating sector has put the industry on the right track, and efforts are also under way to improve efficiency in the transmission and delivery sector.

Upon the unbundling of generation, grid operations, and services at the end of 2002, China's electricity sector took on the reform of the supply structure. In addition, achieving 100 percent electrification before the Beijing Olympic Games was considered a more important national goal than rationalising the demand structure through such measures as demand side management (DSM). Thus, this chapter describes the supply side, where electric power sector policies have focused. There is also great energy conservation potential on the demand side. This is not addressed in this chapter, but the other chapters of this report discuss many demand-side measures.

This chapter first reviews the development and structure of China's electric power sector, which provides fundamental information for considering efficiency policy in the electricity industry. Second, it introduces the key energy efficiency and conservation policies in the sector, including the shutting down of small thermal power plants, improving transmission and delivery systems, and developing combined heat and power (CHP) plants. Finally, it discusses the implementation of these key power sector policies and some preliminary results. A case study at the end of the chapter describes the results obtained by one large CHP project in Beijing.

Background

During the past two decades, China, of all the APEC economies, recorded the largest increase in primary energy consumption in the electric power sector. The increase amounted to 612 million tonnes oil equivalent (Mtoe) per annum. More than 90 percent of the increase was met by coal-fired power generation, and the remainder was met by hydro, nuclear and oil-fired generation.[1] China also made the greatest improvement in energy efficiency at coal-fired power plants among the APEC economies by shutting down smaller units. In recent years, China has accelerated the replacement of small units with high-efficiency ones, such as supercritical and ultra-supercritical thermal power plants. As a result, the energy efficiency of power generation in terms of the amount of coal that is used to generate one kilowatt hour of electricity has been reduced from over 400 grams down to about 330 grams, a 17 percent decrease since the early 1980s.[2]

[1] (NBS 2008a)
[2] (NBS 2008a)

Institutional Structure

In 2002, as part of a large reform effort,[3] the State Power Corporation of China was unbundled into power generation companies, power grid companies, and engineering and service companies, as shown in Figure 6.

On the government side, the National Development and Reform Commission (NDRC) is responsible mainly for the industry's development plan, and the State Electricity Regulatory Commission (SERC) is responsible for business operations, including electricity tariff setting. At present, there are two major power grid companies—the State Grid and the China Southern Power Grid, while the generating sector comprises five national-level power generating companies and many other regional companies and IPPs.

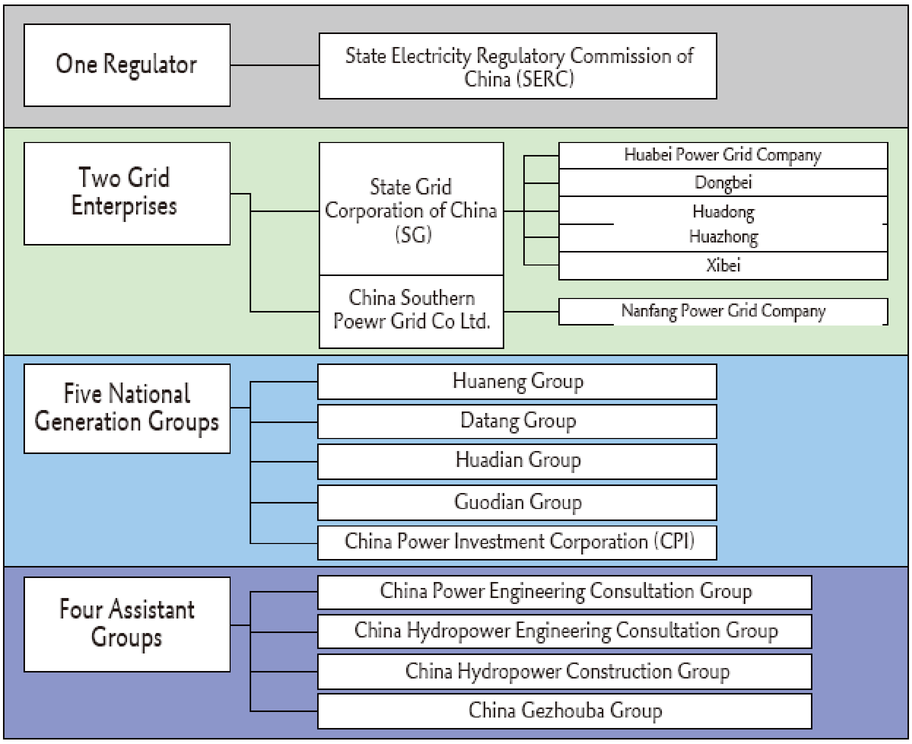


Figure 6: Structure of the electricity sector
Source: Compiled from (CPIA 2006)

Figure 7 illustrates the system for the flow of electricity. The five major generating companies and those owned by local governments supply 90 percent of all electricity, while private and foreign IPPs supply the rest. Two main grid companies are responsible for managing the transmission and delivery of electricity to end users through grid companies at the provincial and county levels.[4] The State Grid Corporation of China owns five regional grid companies including Huabei (covering Beijing, Tianjin, Hebei, Shanxi, and Shandong) with

[3] This reform of the Chinese government system aimed to modernise and rationalise the industrial system by introducing market mechanism and competition into the state-owned companies. The former State Development Planning Commission (SDPC) became the National Development and Reform Commission, which maintains responsibility for industry development policy. The former State Economic and Trade Commission (SETC), which was responsible for management of state-owned companies, was divided by sector and restructured into various units. The State Electricity Regulatory Commission was created as a unit of the State Council to be responsible for implementation of electricity policy.

[4] Some of these companies serve multiple counties, but not an entire province. In such cases, they may be referred to as prefectural distribution companies.

installed power generation capacity of 129.2 GW, Dongbei (East Mongolia, Liaoning, Jilin, and Heilongjang) with 55.8 GW, Huadong (Shanghai, Jiangsu, Zhejiang, Anhui, and Fujian) with 164.6 GW, Huazhong (Jiangxi, Henan, Hubei, Hunan, Chongqing, and Sichuan) with 154.3 GW and Xibei (Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang) with 47.1 GW. Another grid company, China Southern Power Grid Co., Ltd., owns Nanfang Grid Company (Guangdong, Guangxi, Hainan, Guizhou, and Yunnan) with 128 GW.[5]

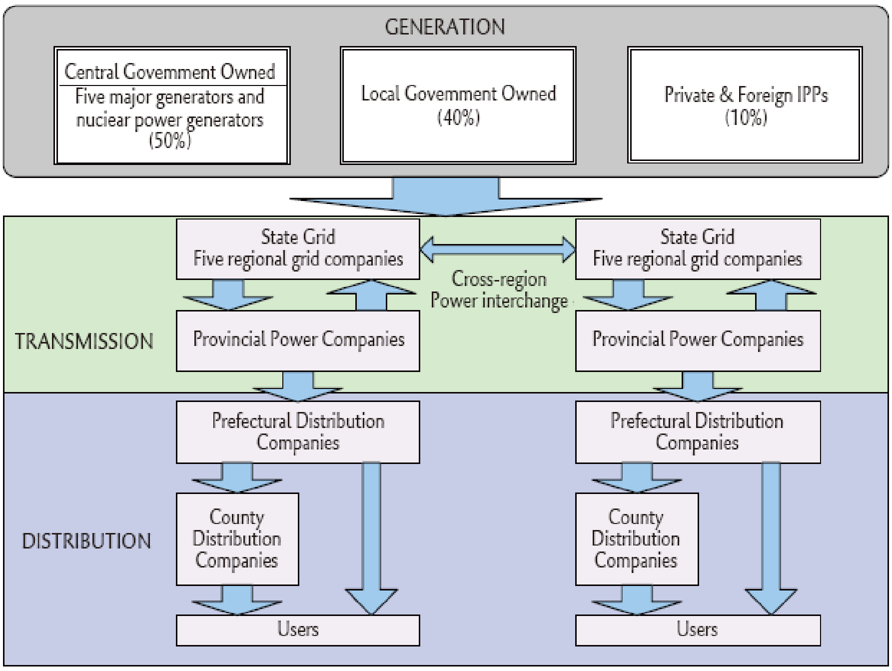


Figure 7: Flow of electricity
Source: Compiled from (CPIA 2006) and(Ni 2006)

Power Sector Development and Structure

During the past two decades, China's installed power generation capacity and amount of generation have grown rapidly (Figure 8). During this period, the annual increase in electricity generation has fluctuated widely from 3 percent in 1998 to 16 percent in 2003. Annual capacity additions have shown similar volatility, ranging from 5 percent in 2002 to 21 percent in 2006.

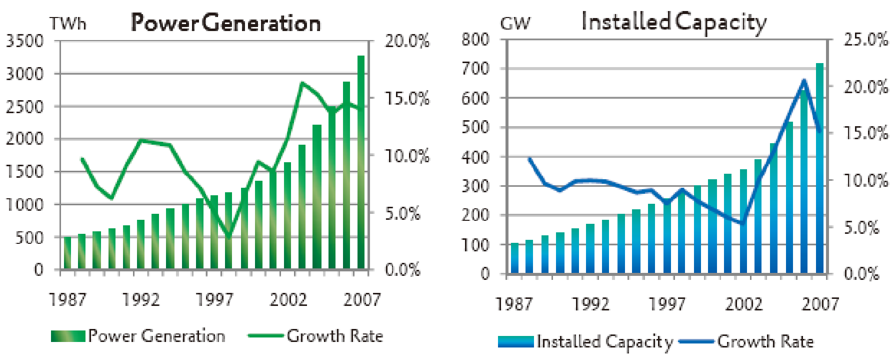


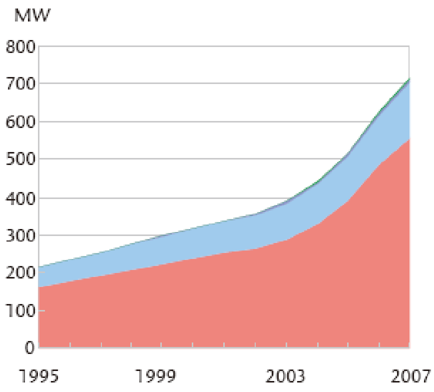
Figure 8: Power generation in China, 1987–2007
Source: (CEPYEC 2008)

[5] (CEPYEC 2008)

The growth rate of electricity generation slid from over 11 percent in 1993 to 3 percent in 1998 as the economic setback accompanying the Asian currency crisis caused serious demand stagnation and substantial excess capacity. The growth rate then picked up to 16 percent in 2003. During the period of stagnation, various policies were implemented to stimulate electricity demand, which pushed the economy toward the serious power shortage that occurred in 2003. Then, to accommodate rapidly rising demand, power generation capacity expanded at double-digit rates until 2007.

Fuel Type of Installed Capacity and Generation

During the 1990s, when energy prices were relatively low, coal-fired and hydro power stations were the dominant power sources in China, as shown in Figure 9. Other electricity sources such as nuclear and renewable energy remained at merely symbolic levels to demonstrate the industry's modernisation. As China's power generation capacity recorded robust increases in the past decade, most of the increase was delivered by coal-fired units, though hydro power continued to claim part of the increase, particularly as the Three Georges Dam Hydro project began operation in 2003.



	Installed Capacity 2007		Capacity Increase 1995 to 2007	
	GW	%	GW	%
Themal	556	77	393	78
Hydro	148	21	96	19
Nuclear	9	1	7	1
Others	5	1	5	1
Total	718	100	501	100

Figure 9: Installed capacity by energy source: 1995–2007
Source: (IEA 2008), (CEPYEC 2008)

In 1993, China's first nuclear power plant began operation with a capacity of 1200 MW. However, nuclear development was relatively slow until recently. Total nuclear power capacity reached 8,850 MW in 2007.[6] After being hit by the serious power shortage in 2003 and 2004, China changed its nuclear power policy to fully develop this secure, non-fossil energy source. Now China is building several other nuclear power plants and considering many more.

In summary, in the past two decades, thermal power maintained its dominant share in the generation capacity mix at around 75 percent, followed by hydro at 21 to 25 percent, while nuclear power remained at about 1 percent. In 2007, renewable energy (other than large hydro) accounted for almost 1 percent, reflecting the efforts of the Chinese government to develop non-fossil energy. As shown in Figure 10, thermal power is dominant in the power source mix of all six regions, though the regional availability of hydro power causes some diversity in the power mix.

[6] (CEPYEC 2008)

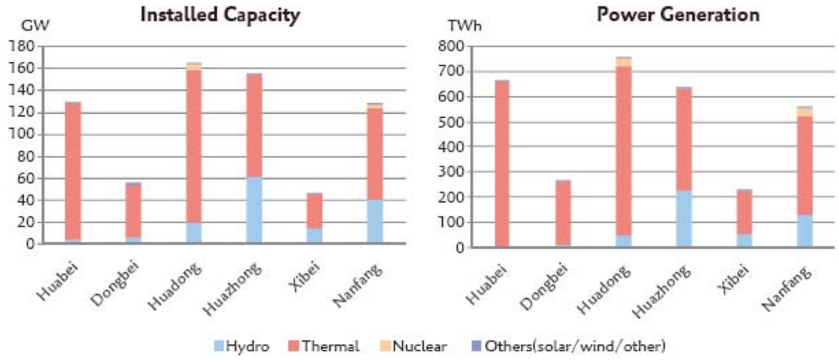


Figure 10: Power generation in six grid areas (2007)
Source: (CEPYEC 2008)

Energy Efficiency in the Electricity Sector

In considering energy efficiency in the electric power industry, the heat rate of power generation and transmission line losses are major factors.[7] They have steadily improved, as illustrated by Figure 11, though line losses have fluctuated in recent years. This irregular movement may have been caused by the flustered responses of the power grids to cope with the serious power shortages that began in 2003, as well as bulk construction of large thermal stations and the start-up of remote power sources like the Three Georges Dam Hydro power station and mine-mouth coal-fired plants.

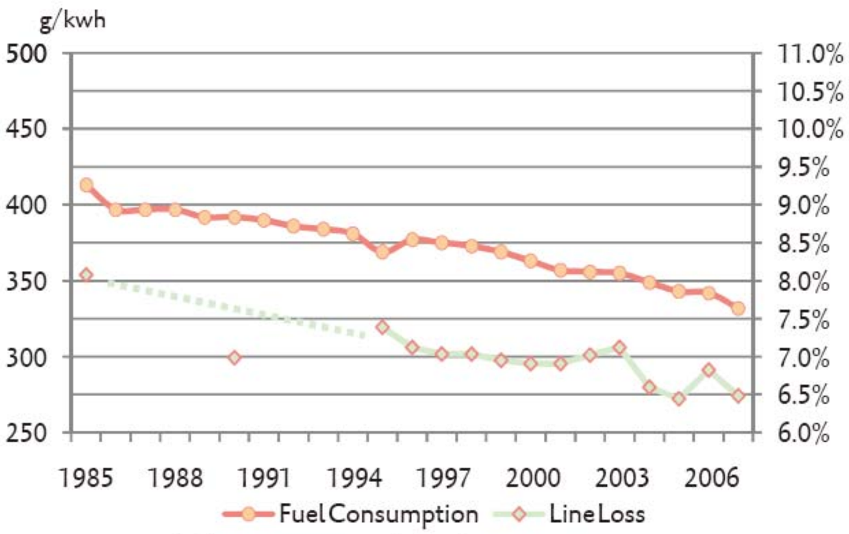


Figure 11: Unit fuel consumption and line loss
Source: (CEPYEC 2008) and (NBS 2008a)

Coal consumption for thermal power generation has substantially increased in recent years. The power sector consumed 272 million tonnes of coal and accounted for 25.8 percent of total coal demand in China in 1990. The amount increased to 1,305 million tonnes and 50.5 percent in 2007, as shown in Figure 12. Thus, energy efficiency at coal-fired power stations is the largest issue on the supply side of the power industry in China.

[7] Heat rate is also sometimes referred to as "unit fuel consumption"

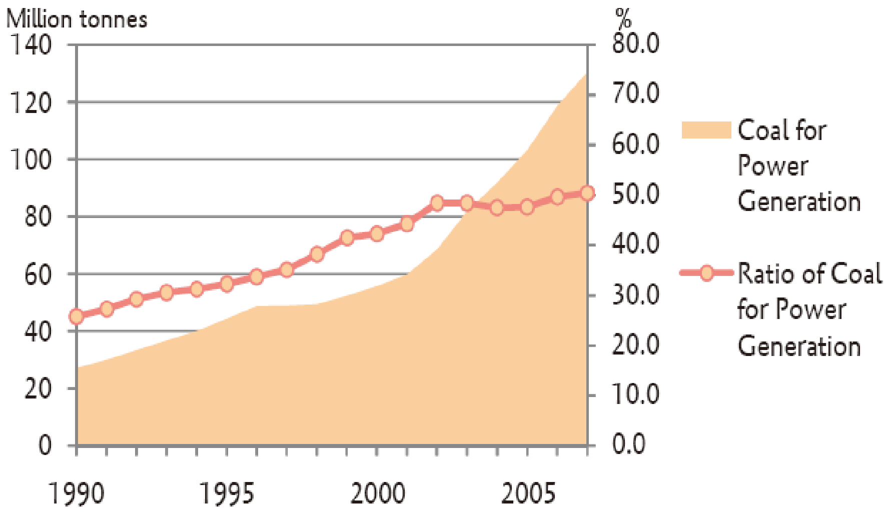


Figure 12: Coal for power generation
Source: (NBS 2008a)

Policies to Improve Efficiency

As the most important policy to improve energy efficiency in the electric power sector under the 11th Five-Year Plan (2006-2010), China is replacing obsolete, low-efficiency facilities with advanced ones in the power generation, transmission, and distribution sectors. This program also specifies increasing the grid network and connectivity among the six major grid areas.

In the 11th Five-Year Plan, thermal power generation efficiency was set to be reduced from 370 g/kWh in 2005 to 355 g/kWh in 2010. To accomplish this, the government is encouraging the construction of large ultra-supercritical coal-fired units above 600 MW that will achieve energy efficiency as high as 44 percent. Replacing smaller, less efficient units with these modern ones can reduce greenhouse gas emissions per unit of electricity output by more than one-third.

China designated the following power sector development policy components, aiming for a more secure, efficient, and resource-conserving power supply:

- Develop advanced power generation facilities, such as large-capacity mine-mouth power plants, waste coal utilization power plants, large hydro power facilities, large-capacity gas combined-cycle plants, gas turbine peak shaving plants, water-saving power generation plants and nuclear power plants.
- Develop power generation technologies with larger capacities and higher efficiency, such as supercritical and ultra-supercritical thermal units with a minimum capacity of 600 MW.[8]
- Restrict construction of conventional medium-sized and small units with a capacity of 300 MW or less that are situated in high-voltage power grids.
- Develop large-capacity, long-distance power transmission technology and upgrade grid operation technology.
- Develop combined heat and power (CHP) supplies for medium-sized and large cities in the northern heating zones.[9]

Energy efficiency is expected to be enhanced through improvement and optimization of

[8] (Zheng and Xu 2006)
[9] (NDRC 2006b)

facilities and their operation. By these policies, the modernization of China's electric power sector is being accelerated; though the sector still has a huge amount of aging, inefficient facilities. The above policy will be further refined in the next five-year plan following a review of implementation progress.

Implementation

The NDRC formulates China's general energy efficiency policy and it also reviews and approves the facility construction plans of the power industry. The SERC reviews and controls the electricity market, electricity tariffs, and the operation of electricity companies. As most of the grid companies and the generating companies belong to the central or local governments, the government is also in a position to direct their management. For example, the government can advise on facility construction plans and monitor how these power companies pursue the national policy. They can also ask grid operators to give dispatch priority to high-efficiency generators to improve the system's average generation efficiency.

The NDRC and SERC thus provide two channels by which the central government policy for improving energy efficiency can be communicated to on-site operators. However, a large share of the government-owned generation capacity is actually administered by the provinces, so the cooperation of these facilities requires coordination of the central and provincial governments.

Phasing Out Small Power Stations

Smaller power plants built under the past rural development programs are a major cause of low efficiency in China's power generating sector. Despite efforts to replace them with larger, more-modern plants, there were 4,804 units with a generating capacity of less than 100 MW at the end of 2006. Their share of total generating capacity was 18.8 percent. The industry association estimated that the installed capacity of small plants (under 135 MW), with high fuel consumption rates amounted to 150 GW.[10] On the other hand, large units of over 600 MW accounted for only 2.1 percent in terms of number of units and 18.4 percent in generating capacity, as shown in Table 13. The Chinese government has started the ambitious program to phase out the smaller units with firm resolve, though this may cause local administrations to lose businesses and jobs.

Table 13: Thermal power generating units, by capacity (end of 2006)

Capacity of Generating Units	Number of Units		Generating Capacity	
MW	Units	%	GW	%
>600	132	2.1	82	18.4
300–600	508	8.1	162	36.3
200–300	241	3.9	50	11.1
100–200	558	8.9	69	15.5
100>	4,804	77.0	84	18.8
Total	6,243	100.0	447	100.0

Source: (CEPYEC 2007)

As a part of its policy to accelerate the closing of smaller thermal power plants, the central government ordered grid companies to reduce electricity prices for the power from small thermal generators. According to the Circular of the State Council, this ruling applies to conventional thermal power generators with a unit capacity of less than 50,000 kW, those with a unit capacity of under 100,000 kW that have been operating more than 20 years, and those with a unit capacity of less than 200,000 kW that are operating beyond their designed service

[10] (CPIA 2008)

life and have an electricity price higher than the benchmark grid price for local coal-fired thermal units.[11]

Consistent with the Regulations on Electric Power Supervision, the NDRC and SERC share responsibility for supervising electricity prices. They are authorized to impose fines up to CNY1 million on generation and grid companies that violate state regulations.[12] In addition to the above directive, the energy efficiency improvement of each generation company is monitored by the government authorities. Because energy efficiency has become more important in national plans, this metric may be a factor in annual performance evaluations. Therefore, power companies are reluctant even to operate low-efficiency plants.

The displacement of the many small, inefficient plants in China will take more time to complete, but the program is being implemented ahead of schedule. Figure 13 shows the capacity of small thermal power units that were closed in the six grid areas during the first nine months of 2007. All together, small thermal power plants with capacity totaling 23.4 GW were closed in 2007, greatly exceeding the national goal of 10 GW. This has substantially contributed to the improvement of energy efficiency.[13]

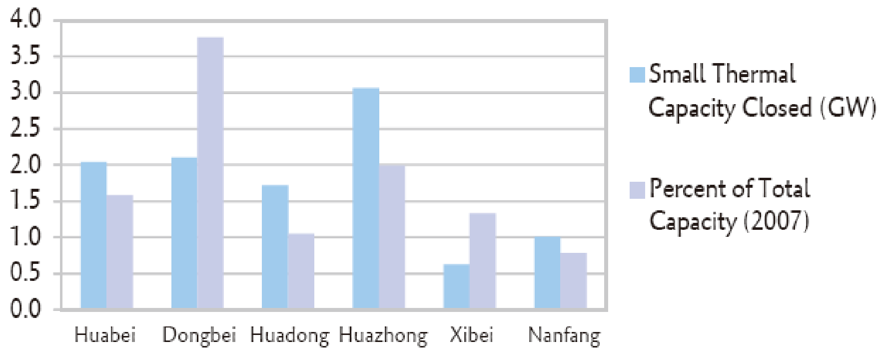


Figure 13: Small thermal power plants closed in six regional grids (Jan–Oct 2007)
Source: (CEPYEC 2008)

In 2007, the average thermal power station fuel consumption decreased from 356 g/kWh to 345 g/kWh in standard coal equivalent. The internal use at thermal power plants was reduced from 6.76 percent to 6.62 percent of generation, total carbon dioxide emission was reduced by at least 10 percent and transmission losses were reduced from 7.04 percent to 6.97 percent.[14] In total, closing small thermal plants is estimated to have saved 10.92 million tonnes of coal, and to have reduced SO_2 and CO_2 emissions by 0.6 million tonnes and 21 million tonnes, respectively.[15]

Improvement of Power Transmission and Delivery Efficiency

One of the biggest burdens for China's electricity sector is the uneven distribution of primary energy resources and electricity market centers. To cope with this, China has been implementing a west-to-east power transmission plan. Long-distance power transmission capability is being expanded through three major trunk lines (north, central, and south) that

[11] (NDRC 2007a)
[12] (State Council 2005b)
[13] (CPIA 2008)
[14] (CPIA 2008)
[15] (CPIA 2008)

connect the power sources in the West to the demand centers in the East. The current total transmission capacity via the three routes is 47.5 GW.[16]

At present, these trunk lines are mostly built with a maximum capacity of 500kV for DC and AC transmission, while a 1,438-km 800kV transmission line connecting Yunnan and Guangdong and a 654-km 1,000kV transmission line connecting Shanxi, Henan and Hubei are under construction. The west-to-east power transmission policy also aims to develop the economies of the central and western regions.[17]

One critical component of the energy efficiency policy in the electricity sector is to increase transmission capacity, reduce transmission loss, and raise supply reliability in order to accommodate the increasing demand. Present efforts are expected to significantly increase transmission efficiency and reduce transmission losses to 7 percent by 2010.[18] In addition, continued efforts need to be made in areas to optimise grid operating modes and transformer tap configuration, and also to strengthen passive power compensation and its regulation capability. Because the scaling-up of power plants and introduction of unstable renewable energies are being accelerated, grid management with wider coverage may also be required to enhance energy efficiency improvement in the transmission and delivery sector.

Combined Heat and Power (CHP)

Construction of CHP plants is an important measure to address air pollution in urban areas, as well as to improve energy efficiency. The Rules on the Development of Heat and Power Generation, issued in 1998, call on the local authorities and departments to support the development of CHP plants. Specifically, local authorities are required to create a local heat and power cogeneration plan. The planning commission is assigned responsibility to review and approve the plans. Large projects (greater than 25 MW) are to be approved by the NDRC, where smaller projects may be authorized by the local planning commission.[19] To promote CHP, the State Council has set out clear rules governing its construction and connection to the electricity grid. According to these rules, the fee for connecting to the electricity grid is exempted for new and expanded CHP facilities. It also stipulates that local authorities should support CHP projects for their efficient and harmonious operation. To this end, CHP plants and local electric power authorities are to collaborate to balance power dispatch with the heating load. The local power authorities that do not collaborate to achieve the efficient utilization of CHP plants may face penalties under the Energy Conservation Law and the Unfair Competition Law.[20]

Implication

There are small thermal power stations throughout China, built during the time of rural development. These stations reduce overall generation efficiency and cause serious air pollution. Thus, replacing them with large, state-of-the-art plants conserves resources and improves air quality. However, it is a thorny policy for China to urge rural villages to give up businesses, jobs and tax income. A huge capital investment is required to replace the small plants with larger ones, though the reduced fuel costs due to greater efficiency offer some compensation. Despite these hurdles, the Chinese government is implementing the policy to phase out smaller thermal power plants with the firm resolution to improve energy efficiency and air quality.

[16] (CPIA 2008)
[17] (CPIA 2008)
[18] (CPIA 2008)
[19] (SPC 2000)
[20] (NDRC 2004)

China's medium-sized thermal power plants (those smaller than 300 MW) are inefficient by advanced world standards. In China, these still account for more than 40 percent of total thermal capacity. Replacing these aging plants offers an opportunity to further reduce resource use and environmental impact in the future.

Only recently, 600 MW-class ultra-supercritical units were introduced, and the trend is moving to the 1000 MW-class ultra-supercritical units. In the next stage, the power sector's resource conservation and energy efficiency policy will be diversified to include non-fossil power generation, long-distance transmission, local distribution grids and DSM. To implement these policies while simultaneously ensuring that the power sector adequately supports regional development, the roles of local authorities will continue to be important.

Case Study: CHP Units of Beijing Huaneng Thermal Cogeneration Plant

The first phase project of the CHP plant of the Huaneng Power International Development Company and Beijing Municipality was a key state construction project. This project included four units with a total electricity supply capacity of 650-770 MW, heat supply of 3182 GJ/h, and steam supply for industry of 500 t/h. Construction of the project started in April 1995 and was completed in June 1999. Four generation units have been put into operation to date.

Because the plant is located in central Beijing, environmental protection and clean production were given top priority in its development. The boilers of the plant use ultra-high-pressure technologies, and the plant also features low-NOx burners, liquid ash removal, and other state-of-the-art technologies.

Combined heat and power production is a means of reducing energy consumption that has great potential in China. The Huaneng plant's total installed capacity of 845 MW supplies 10 percent of Beijing's power requirements, 70 percent of the city's steam needs, and covers 30 percent of its central heating load. This facility has the largest heating capacity of any CHP in the country. The annual average thermal efficiency of the generation unit is more than 60 percent, which is 20 percent higher than that of a conventional power plant. During the heating period, the unit thermal efficiency is as high as 84 percent. Since 1999, the plant has achieved an estimated savings of more than 400 million tce of fuel. In the summer of 2008, the use of waste heat for cooling was being studied in a pilot project; this may ultimately raise the average thermal efficiency by another 10 percent or more.

The emission level of pollutants from the boilers is in full compliance with both the national standard and the Beijing municipal standard (the latter is stricter than the national standard). The exhaust gas is monitored by the Beijing Municipal Environmental Protection Bureau 24 hours a day, and the discharged ash is 100 percent recycled. The factory also has installed three sewage treatment systems with combined annual processing of more than 10 million tonnes. The company is proposing a second-phase project to construct two 300 MW coal-fired generation units.

CHP plants can realize a very efficient energy supply system when the customers have sufficient heat requirements. The high potential efficiency and the industrial sector's large appetite for heat and high-quality steam suggest a promising area for CHP deployments. Large building complexes that require heat and steam are other, relatively easy applications, though seasonality of demand and geographic concentration are important constraints. Careful consideration of CHP in the design of city and district development plans will facilitate the most effective use of this highly efficient technology.

Case Study Source: (China Huaneng Group not dated)

HONG KONG, CHINA

Introduction

Hong Kong, China—a special administrative region of the People's Republic of China—is a world-class financial, trading and business centre of some 6.98 million people situated at the south-eastern tip of China. It has no natural resources; all of the energy consumed in Hong Kong, China, is imported. The energy sector consists of investor-owned electricity and gas utility services.

In 2008, the per capita GDP of Hong Kong, China, was USD 35 912, among the highest of the Asia–Pacific Economic Cooperation (APEC) economies. GDP expanded by a robust 2.37% in real terms in 2008. The services sector remained the dominant driving force of overall economic growth, accounting for 92% of GDP in 2008 (CSD 2010a).

The economy of Hong Kong, China, is driven by its vibrant financial services sector. The shift towards higher value-added services and a knowledge-based economy will continue. To stay competitive and attain sustainable growth, Hong Kong, China, needs to restructure and reposition itself to face the challenges posed by globalisation and closer integration with mainland China. The Mainland and Hong Kong Closer Economic Partnership Arrangement (CEPA) is a manifestation of the advantages of 'one country, two systems'. As part of the liberalisation of trade in goods under CEPA, all products originating in Hong Kong, China, enjoy tariff-free access to mainland China on application by local manufacturers, provided all CEPA rules of origin are agreed and met. Since January 2008, the economy's service suppliers have enjoyed preferential treatment in 38 service areas in mainland China (HKTID 2010). In addition, the Pan–Pearl River Delta Regional Co-operation Framework Agreement has brought more business opportunities for Hong Kong, China. In October 2007, the government announced it was undertaking 10 major infrastructure projects, including some cross-boundary infrastructure projects such as the Guangzhou–Shenzhen–Hong Kong Express Rail Link, Hong Kong–Zhuhai–Macao Bridge, and Hong Kong–Shenzhen Airport Cooperation.

Table 9 Key data and economic profile, 2008

Key data		Energy reserves	
Area (sq. km)	1 104	Oil (million barrels)	–
Population (million)	6.98	Gas (billion cubic metres)	–
GDP (USD (2000) billion at PPP)	250.58	Coal (million tonnes)	–
GDP (USD (2000) per capita at PPP)	35 912		

Source: EDMC (2010).

Energy supply and demand

PRIMARY ENERGY SUPPLY

Hong Kong, China, has no domestic energy reserves or petroleum refineries; it imports all of its primary energy needs. It generates some electricity. Total primary energy supply in Hong Kong, China, was 13.8 million tonnes of oil equivalent (Mtoe) in 2008, a decrease of 4.05% from 2007. Coal maintained the highest share of the total primary energy supply (51%), followed by oil (29%), gas (14%) and other sources (6%).

In 2009, the total installed electricity generating capacity in Hong Kong, China, was 12 644 MW (CSD 2010b), including imported power from Guangdong, China. All locally-generated power is thermal fired. Electricity is supplied by CLP Power Hong Kong Limited (CLP

Power) and the Hong Kong Electric Company Limited (HEC). CLP Power supplies electricity from its Black Point (2500 MW), Castle Peak (4108 MW) and Penny's Bay (300 MW) power stations. Natural gas and coal are the main fuels used for electricity generation at the Black Point and Castle Peak power stations. Natural gas is imported from the Yacheng 13-1 gas field off Hainan Island in southern China via a 780 kilometre high-pressure submarine pipeline. CLP Power also has the right to use 50% of the 1200 MW capacity of Phase 1 of the Guangzhou Pumped Storage Power Station at Conghua. HEC's electricity is supplied by the Lamma Power Station, which has a total installed capacity of 3756 MW. Natural gas used at HEC's power station is mainly imported through a submarine pipeline from the Dapeng liquefied natural gas (LNG) terminal in Guangdong, China. HEC has also operated a commercial wind turbine (800 kW) since February 2006 (HEC 2010).

Table 10 Energy supply and consumption, 2008

Primary energy supply (ktoe)		Final energy consumption (ktoe)		Power generation (GWh)	
Indigenous production	103	Industry sector	658	Total[a] (gross)	39191
Net imports and other	25192	Transport sector	2 154	Thermal	39191
Total PES	13 762	Other sectors	4141	Hydro	–
Coal	6 850	Total FEC	6 850	Nuclear	–
Oil	3 917	Coal	–	Other	–
Gas	2221	Oil	2 666		
Other	774	Gas	659		
		Electricity and other	3 523		

a Total does not include electricity generated by hydro and nuclear facilities located in China.

Source: EDMC (2010).

Town gas and liquefied petroleum gas (LPG) are the two main types of fuel gas used in Hong Kong, China. Town gas is distributed by the Hong Kong and China Gas Company Limited. It is manufactured at plants in Tai Po and Ma Tau Kok, using naphtha and natural gas as feedstock. LPG is supplied by oil companies, imported into Hong Kong, China, by sea and stored at the five terminals on Tsing Yi Island (Towngas 2010).

FINAL ENERGY CONSUMPTION

In 2008, the total final energy consumption in Hong Kong, China, was 6879 ktoe, almost 2.2% lower than in the previous year. The other sectors (residential and commercial) accounted for the largest share at 58%, followed by the transport sector (31%) and the industrial sector (11%). By energy source, electricity and other made up 51% of end-use consumption, followed by petroleum products (40%), and gas (8.7%).

Gas is supplied for domestic, commercial and industrial uses in two main forms—town gas and LPG. In addition, LPG is used as a fuel for LPG taxis and light buses, and natural gas is used for electricity generation and city gas production.

Policy overview

ENERGY POLICY FRAMEWORK

The government of Hong Kong, China has pursued two key energy policy objectives. The first is to ensure the energy needs of the community are met safely, efficiently and at reasonable prices. The second is to minimise the environmental effects of energy production and consumption, and to promote the efficient use and conservation of energy. In keeping with the free market economic policy of Hong Kong, China, the government intervenes only when it is necessary to safeguard the interests of consumers, to ensure public safety and to protect the environment. The government works with the power, oil and gas companies to maintain strategic reserves of coal, diesel and naphtha. It monitors the power companies' performances through the Scheme of Control Agreements and, in consultation with the power companies, promotes energy efficiency and energy-saving measures. It has also entered into an information and consultation agreement with the Hong Kong and China Gas Company Limited to make the town gas tariff adjustment mechanism more transparent.

ENERGY MARKETS

A memorandum of understanding signed by the government and the National Energy Bureau on 28 August 2008 ensures the long-term and stable supply of nuclear-generated electricity, and the supply of natural gas from three different sources: offshore gas, piped gas and LNG from a LNG terminal to be built as a joint venture on a neighbouring mainland China site. Gas-fired power plants generated 23% of the economy's electricity in 2009. To improve air quality and to address the challenges posed by global warming, the government is exploring ways to gradually increase the use of clean energy.

ENERGY EFFICIENCY

BUILDINGS

Energy consumption indicators and benchmarks have been developed for hospitals, clinics, universities, schools, hotels and boarding houses, offices and commercial outlets in the commercial sector. The periodically-updated indicators and benchmarks help users to compare energy efficiency performances and to identify and implement improvements. The indicators and benchmarking tools are available on the Electrical and Mechanical Services Department's website (EMSD 2010a).

A voluntary Energy Efficiency Labelling Scheme (EELS) covers 18 types of household and office appliances, including refrigerators, room coolers, washing machines, electric clothes dryers, compact fluorescent lamps, electric storage water heaters, electric rice-cookers, dehumidifiers, televisions, multifunction office devices, photocopiers, laser printers, LCD monitors, electronic ballasts, computers, domestic gas instantaneous water heaters, fax machines and bottled cold/hot water dispensers.

To further encourage the use of energy-efficient products, the government introduced a mandatory EELS through the Energy Efficiency (Labelling of Products) Ordinance (EMSD 2010b). The initial phase of the mandatory EELS, covering room air conditioners, refrigerating appliances and compact fluorescent lamps, was implemented in November 2009. The second phase of the mandatory scheme, covering washing machines and dehumidifiers, started in March 2010 with an 18-month grace period.

The government has been promoting a voluntary building energy code (BEC) since 1998 through its Hong Kong Energy Efficiency Registration Scheme for Buildings. The BEC covers prescriptive minimum energy performance standards (MEPS) on lighting, air conditioning, electrical and lift and escalator installations. The government also takes an alternative performance-based approach to a building's total energy consumption as compared to the energy budget of a hypothetical building which can meet all prescriptive code requirements. Since March 2007, an alternative certification path for energy-audited buildings with good energy performance has been provided. By December 2009, 1086 building venues had been registered under the scheme.

To further enhance energy efficiency in buildings, the government introduced the Buildings Energy Efficiency Bill into the Legislative Council (LegCo) in December 2009 to start the vetting procedures for mandatory compliance with the BEC. The Bill was passed in November 2010 and the Buildings Energy Efficiency Ordinance was gazetted in December 2010. With an 18-month grace period, the Ordinance is expected to be fully implemented by mid-2012. It is estimated mandatory compliance will result in an energy saving of 2.8 billion kWh for new buildings in the first 10 years of the Ordinance's implementation. This will contribute to a reduction in carbon dioxide emissions of 1.96 million tonnes. Further energy savings will be realised in existing buildings constructed before the new legislation came into effect, by requiring compliance with the BEC when prescribed major retrofitting works are carried out in these buildings.

In October 2008, the government of Hong Kong, China, announced a district cooling system (DCS) would be implemented at the new Kai Tak Development as one of the measures to promote energy efficient buildings. The proposed DCS will have a designed cooling capacity of 284 MW and will supply chilled water to non-domestic buildings for centralised air conditioning. The project will be developed in phases and the design and construction work is targeted to start in 2011 to match the schedule of development at Kai Tak.

Water-cooled air conditioning systems using cooling towers are more energy efficient than conventional air-cooled systems. To promote energy efficiency in buildings, the government launched a scheme for the wider use of fresh-water cooling towers for air-conditioning systems in 2000; it became a standing scheme in June 2008. The number of designated areas has expanded from an initial six areas to 102 as at the end of November 2010. The scheme now covers about 78% of the non-domestic floor area of Hong Kong, China, and 268 cooling tower installations have been completed and put into operation. It is estimated these installations could save up to 194 million kWh of electricity consumption and reduce carbon dioxide emissions by 136 000 tonnes per year.

In April 2009, the government promoted a comprehensive target-based green performance framework (the framework) for new and existing government buildings and set targets on various aspects of environmental performance. It also aims to achieve a 5% saving on the total electricity consumption in government buildings from 2009–10 to 2013–14 after discounting activity changes, using the electricity consumption in 2007–08 as the baseline.

The government has allocated HKD 450 million from the 2009–10 Budget to improve the green performance of government buildings, such as installing energy efficient lighting systems, retrofitting plumbing with water saving devices and incorporating energy efficient features in air conditioning, lift and escalator systems. Furthermore, the government has allocated an additional HKD 130 million in 2009–10 to carry out works to enhance the energy efficiency of government buildings and public utilities.

Two funding schemes totalling HKD 450 million were launched under the Environment and Conservation Fund in April 2009, to encourage building owners to carry out energy/carbon audits and energy efficiency projects. These schemes will create business opportunities for electrical, mechanical, building services and environmental and related industries. As at November 2010, there were over 600 audits/projects approved, with an estimated energy saving of about 106 million kWh or a carbon dioxide emission reduction of about 74 600 tonnes per year.

TRANSPORT

Energy consumption indicators and benchmarks have also been developed for private cars and light, medium and heavy goods vehicles in the transport sector. The indicators and benchmarks are updated periodically so users can compare energy efficiency performances, and identify and implement improvements. The indicators and benchmarking tools are available on the Electrical and Mechanical Services Department's website (EMSD 2010a).

The voluntary Energy Efficiency Labelling Scheme was extended to cover petrol passenger cars in 2002, to raise the level of public awareness of vehicle energy efficiency.

A competition entitled 'Eco-drivers' was launched in September 2008. This fuel economy run aimed to raise the awareness of energy and fuel conservation and the role it plays in sustainable development, and called for public actions to realise this principle in daily life, particularly through driving.

In Hong Kong, China, almost all the diesel taxis have been replaced by liquefied petroleum gas (LPG) models. In August 2002, the government launched a voluntary incentive scheme to encourage owners of existing diesel public and private light buses to replace their vehicles with LPG or electric models. The scheme finished at the end of 2005; but as of the end of 2009, there were over 3100 LPG light buses in operation, representing about 49% of all public/private light buses in Hong Kong, China. Taking the leading role in the use of green vehicles, the government introduced petrol-electric hybrid vehicles in its vehicle fleet in 2005. From April 2007, the government has allowed a reduction of First Registration Tax to encourage car owners to use environment-friendly petrol private cars. A similar scheme to encourage the use of environment-friendly commercial vehicles was launched in April 2008. In addition, the government is continuously identifying possible ways to encourage vehicle owners to use cleaner alternative fuel vehicles.

In the 2009–10 Budget, the Financial Secretary announced measures to promote the use of electric vehicles in Hong Kong, China. These measures include extending the waiver of First Registration Tax on electric vehicles for five years until the end of March 2014, promoting the setting up of electric vehicle (EV) battery charging facilities, and setting up a steering committee to make recommendations on strategy and specific measures for their promotion. In the 2010–11 Budget, it was further proposed to accelerate the tax deduction for capital expenditure on electric vehicles so enterprises can enjoy a 100% profits tax deduction in the first year. The budget also proposed a HKD 300 million Pilot Green Transport Fund to provide funding support for the transport industry to introduce more innovative green technologies, including electric vehicles. Electric vehicles such as 'MyCar', Mitsubishi's 'i-MiEV' and Tesla's 'Roadster', have already been launched in the retail market in Hong Kong, China, and more new models are expected. By mid-2010, the two local power companies had set up around 60 EV charging points in the territory. The government is soliciting the support of property developers to sponsor the setting up of EV charging facilities at their developments. It is expected that there has been a substantial increase in the number of EV charging points in Hong Kong, China, by the end 2010.

DATA

The government maintains and updates an energy end-use database. The database provides a useful insight into the energy consumption patterns of different sectors, sub-sectors and end uses in Hong Kong, China. The Hong Kong Energy End-use Data 2010, using 2008 basic data, is publically available on the Electrical and Mechanical Services Department's website (EMSD 2010c).

RENEWABLE ENERGY

To support the development of renewable energy (RE) in Hong Kong, China, the government has put in place provisions under a new Scheme of Control Agreements for the two power companies, to encourage them to use RE and to invest in RE facilities. In the new agreements, power companies will enjoy a higher permitted rate of return of 11% for their investment in RE facilities, compared with a return of 9.99% for ordinary investments. The power companies will also be offered a bonus in the range of 0.01 to 0.05 percentage points on their return, depending on the extent of RE usage in their electricity generation.

To promote the wider use of RE in the community, the government provided tax incentives for RE installations during the 2008–09 assessment year. In view of the increasing popularity of RE installations, it has published a set of technical guidelines to help the public better understand the technical issues and the application procedures for grid connections of RE power systems. The guidelines apply to RE power systems with a rating up to 1 MW and are publically available on the Electrical and Mechanical Services Department's website. The government has also developed the Hong Kong Renewable Energy Net website (HK RE Net) to provide comprehensive information on renewable energy technologies, with an emphasis on those technologies suitable for applications in Hong Kong, China (EMSD 2007).

The findings of a government-commissioned study to investigate the viability of using renewable energy technologies suggested the eastern side of Hong Kong, China, may have sufficient wind resources for commercial wind farms. Five wind-monitoring stations were erected at the Government Logistics Centre, Pottinger Peak, Town Island, Tung Lung Chau and Miu Tsai Tun to gather wind resource data in the region. The wind data collected at the five stations has been analysed and, with data collected from the Hong Kong Observatory, used to produce a detailed wind resource map covering all parts of the Hong Kong, China, territories. The map and an online wind resources calculator are publically available through the HK Sustainable Technology Net portal site (EMSD 2008). The technical guidelines for grid connections of small-scale RE power systems are on the Electrical and Mechanical Services Department's website.

A 350 kW photovoltaic (PV) installation, the largest in Hong Kong, China, has been installed on the roof of the EMSD headquarters in Kowloon Bay. It comprises (1) a solar array made up of more than 2300 PV modules which together has a total area of around 3180 m^2, and (2) a smaller system made up of PV glass laminates (EMSD 2009). The largest solar power system in Hong Kong, China, was commissioned by HEC on Lamma Island in July 2010.

NUCLEAR

CLP Power is contracted to purchase around 70% of the electricity generated by the two 984 MW pressurised water reactors at the Guangdong Daya Bay Nuclear Power Station at Daya Bay in mainland China, to help meet the long-term demand for electricity in its supply area (CLP 2010). In September 2009, the government approved the extension of CLP Power's contract for the supply of nuclear-generated electricity from Guangdong Daya Bay Nuclear Power Station for another 20 years, from 7 May 2014. The extension of the contract ensures a continued supply of cleaner electricity to Hong Kong, China, which will help to alleviate air pollution and greenhouse gas emissions locally.

CLIMATE CHANGE

The government aims to reduce the energy intensity of GDP by 25% by 2030 relative to 2005 levels, and to reduce electricity consumption in government buildings by 5% by 2013–14 relative to 2009–10 levels. It will also make efforts in support of China's target to reduce carbon intensity.

In July 2008, to help the users and managers of buildings to enhance their awareness of greenhouse gas (GHG) emissions, to measure the GHG emissions performance of their buildings and to voluntarily participate in reducing and/or offsetting GHG emissions to combat climate change, the government published the Guidelines to Account for and Report on Greenhouse Gas Emissions and Removals for Buildings of Commercial, Residential or Institutional Purposes in Hong Kong (also known as the carbon audit guidelines). The guidelines have been designed for voluntary and self-reporting by the reporting entities, and they provide a systematic and scientific approach to accounting for and reporting on GHG emissions and emissions removals from buildings. In February 2010, a revised edition of the guidelines with updated emission factors was made publically available on the Environmental Protection Department's website (EMSD 2010d). At the same time the government launched the Green Hong Kong Carbon Audit campaign. Organisations from all sectors are encouraged to join the campaign as Carbon Audit Green Partners to conduct or help to conduct carbon audits on their buildings, and/or to initiate carbon reduction programs according to the Carbon Reduction Charter. By the end of November 2010, over 210 organisations from various sectors had joined the Carbon Audit Green Partners scheme.

Notable energy developments

REDUCING GREENHOUSE GAS EMISSIONS OF POWER GENERATION

Power generation is the largest source of greenhouse gas (GHG) emissions in Hong Kong, China. Revamping the fuel mix for local power generation is an essential step for suppressing the economy's GHG emissions and carbon intensity. In 2009, coal (about 54%) dominated the fuel mix for power generation in Hong Kong, China, followed by natural gas (about 23%) and nuclear-generated power imported from mainland China (about 23%). A consultation document on climate change, rolled out in September 2010, proposes a revamp of the fuel mix by 2020 as follows:

1. To keep coal-fired power plants at a very low utilisation rate or as a reserve, such that coal would account for no more than 10% of the fuel mix
2. To increase the share of natural gas in the fuel mix to around 40%
3. To use substantially more non-fossil low-carbon fuels, such that renewable energy would make up about 3%–4% of the fuel mix, and the balance of about 50% would be met by imported nuclear-generated power.

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useful links

Census and Statistics Department—www.censtatd.gov.hk

Electrical and Mechanical Services Department—www.emsd.gov.hk

Environment Bureau—www.enb.gov.hk

Environmental Protection Department—www.epd.gov.hk

Transport Department—www.td.gov.hk

CHINESE TAIPEI

Introduction

Chinese Taipei, consisting of the islands of Taiwan, Penghu, Kinmen and Matsu and several islets, is located in the middle of a chain of islands stretching from Japan in the north to the Philippines in the south. Its position, just 160 kilometres off the south-eastern coast of China, makes it a natural gateway to East Asia. It has an area of around 36 188 square kilometres. Only one quarter of the land is arable, but the subtropical climate permits the multi-cropping of rice and the growing of fruit and vegetables all year round.

In 2008, Chinese Taipei's GDP was USD 634.41 billion, and its per capita income was USD 27 652 (USD (2000) at PPP). Rapid economic development over the past decade has substantially changed the economic structure of Chinese Taipei, shifting the emphasis from industrial production to the services sector. In 2008, the services sector contributed 69.1% to GDP, followed by the industrial sector (29.3%) and the agriculture sector (1.6%). There has been an increase in the population of Chinese Taipei, which is one of the most densely populated areas in the world, but the rate of increase has been relatively mild. The population of 22.94 million grew at a rate of 0.33% between 2007 and 2008. This was much slower than the average annual growth of 0.4% between 2000 and 2008.

Chinese Taipei has very limited domestic energy resources and relies on imports for most of its energy requirements. There are no oil or coal reserves in Chinese Taipei, but it has gas reserves of around 6.2 billion cubic metres (EIA 2010). In 2008, installed electricity generation capacity totalled 46 381 MW.

Table 32 Key data and economic profile, 2008

Key data		Energy reserves[b]	
Area (sq. km)[a]	36 189	Oil (million barrels)	–
Population (million)	22.94	Gas (billion cubic metres)	6.2
GDP (USD (2000) billion at PPP)	634.41	Coal (million tonnes)	–
GDP (USD (2000) per capita at PPP)	27 652		

a Directorate-General of Budget (2010).

b EIA (2010).

Source: EDMC (2010).

Energy supply and demand

PRIMARY ENERGY SUPPLY

In 2008, Chinese Taipei's total primary energy supply was 107 218 kilotonnes of oil equivalent (ktoe), a decline of 4.6% from the previous year. By fuel, oil contributed the largest share (40%), followed by coal (36%), natural gas (12%) and other fuels (12%). Chinese Taipei has limited indigenous energy resources and imports around 99% of its energy needs.

Chinese Taipei imports almost its entire crude oil requirement. The Middle East is its major supplier, accounting for 82% of total imports. In 2008, Chinese Taipei imported 45.6 million tonnes of crude oil. However, because the refining capacity of the economy exceeds domestic demand, Chinese Taipei is a net exporter of petroleum products. Exports of petroleum products were around 10 million tonnes in 2008. To prevent supply disruption, Chinese Taipei's refiners are required by the Petroleum Administration Act to maintain stocks of more than 60 days of sales volumes.

The total refining capacity of 1.26 million barrels per day is operated by Chinese Petroleum Corporation (CPC) (57.1%) and Formosa Petrochemical Corporation (FPCC) (42.9%). CPC—the state-owned oil company—is the dominant player in all sectors of the economy's petroleum industry, including exploration, refining, storage, transportation and marketing. FPCC is a subsidiary of the private petrochemical firm Formosa Plastics Group. In August 2006, FPCC completed an upgrade of its refinery facility at Mailia, increasing its refining capacity from 450 000 to 510 000 barrels per day. Although refining capacity exceeds the domestic consumption of petroleum products, both CPC and FPCC are considering constructing new refineries or expanding their existing plants (BOE 2008a).

As natural gas resources are also limited, domestic demand is almost entirely met by imports of liquefied natural gas (LNG), largely sourced from Indonesia and Malaysia. LNG imports in 2008 were 9.0 million tonnes, a 9% increase from 2007. CPC operates Chinese Taipei's only LNG receiving terminal at Yungan, Kaohsiung, with a handling capacity of 8.56 million tonnes a year. To meet the increasing demand and the first-stage goal of supplying gas for use by Taiwan Power Company's (TPC's) Datan Power Station from 2008, CPC has built a second terminal at Taichung Harbour, with a design capacity of 3 million tonnes a year. It was completed at the end of 2009 (CPC 2009).

Table 33 Energy supply and consumption, 2008

Primary energy supply (ktoe)		Final energy consumption (ktoe)		Power generation (GWh)	
Indigenous production	13 727	Industry sector	24 261	Total	235 108
Net imports and other	98 078	Transport sector	8 469	Thermal	183 720
Total PES	107 218	Other sectors	31 602	Hydro	4 257
Coal	38 729	Total FEC	64 332	Nuclear	40 827
Oil	42 395	Coal	6 240	Other	6 304
Gas	12 700	Oil	37 889		
Other	13 394	Gas	2 036		
		Electricity and other	18 167		

Source: EDMC (2010).

Coal is used for electricity generation as well as by the steel, cement and petrochemical industries. All Chinese Taipei's coal requirements are imported, mainly from Australia (69.9%) and Canada (25.6%). In 2008, the primary coal supply was 38.7 million tonnes of oil equivalent (Mtoe), which was 3.9% lower than in 2007. To secure a stable supply of coal, joint ventures to undertake exploration and development overseas are necessary.

Chinese Taipei generated 235 108 GWh of electricity in 2008. TPC's thermal power and nuclear power contributed 47.6% (29% from coal, 4.8% from oil and 13.7% from LNG) and 17.1%, respectively; privately owned cogeneration 16.5%; independent power producers (IPPs) 15.5%; hydro power 3.3% and wind power 0.1%. TPC dominates Chinese Taipei's electric power sector, and IPPs account for only 15.9% of the total capacity. IPPs are required to sign power purchase agreements with TPC, which distributes power to consumers. To expand foreign participation, in January 2002 the government permitted foreign investors to own up to 100% of an IPP. Currently, two 1350 MW advanced light water reactors in the Fourth Nuclear Power Project are under construction to boost electricity generation (EDMC 2010).

FINAL ENERGY CONSUMPTION

Final energy consumption in Chinese Taipei was 64 332 ktoe in 2008, 5.18% lower than in 2007. Other sectors (including residential and services) consumed 49.1% of the total, followed by the industrial sector (37.7%) and transportation (13.1%). By energy source, petroleum products accounted for 58.9% of the total final energy consumption, followed by electricity (28.2%), coal (9.7%) and city gas (3.2%).

The other sectors (heat and other) was the main energy consumer (31 602 ktoe). Rising gasoline prices and a more convenient mass transportation system have moderated energy consumption in the transportation sector. Consumption in the sector was 8469 ktoe in 2008, a 30.28% decrease from 2007 (12 148 ktoe). In 2008, consumption in the industry sector increased by 5.93%.

Policy overview

ENERGY POLICY FRAMEWORK

POLICY

The Bureau of Energy is responsible for formulating and implementing Chinese Taipei's energy policy. It is also charged with enforcing the Energy Management Law and Electricity Law; regulating natural gas utilities, petroleum and liquefied petroleum gas filling stations; regulating the importation, exportation, production and sale of petroleum products; maintaining an energy database; evaluating energy demand and supply; promoting energy conservation; implementing research and development programs; and promoting international energy cooperation.

The fundamental goal of Chinese Taipei's energy policy is to promote energy security, supported by the secure importation of oil, natural gas and coal, and the development of domestic energy resources, including nuclear, fossil fuels and new renewable energy.

In December 2005, the Bureau of Energy released an Energy Policy White Paper addressing worldwide trends, short-term and long-term energy security challenges and the corresponding measures to be taken. Future energy policy will focus on:

- stabilising energy supply to increase energy independence
- increasing energy efficiency and reinforcing the management of energy efficiency
- further promoting the liberalisation of the energy market
- coordinating the development of the 3Es (energy, environment, economy)
- reinforcing research and development
- promoting education campaigns and expanding public participation.

The aims of Chinese Taipei's energy policy are to establish a liberalised, orderly, efficient and clean energy supply and demand system based on the environment, local characteristics, future prospects, public acceptability and practicability.

The Bureau of Energy released the Framework of Sustainable Energy Policy on 5 July 2008. It includes:

- policy objectives—to achieve a win-win-win solution for energy, environment and economy, and to set targets for improving energy efficiency, developing clean energy and securing a stable energy supply
- policy principles—to establish a high-efficiency, high value-added, low-emissions and low-dependency energy consumption and supply system
- a strategic framework—divided into two parts: cleaner energy supply and rationalised energy demand
- follow-up work—government agencies to formulate concrete action plans which clearly set carbon reduction targets and build monitoring and follow-up mechanisms to review effectiveness and performance and to establish quantitative objectives for each task to measure performance and facilitate implementation (BOE 2008b).

ENERGY SECURITY

As Chinese Taipei is almost completely dependent on oil imports, the government has been working to secure supply. To stabilise oil supply, private oil stockpiling could replace the 60 days of sales volumes (which is defined as the average domestic sales and private consumption over the past 12 months) required under the Petroleum Administration Act. Using the Petroleum Fund to finance the storage of oil, the government is responsible for stockpiling 30 days of oil demand (BOE 2009a, Article 24). Under the Act, the liquefied petroleum gas stockpile should be more than 25 days of supply.

For many years, CPC has engaged in cooperative exploration with governments and large international oil companies under the name of the Overseas Petroleum and Investment Corporation (OPIC), in operations throughout the Americas, the Asia–Pacific region and Africa. Following rising oil prices in recent years, CPC made strenuous efforts to develop upstream exploration to secure oil sources. In line with the government's policy of 'deepening the energy supply safety mechanism and promoting international energy cooperation', CPC has engaged in international cooperation in exploration and development in the hope of discovering new reserves of oil and natural gas. In 2008, CPC engaged with international oil companies in cooperative exploration in 13 fields in eight economies.

On 26 December 2008, CPC signed exploration cooperation agreements with the China National Offshore Oil Corporation (CNOOC). Among other things, the agreements covered the renewal of an agreement on joint exploration in the Tainan Basin of the Taiwan Strait, a feasibility study of exploration in the Nanridao Basin off northern Taiwan, and the transfer of a 30% stake in CNOOC's onshore Block 9 in Kenya to CPC.

In the future, CPC's strategy is to increase overseas exploration and production by raising the value of its existing overseas oil and gas fields and establishing core areas with high rates of growth, participating actively in bidding for open blocks, seeking opportunities to take over fields from large oil companies, and pursuing opportunities for mergers and acquisitions in new oil and gas fields to add to the company's reserves (CPC 2010).

ENERGY MARKETS

MARKET REFORMS

The Petroleum Administration Act has been amended to further liberalise the petroleum market. The government is now coordinating with the relevant agencies to implement the amendments. Key actions include the following:

- Petroleum prices will be determined by market mechanisms. The equation used to adjust gasoline and diesel prices, originally determined by CPC, was abolished in September 2000 after FPCC's petroleum products were released to the market. Following significant fluctuations in international petroleum prices in the second half of 2005, the Ministry of Economic Affairs (MOEA) authorised CPC to adopt a floating fuel pricing mechanism at the beginning of 2007; this is still in force.
- The petroleum market will be further liberalised through the following three actions. First, the amendments made to the Petroleum Administration Act in 2008 and 2009 to reflect changes that had occurred over time in the social environment and to ensure a secure supply of domestic petroleum. Second, the security reserve threshold for the petroleum import business was reduced from 50 000 kilolitres (kL) to 10 000 kL, while the reserve for the petroleum refinery will be maintained at 50 000 kL. This is expected to reduce the barriers to entry to the market. Third, the partial import tariff on petroleum products was relaxed in line with global trends. The Ministry of Finance has accepted the World Trade Organization's suggestion to reduce the tax difference between petroleum products and crude oil (that is, tariffs on gasoline, kerosene, jet fuel and diesel should be reduced to 0%).
- There are 23 private and two state-run natural gas companies, administered by the MOEA according to the Act for Regulating Privately Owned Public Utilities and the

Regulations Governing the Administration of Gas Utilities. To establish the sound management of natural gas utilities and to incorporate the production and importation of natural gas into regulations, a draft Natural Gas Business Bill has been completed and submitted to the Legislative Yuan for deliberation. The Bill outlines the responsibilities of authorities and has provisions for the operation of businesses, the safety of related facilities, disaster prevention, customers' rights and the establishment of a safety inspection system. Penalties for noncompliance are also addressed (BOE 2008c).

ELECTRICITY MARKETS

The Chinese Taipei Government's aim is to have a total electricity supply that provides a reserve capacity of 15%–20% based on peak demand. During the 1990s, some of TPC's new power plants were unable to meet their construction schedules because of environmental issues and complex government approval processes. This kept the total electricity supply below reserve capacity between 1990 and 2004. Reserve capacity was under 8% between 1990 and 1996. Beginning in 1995, to stabilise the power supply, Chinese Taipei's electricity market was opened to IPPs when the reserve capacity fell below 16%. Power produced by IPPs is sold to TPC through TPC's transmission lines. To prevent electricity supply outages, the MOEA announced the Fourth Stage of Opening the Electricity Market to IPPs in June 2006. IPP investors did not meet the bidding price offered by TPC for this stage. Fortunately, power demand is not expected to increase between 2011 and 2013. The MOEA will announce a fifth stage of opening the electricity market to IPPs if the reserve capacity falls below 16% in the future.

To comply with the schedule for privatising TPC and promoting the liberalisation of the domestic power market, the MOEA has completed a program of liberalising the electricity industry. Based on the program, a draft amendment to the Electricity Act was submitted to the Legislative Yuan for review. Now the legislative process to amend the Electricity Act has been completed, the generation sector will be able to set up and invest in the integrated utility, transmission utility and distribution utility. In addition, generators will be able to sell power to consumers directly, which means the market structure will no longer be a monopoly. A competitive mechanism will also be established to improve the performance of utilities (BOE 2008b).

FISCAL REGIME AND INVESTMENT

Chinese Taipei has limited indigenous resources so it has no formal policy on investment in upstream assets. Foreign investors are welcome to participate in the IPP electricity market bidding process discussed above.

ENERGY EFFICIENCY

Chinese Taipei's energy efficiency strategy will target both the supply and demand sides (BOE 2008d).

On the supply side, the strategy has two main aims:

- Increasing the proportion of low-carbon and high-efficiency electricity generation plants by increasing the ratio of efficient gas combined-cycle generation. In 2025, gas combined-cycle generation is expected to account for 25% of the power generation system.
- Introducing the world's best available technology for electricity generation by speeding up power plant replacement, setting plans to raise the overall efficiency of power plants and calling for the world's best practice power conversion efficiency standards for all new power plants.

On the demand side, the strategy has three main aims for the manufacturing sector:

- Establishing financial incentives and regulatory mechanisms by providing preferential loans and investment tax credits, accelerated depreciation, and other financial incentive measures; by establishing energy-saving performance measurement verification mechanisms; by promoting energy-saving performance guarantee projects; and by introducing energy services companies to provide technology, capital and human resources.

- Improving energy efficiency by promoting high-efficiency motor programs and boiler efficiency plans and by establishing specific energy consumption indicators.
- Establishing full-service energy-saving systems by establishing the MOEA Service Centre and in-house counselling services; and strengthening and deepening energy technology services.

On the demand side in the residential sector, the strategy has four main aims:

- Encouraging the service industry to sign a voluntary agreement for energy conservation and setting an energy-saving goal of 5%–10%.
- Enhancing the use of electrical appliances with high energy efficiency, expanding electrical products energy-efficiency management, subsidising the purchase of energy-saving products, and promoting the use of high-efficiency and low standby power products.
- Promoting a revolution in lighting. By 2012, incandescent bulbs will be extensively replaced and LED lighting will be promoted.
- Promoting price discount programs. Residential customers and primary schools using less than the average daily kWh usage in the same period of the previous year will be given a discount.

In the transportation sector, the aims are to raise standard fuel efficiency for private vehicles (measured in passenger kilometres per litre) stepwise to 25% by 2015, and to promote the replacement of traditional traffic lights with LED lighting.

In the government sector, the intention is to promote negative growth in oil and electricity consumption within government agencies and schools, aiming for an accumulated saving of 7% in 2015.

RENEWABLE ENERGY

In response to high oil prices and the global trend towards reducing greenhouse gas emissions, promoting the development and use of renewable energy is considered a critical strategy internationally. In Chinese Taipei, 99% of energy supply is imported. Therefore, promoting renewable energy development can diversify the energy supply, increase the share of domestically produced energy and lead the development of local industry. This will help the economy reach the goal of the three 'wins' of energy security, environmental protection and economic development. To promote the use of new renewable energy, the government has selected some major areas with viable market potential: solar energy, wind energy, geothermal energy, ocean energy, biomass, and energy from waste.

Chinese Taipei mainly emphasises wind power, solar photovoltaic and biofuels, and also promotes other renewable energies as auxiliary means. By December 2008, the total installed capacity of renewable electricity generation was 2843 MW, which can produce approximately 7.65 billion kWh of electricity annually (BOE 2008d).

To effectively promote renewable energy and to respond to the requirements of the private sector for institutionalised incentive measures, Chinese Taipei promulgated the Renewable Energy Development Bill on 8 July 2009 (BOE 2009b). The essence of the Bill is based on fixed feed-in tariffs and grid-connecting obligations to secure the market for electricity generated from renewable energy. The subsidisation of photovoltaic, hydrogen energy and fuel cells was also proposed. Because of the differences between the non-renewable electricity generating costs of power utilities and the renewable electricity feed-in tariffs, a fund will be established to subsidise utilities when they produce or purchase renewable electricity. It is hoped that electricity from renewable resources will account for 8% of total electricity generation by 2025.

NUCLEAR

To diversify the electricity generation mix, the government encourages the development of nuclear energy. At the end of 2009, there were three nuclear energy plants with six units and a total installed capacity of 5144 MW; the first reactor has two units of 636 MW, the second two units of 985 MW and the third two units of 951 MW. The first unit of the fourth nuclear energy plant (1350 MW) will be completed in 2011, and the second (1350 MW) will be completed in 2012. By 2012, there will be 7844 MW of installed nuclear energy generation capacity (TPC 2010).

CLIMATE CHANGE

In view of global climate change and energy shortages, the policies of the Chinese Taipei Government focus on energy conservation and reducing carbon emissions. To achieve those aims, the Executive Yuan approved the Sustainable Energy Policy on 5 June 2008, and issued the Sustainable Energy Policy—Energy Carbon Reduction Action Program on 4 September 2008. However, because the action program spans only four years of policy planning, long-term and controversial energy issues, which require extensive discussion, are discussed through the National Energy Conference. The Executive Yuan held the Third National Energy Conference on 15–16 April 2009. The main topics included sustainable development and energy security; energy management and efficiency enhancement; energy prices and the opening of the market; and energy technology and industrial development (BOE 2009c). Chinese Taipei's targets are to reduce economy-wide CO_2 emissions so total emissions return to the 2008 level during the period 2016–20, and are then further reduced to the 2000 level in 2025. The main measures to achieve this goal are to develop carbon-free renewable energy, to increase the use of low-carbon natural gas, and to promote energy conservation schemes in various sectors.

Chinese Taipei has overall energy efficiency goals of reducing energy intensity by 20% by 2015 and by 50% in 2025, based on the 2005 level. All sectors have specific energy efficiency goals, such as: reducing the CO_2 intensity of industry by 30% by 2025; raising new car energy efficiency standards by 25% by 2015; improving the energy efficiency of appliances and devices by 10%–70% by 2011; and a 7% reduction in the government's energy use by 2015. In 2006, the MOEA conducted four projects for: establishing the auditing, registry, verification and certification systems of the energy industry; building the capacity of the energy industry to reduce emissions and promoting a program of voluntary CO_2 emissions reductions; promoting an environmental accounting system for the energy sector; and promoting a greenhouse gas emissions management system.

The main achievements of these and related activities include:

- the establishment of a domestic greenhouse gas emissions auditing tool
- the selection of 40 energy industry companies to participate in demonstration projects
- the provision of education and training to demonstration companies
- assistance for five demonstration companies to obtain international certification.

Notable energy developments

PEER REVIEW ON ENERGY EFFICIENCY (PREE)

Chinese Taipei hosted an APEC Peer Review on Energy Efficiency during 23−27 August 2010. The Peer Review was well organised; the government arranged a comprehensive consultation program with government officials and industry representatives, and provided the review team with detailed background information to help with their analysis.

The review team noted a strong history of government engagement with businesses and the public on energy efficiency and conservation issues. This leadership element is critical to ensure further progress is made on energy efficiency in Chinese Taipei. The commitment to energy efficiency and conservation extends from the highest level of government (the Executive Yuan) to the general public, and is reflected in the implementation of international best practice energy efficiency policies and measures. The review team made 35 recommendations in its draft final report to support the Chinese Taipei Government's energy efficiency strategy. The recommendations cover the institutional context; energy efficiency goals, targets and strategy; energy data collection and monitoring; the industry, electricity, residential and commercial and transport sectors; appliances and equipment; and education and energy efficiency related R&D.

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Useful links

Bureau of Energy, Ministry of Economic Affairs—www.moeaboe.gov.tw

Chinese Petroleum Corporation—www.cpc.com.tw

Directorate General of Budget, Accounting and Statistics, Executive Yuan—www.dgbas.gov.tw

Industrial Development Bureau, Ministry of Economic Affairs—www.moeaidb.gov.tw

Ministry of Economic Affairs—www.moea.gov.tw