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出國報告（出國類別：其他）

赴日本參加 AICFM 國際研討會與參訪 JFE 鋼鐵公司及東京工業大學出國報告

服務機關：核能研究所
姓名職稱：林彥廷　副研究員
派赴國家：日本
出國期間：104 年 9 月 6 日~104 年 9 月 13 日
報告日期：104 年 10 月 7 日

摘　要

本次出國行程由核能研究所副研究員林彥廷赴日本參加2015 AICFM-13國際研討會並口頭發表論文，之後參訪JFE鋼鐵公司熱軋工廠、東京電力公司史料館，並與東京工業大學CFD實驗室尋求合作事宜。AICFM-13(Asian International Conference on Fluid Machinery)為亞洲最大的流體機械國際研討會，此行主要與參與議會之國際學者交流風機模擬與實驗技術並口頭發表論文，論文題目為“Experimental and Numerical Investigation of a 150 kW Horizontal-axis Wind Turbine ”。之後參訪日本最大之JFE鋼鐵公司於東京灣扇島工業區的東日本製鐵所與東京電力公司史料館。日本東京電力公司電氣史料館介紹日本重要歷史電器設備與發電機組的介紹。相關的歷史文件也藉由史料館公開給大眾閱覽查詢，對於311等公共安全事件也透過史料館將後續過程呈列於展區。JFE鋼鐵公司-東日本鋼鐵廠之現場營運狀況落實工安所要求的5S現場管理法。東日本鋼鐵廠不論是內部作業區或是外部廠區皆呈現井然有序與整潔的態樣。最後前往東京工業大學能源科學系計算流體力學實驗室與肖鋒教授技術交流，對於台灣目前積極發展離岸風電所需的氣象陣風、颱風氣動力等分析技術以及洋流與海波浪等對離岸塔架的衝擊分析，肖教授建議兩方可以擬定共同開發計畫以幫助台灣開發離岸風場分析，並藉此啟動跨國合作機會與增強本所的國際競爭力，將有助於核研所未來於風力機設計開發與風場評估之應用與研發規劃。日本在發生311核災事件之後積極發展離岸風電再生能源計畫。日本離岸浮動風電計畫透過日本經濟產業省委託11家公司組成之聯合研發團隊且投資188億日圓並已成功開發出各類離岸浮台機組。因台灣特殊且嚴苛的地形與氣候條件，台灣應積極開發自主分析軟體與程序以成功開發離岸風電與風機技術並跟上國際腳步。

關鍵字：東京電力公司、JFE鋼鐵公司、東京工業大學、亞洲國際流體機械研討會

目　　次

一， 目的

風能是再生能源重要的選項之一，國際上對於風力發電的技術發展過去 10 年來突飛猛進，不僅從 kW 級的風機快速升級研發至 MW 級的大型風機，並且從過去主要以陸域為主的風電場，累積設計、製造、組裝及維護技術經驗，而逐漸朝向設置離岸風電場。依據世界風能協會(WWEA)資料顯示，截至 101 年底，全世界累積的風電裝置容量為 238GW，其中以中國其累積的風電裝置容量為 62GW 居世界領先地位，而離岸風電的全世界累積容量則為 3.5GW，以英國的 2.1GW 最多。

國內目前配合政府再生能源發展的政策規劃，經濟部於 101 年 7 月通過風力發電離岸系統示範獎勵辦法，預計 105 年底國內即將有第一部的離岸風機系統。此外，科技部為配合國內離岸風機的設置亦透過能源國家型計畫，推動離岸風力主軸計畫，整合產官學研各界之科技研發資源，以協助相關技術的建立，順利推動此國家重大的風力發電政策。

國內發展風力發電已經歷多年的研發技術建立與相關產業的發展，然而尚欠缺完整的設計、分析與製造的系統工程整合技術能力。綜觀目前國內風電市場，整體包括技術與產業技術能力都亟待提升。中小型風機相較於大型風機目前在國內是具有較佳的競爭力，不過其業者大都以製造為主，將來面對產品提升以及出口風機驗證，都應積極提升國內小型風機的系統整合及風機驗證技術能力。依據經濟部能源局彙整國際世界風能協會(GWEC)的預測，未來 10 年小風機的年複合成長率甚至超越陸海域大型風機，因此其需求相當強勁，協助國內小風機產業技術提升需求有相當的迫切性。另外也有鑑於全球風能以及再生能源的蓬勃發展，國內產業亟欲建立完整的系統技術能力，以爭取成為這個廣大市場的優勢競爭者，這也需要國內建置有雄厚的研發支援能量。

核研所過去的風機研發主要以小風機技術建立為主，經歷 400W、25 kW 及 150 kW 的中小型風機研製，是目前國內唯一具有設計及系統整合技術能力的國家級研究實驗室。因此，為精進中小型風機系統設計、分析、測試及運轉之機械系統整合工程技術能力，本次出國參與亞洲國際流體機械研討會(AICFM-13)將與各國學者討論中小型風機分析與實驗技術等研究，並透過大會舉辦的參訪行程參觀日本最大鋼鐵公司-JFE 鋼鐵在東京灣扇島工業區之東日本鋼鐵廠以及參觀東京電力公司電氣史料館。之後前往東京工業大學能源科學系參訪肖鋒教授之計算流體實驗室，並與之商討風力機模擬計算合作事宜。本行程主要目的為加強本所與日本風能研究單位之技術交流並了解日本計算分析的發展現況及未來規劃方向，並希冀能促成國際合作機會，強化本研究單位風機研發能量與競爭力。透過與日本等國際學者於風機研發技術交流有助於本所「中小型風機工程技術研發」計畫及「大型風機工程技術研發」計畫的執行及未來風能研發方向之規劃。

二， 過程

此行於 104 年 09 月 06 日週日由桃園機場搭機前往日本，本次公差行程包含 3 個部分(如表 1 及圖 1)分別為參與亞洲國際流體機械研討會(AICFM13)、參訪 JFE 鋼鐵公司-東日本鋼鐵廠與東京電力公司電氣史料館以及拜訪東京工業大學能源科學系肖鋒教授與其計算流體力學實驗室。首先於 09 月 07 日週一赴東京早稻田大學國際會議中心註冊報到並參加開幕儀式，AICFM13 研討會共計 4 日。之後於 9 月 8 日參與學者邀請演講並參加研討會參與大會開幕儀式，研討會邀請主講人為韓國學者 Prof. Je-Hyun Baek 與瑞士學者 Prof. Francois Avellan 發表渦輪機數值方法與穩定性分析技術。9 月 9 日亦參與學者邀請演講並參加研討會，邀請主講人為日本 Ebara 公司研究員 Dr. Akira Goto、中國大陸清華大學 Prof. Yangjun Zhang、德國 Aachen 大學 Prof. Dieter Bohn 以及美國 John Hopkins 大學 Prof. Joseph Katz 發表渦輪機的最佳化與工業化應用的相關議題，晚上則參與大會提供的晚宴活動，提供各界人士交流聯誼。9 月 10 日代表核研所風機小組發表口頭論文報告以及參與研討會之各類廠商設備展覽並收集資料，口頭發表論文題目為 Experimental and Numerical Investigation of a 150 kW Horizontal-axis Wind Turbine，研討會成功舉辦。9 月 11 日參加研討會安排的參訪行程，主要參觀東京電力公司電氣史料館與日本最大鋼鐵公司-JFE 鋼鐵在東京灣扇島工業區之東日本鋼鐵廠。東京電力公司史料館主要展覽日本目前的電力來源技術簡介，以及收藏東京電力公司的歷史文件與重要除役發電設備；JFE 鋼鐵公司位於東京灣之東日本鋼鐵廠，主要參觀其鋼品一貫化生產作業流程。緊接著於 9 月 12 日前往位於橫濱的東京理工大學之能源科學系拜訪肖鋒教授，肖鋒教授為數值技術相關領域專家且與國際各研究單位共同合作。本次拜訪主要討論進行國際大型風機模擬技術與離岸風電最佳化佈置相關技術之交流，並針對核研所 150kW 風機模擬計算討論並尋求未來雙方的合作機會。本次公差工作人員為核研所林彥廷副研究員，工作日期自 9 月 6 日至 9 月 13 日，為期共 8 天。

圖一，日本東京出差行程地理位置圖

表一，出國公差行程表

行程 月	日	星期	地點 出發	地點 抵達	公差地點 國名	公差地點 地名	行程內容
9	6	日	桃園	日本東京	日本	東京	去程與資料準備
9	7	一			日本	東京	報到與參加 AICFM 研討會開幕儀式
9	8	二			日本	東京	參加 AICFM 研討會與技術交流討論
9	9	三			日本	東京	參加 AICFM 研討會與技術交流討論
9	10	四			日本	東京	口頭報告論文發表與參加 AICFM 研討會
9	11	五			日本	東京	參訪東京電力公司電力史料館與 JFE 鋼鐵公司東日本製鐵所
9	12	六			日本	橫濱	參訪東京工業大學能源科學系肖鋒教授及其計算流體實驗室並技術交流討論
9	13	日	日本東京	桃園			回程

(一) AICFM13 亞洲國際流體機械研討會參與過程

2015 年亞洲國際流體機械研討會(AICFM-13, Asian International Conference on Fluid Machinery)在東京早稻田大學舉辦，主辦單位為亞洲流體機械委員會(Asian Fluid Machinery Committee)以及日本渦輪機械學會(Turbo machinery Society of Japan)，早稻田大學為協辦單位，大會主席為韓國 Inha University 的 Kim, Kwang-Yong 教授。本次研討會由 9 月 7 日到 9 月 10 日共計 4 天，會議地點在早稻田大學的 Ibuka Masaru Memorial Hall 以及 RIHGA Royal Hotel Tokyo，如圖 2，大會主要邀請國際知名流體機械專家與會並專題演

講。研討會現場亦有許多研究設備代理商與分析軟體公司駐點介紹，主要的廠家主要為 CFD 軟體設計公司或是提供運算服務的電算中心，以及各類實驗量測設備與渦輪機製造公司，如圖 3 所示。大會 9 月 8 日邀請韓國 Pohang University of Science and Technology 的 Professor Je-Hyun Baek 演講 Development of a Numerical Solver for Flows through Steam Turbines 以及邀請瑞士 Director of the EPFL Laboratory for Hydraulic Machines 的 Professor François Avellan 演講 Francis Turbine Operating Stability Assessment: Transposition of Model Test Results to Prototype Operation。此兩篇研究主要討論流體機械的模擬計算的程式開發以及渦輪機械的穩定性應用議題。9 月 9 日大會邀請中國 Tsinghua University 的 Professor Yangjun Zhang 演講 Turbo-compound Study for Engine Waste Heat Recovery 以及日本國內 Ebara 公司研究員 Dr. Akira Goto 演講 Historical Perspective on Fluid Machinery Flow Optimization in an Industry，兩位講者分別介紹引擎廢氣回收之渦輪設計以及 Ebara 公司在電腦渦輪設計上的歷史發展，如圖 4。

圖 2，AICFM13 研討會會場圖組

國外演講者亦邀請德國 Aachen 大學 Prof. Dieter Bohn 演講 Industrial Application of Conjugate Heat Transfer Technology for Cooled Gas Turbines 以及美國 John Hopkins 大學 Prof. Joseph Katz 發表 Experimental Characterization Flow, Turbulence, Instabilities and Cavitation in the Tip Region of Axial Turbomachines，兩位學者主要介紹渦輪機的熱傳現象以及渦輪機在應用上面臨的議題。9 月 10 日代表核研所風機小組發表口頭論文報告以及參與研討會之各類廠商設備展覽並收集資料，口頭發表論文題目為 Experimental and Numerical Investigation of a 150 kW Horizontal-axis Wind Turbine。發表過程與國外學者討論實驗過程之數據擷取時間以及整體實驗過程經歷。

圖 3，AICFM13 研討會會場業界攤位圖組

整個研討會議程皆有安排風力機與再生能源研究主題，主要與會學者大多著墨於風力機的實驗驗證與設計開發，日本國內主要研究風機研究大致為九州大學(Kyushu University)以及大阪大學(Osaka University)，風機噪音分析與計算則以長崎大學為主(Nagasaki University)。大阪大學主要發表小型水平軸風機風洞實驗與模擬驗證，如圖 5。該團隊研究方向與本所風機小組相似，亦已與對方教授交換聯絡訊息並討論未來合作研究方向。亞洲國際流體機械研討會攤位廠家如圖 6 以及全體參與人員、研討會議程與剪報資料如附錄 1。

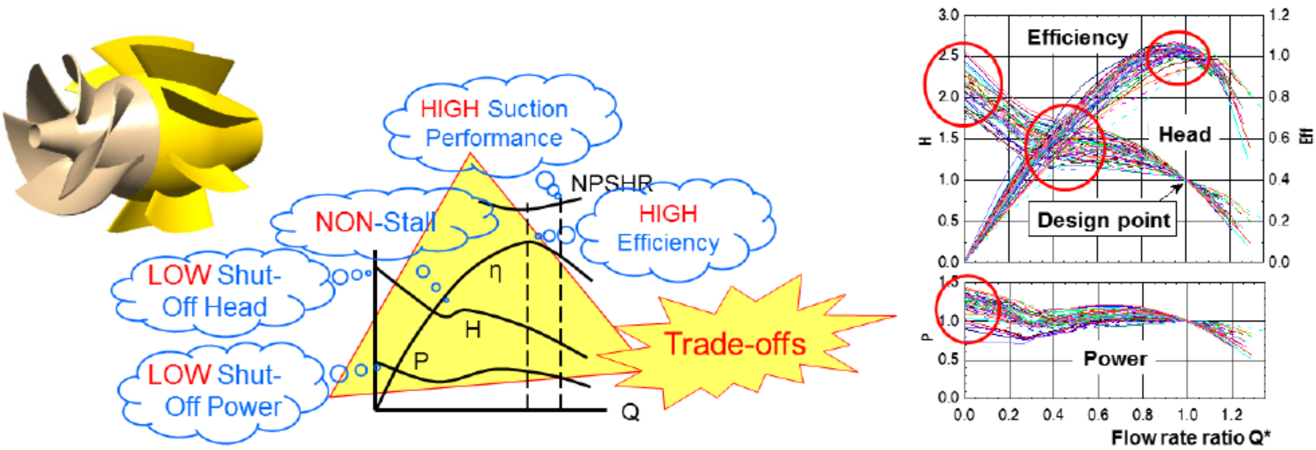

圖 4，Ebara 公司的電腦渦輪設計概念

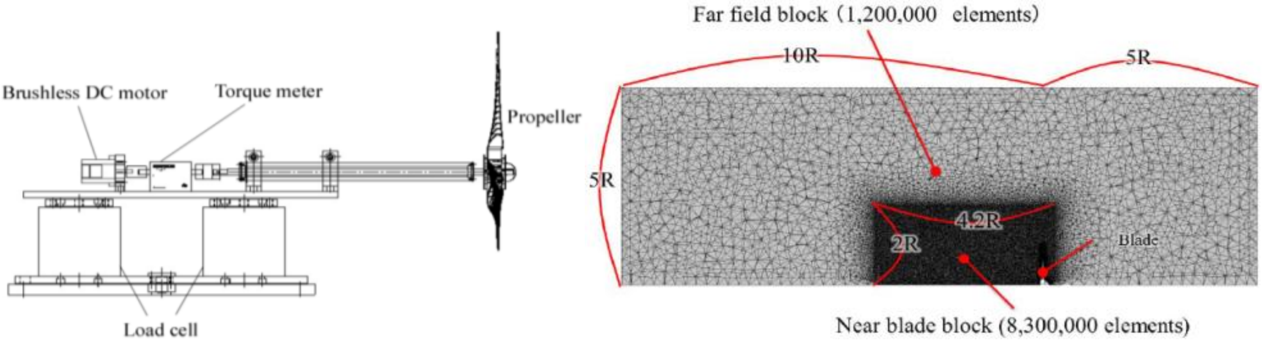

圖5，大阪大學 Koichi Yonezawa教授研究方向

The 13th Asian International Conference on
Fluid Machinery, 2015 (AICFM13)

Exhibitors list

Exhibitors 1-Instruments (in alphabetical order)

The following companies or organizations are exhibiting their products.

- CD-adapco CO. , LTD.
- Center for Research on Innovative Simulation Software, Institute of Industrial Science, The University of Tokyo
- Daiichi System Engineering CO. , LTD.
- DITECT Corporation
- ENGINEER DESIGN LAB
- Fujitsu Limited
- HODEN SEIMITSU KAKO KENKYUSHO CO. , LTD.
- Information Services International-DENTSU
- KANOMAX JAPAN INC.
- Library CO. , LTD.
- Mizuho Information & Research Institute
- NUMECA Japan CO. , LTD.
- OHTE GIKEN,INC.
- PHOTRON LIMITED.
- Seika Digital Image Corporation
- Siemens K. K.
- Software Cradle CO. , LTD.
- VINAS CO. , LTD.
- Visual Technology, Inc.
- WASEDA UNIVERSITY

Exhibitors 2-Product brochures (in alphabetical order)

The following companies or organizations are exhibiting their product brochures.

- Advanced Simulation Technology Of Mechanics R&D, CO. , LTD.
- DMW Corporation
- EAML Engineering CO., LTD.
- EBARA CORPORATION
- EBARA HAMADA BLOWER CO. , LTD.
- Hitachi Mitsubishi Hydro Corporation
- Hitachi, Ltd., Industrial Products Company
- IHI Compressor and Machinery CO. , LTD.
- IHI Corporation
- IHI Inspection & Instrumentation CO. , LTD.
- IHI Turbo CO. , LTD.
- KINKI METAL CO. , LTD.
- KOBE STEEL, LTD.
- KYOWA ELECTRONIC INSTRUMENTS CO. , LTD.
- MATSUI Corporation
- Mitsubishi Heavy Industries Compressor Corporation
- MITSUBISHI HEAVY INDUSTRIES,LTD.
- MITSUBISHI HITACHI POWER SYSTEMS,LTD
- Mitsuya Fan Mfg CO. , LTD.
- NIKKISO CO. , LTD.
- OSAKA UNIVERSITY
- SHIN NIPPON MACHINERY CO. , LTD.
- Software Cradle CO. , LTD.
- TANAKA HYDROPOWER CO. , LTD.
- TATSUNO CORPORATION
- TORISHIMA PUMP MFG CO. , LTD.
- Toshiba Corporation Power Systems Company
- YONAGO STEEL CO. , LTD.

圖 6，AICFM13 研討會會場業界攤位資料

(二) 參觀東京電力公司電氣史料館與 JFE 鋼鐵-東日本鋼鐵廠

9 月 11 日參加亞洲國際流體機械研討會安排的參訪行程，主要參觀東京電力公司電氣史料館與日本最大鋼鐵公司-JFE 鋼鐵在東京灣扇島工業區之東日本鋼鐵廠。東京電力公司史料館主要展覽日本目前的電力來源技術簡介，以及收錄東京電力公司的歷史文件與收藏重要除役設備；9 月 11 日上午前往搭乘遊覽車前往東京電力公司在橫濱市的電氣史料館，該館目前已不接受散客參觀，必須透過團體申請才有專人導覽。電氣史料館建於 2001 年主要收藏東京電力公司歷史文件、各類除役設備以及日本能源建設現況教學，也由於 311 福島事件之後該館也建立專區特別收錄事件之後的處理現況。但現場人員告知不能拍照因此只於門口拍照記錄(如圖 7)，現場照片取於網路資料搜尋。電氣史料館主要展覽的重型設備為被除役的美國奇異公司於千葉火力發電站之渦輪轉子，現場可看到完整的高壓與低壓區轉子以及後方的發電機；以及信濃川發電所之水力發電機渦輪主軸(如圖 8)，現場可明顯看到在經過多年運作之後渦輪葉片呈現空蝕與翼尖磨耗現象。現場也展示了核能機組模型與日本風力發電開發現況，

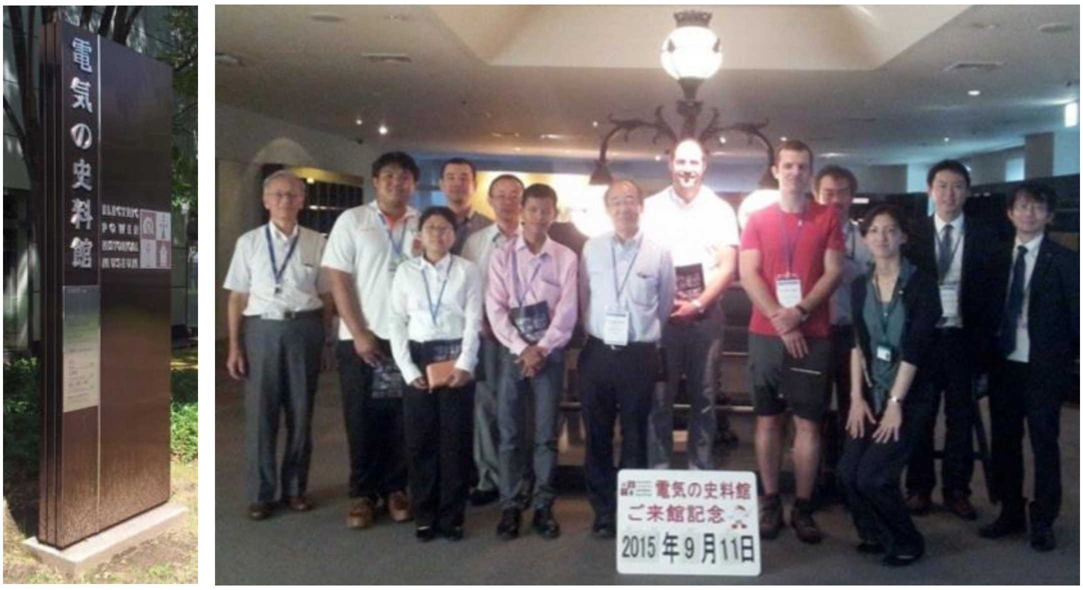

圖 7，東京電力公司電氣史料館參觀合照

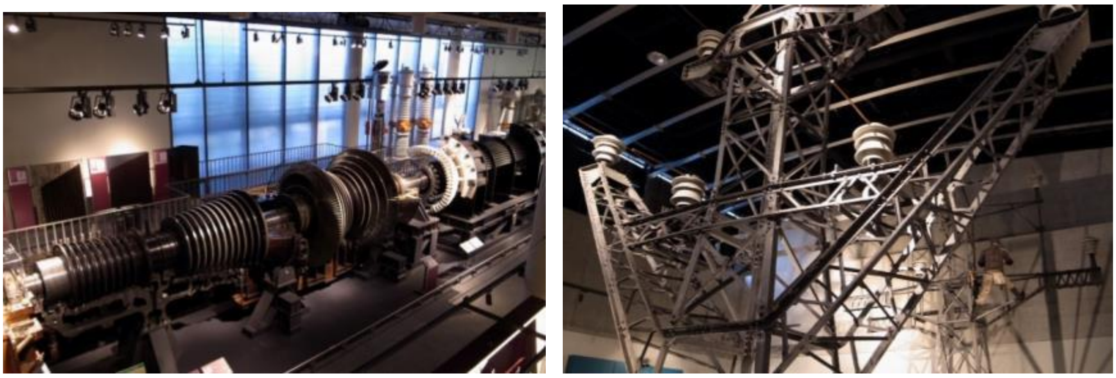

圖 8，東京電力公司電氣史料館內部(資料來源：http://gaa31.exblog.jp/15356644/)

參觀完東京電力公司電氣史料館之後下午前往位於東京灣的扇島工業區之 JFE 鋼鐵公司之東日本鋼鐵廠。扇島工業區為人工島嶼，佔地面積為 6.717 平方公里主要透過海底隧道與橫濱市相連，入駐的工廠有 1.東日本鋼鐵廠、2.日礦日石公司扇島風力發電廠、3.LNG 液化天然氣

儲存站與 4. 扇島太陽能發電廠，如圖 9 與圖 10。為了因應全球鋼鐵行業日益激烈的競爭，日本鋼鐵企業執行整合資源與實施公司合併政策，JFE 鋼鐵公司即是於 2001 年時由日本 NKK 日本鋼管公司與川崎製鐵公司的合併，兩間公司合併後名稱變更為 JFE（Japan-Fe-Engineering）鋼鐵集團並于 2002 年 10 月成立控股公司。2003 年 4 月則分別成立城市開發、鋼鐵、工程技術、半導體、研究開發等分公司。合併後公司鋼鐵產量規模與新日鐵持平，約可年生產粗鋼為 2500 萬噸。兩公司合併後共分 3 個生產基地：以東京（NKK 日本鋼管）和千葉（川崎鋼鐵）為主的東日本鋼鐵廠；以水島（川崎鋼鐵）和福山（NKK 日本鋼管）為主的西日本鋼鐵廠；第三是知多製造所鋼管生產基地。本次前往東日本鋼鐵廠參觀完整的產線過程，由港口邊的原物料散裝航運船卸貨、鐵礦砂等原料堆置場、原料礦石燒結、旋風爐、熱軋工廠到盤捲機等，如圖 10。行程還參觀該工廠的能源中心控制室監看所有製程現況。整個參觀過程在一開始先到公司的簡報室，由現場工程師大致介紹公司概況、扇島工業區現況以及現在所在工廠(東日本鋼鐵廠)的營運規模。之後換上工程服裝與戴上安全帽、工程手套與導覽耳機透過遊覽車環繞與參觀整個廠區並有現場領班人員上車以英文與日文講解，之後全體參觀人員進入能源中心監控室由現場領班簡報鋼鐵廠的能源使用、製程尾氣回收發電、尾氣排放監控、製程水資源回收再利用與能源監控過程。參觀完能源中心後來到現場參觀熱軋工廠，熱軋工廠為將鋼胚透過一連串的滾軋機熱壓延、冷壓延、薄型壓延、水淬熱處理、整平與校正後再利用盤圓機將鋼板包裝並以機械手送出，整個製程皆由自動化設備完成，現場只有監控室與少量工作人員待命。由於機密為由，現場的照片為網路尋得，只於活動後於現場拍照留念(見圖 11)，行程也帶回公司簡介資料，詳見附錄 2。

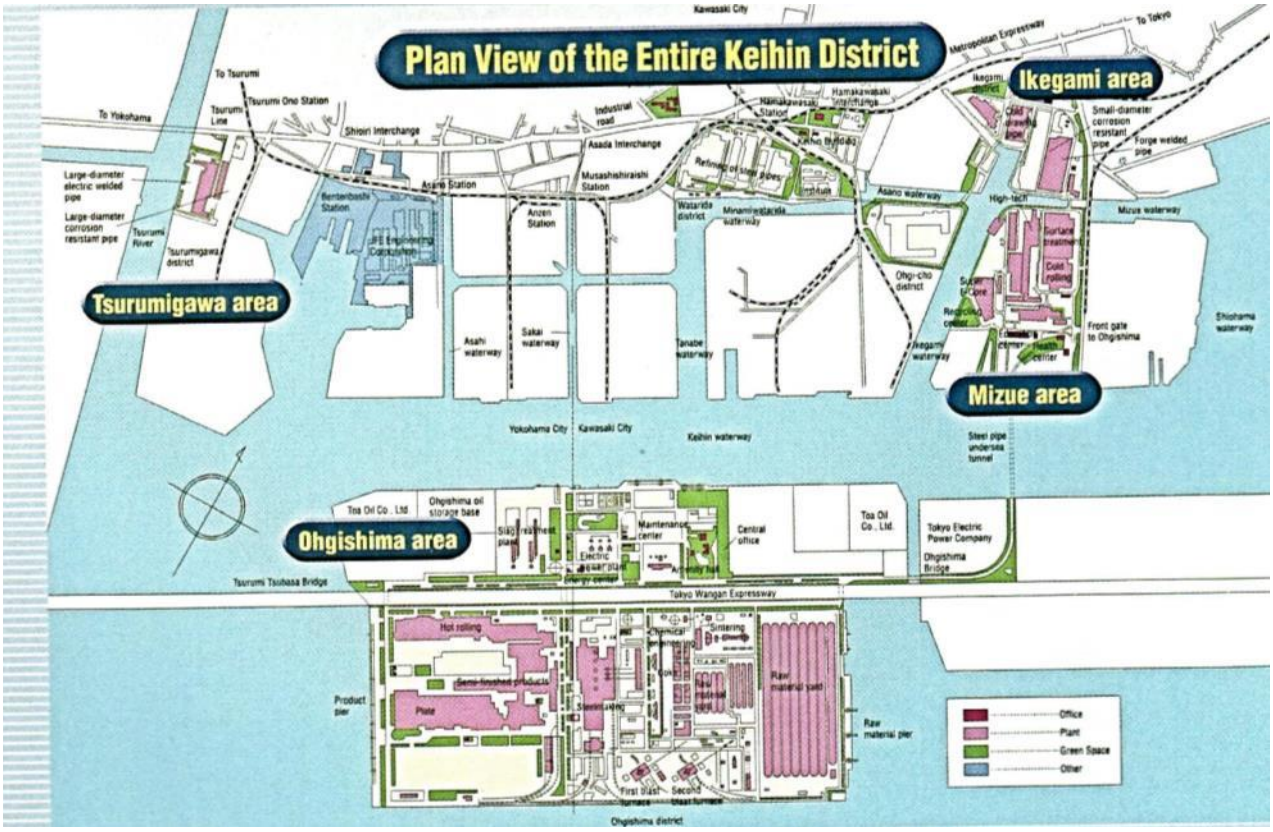

圖 9，扇島工業區

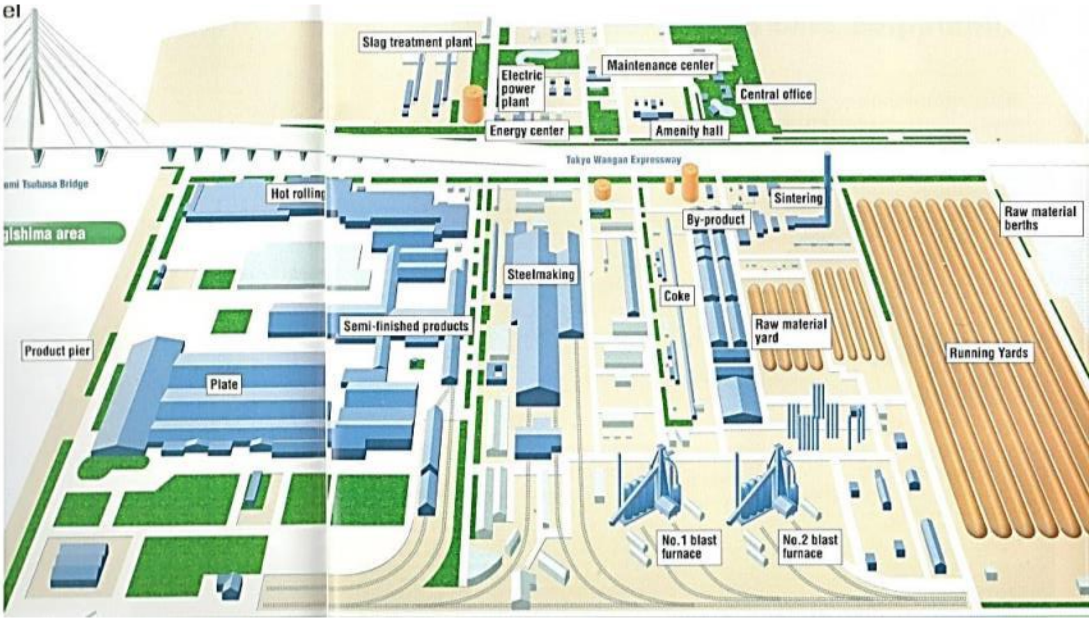

圖 10，JFE 鋼鐵公司-東日本鋼鐵廠

圖 11，JFE 鋼鐵-東日本鋼鐵廠參觀合照圖組(照片來源 http://k-kankou.jp/industrial_night/detail.html?CN=53838)

(三)　參訪東京工業大學能源科學系

於 9 月 12 日前往位於橫濱的東京理工大學之能源科學系拜訪肖鋒教授(http://t2r2.star.titech.ac.jp/cgi-bin/researcherinfo.cgi?q_researcher_content_number=CTT100381285)，肖鋒教授為數值技術相關領域專家且為日本流體力學會、日本計算工學會、日本數值流體力學會、日本氣象學會與日本機械學會會員並擔任國際期刊 Jounral of Computational Physics 的副編輯。肖鋒教授也與國際知名研究單位共同合作，如中國科學院，中國氣象科學研究院，西安交通大學，Johns Hopkins 大學等。肖鋒教授在 Journal of Computational Physics 知名國際期刊上的數值方法論著 "The Constrained Interpolation Profile Method for Multiphase Analysis" 達到 658 次的高引用，研究結果已成功應用於雙相流模擬、流故耦合、大氣現象與波浪行為模擬。肖鋒教授已利用研究成果開發離岸風電之風場模擬與風機最佳化布置(圖 12)，對於大氣在城市中的流動狀況與颱風模擬也提出相應的分析技術(圖 13)；針對日本容易發生的海底地震與相應的海嘯災害亦已提出模擬方法(圖 14)。

根據肖教授解說，離岸海波浪雙相流模擬主要的困難點在兩相區間的表面張力項的數值處理，錯誤的張力項計算方式不僅會獲得不合宜的流場結果，更容易導致數值計算的不收斂而發散。一般來說表面張力項的計算通常分為 continuum surface tension force approach 和 sharp-interface approach ，sharp-interface 的方式是採用任意兩相不相互容流體間的不連續條件與曲率及表面張力的關係,利用如Ghost fluid 方法求得兩相流場表面張力項。通常使用此 sharp-interface 方式獲得之雙相流場結果較為可靠，然而在數值程式上的開發較為繁瑣。為了在準確與計算效率上計算表面張力項，continuum surface tension force(CSF)則是近年來較為可靠的方式。continuum surface tension force 方法是利用將不連續的表面張力項轉換為 volume force 且散佈於兩相流界面的區間。然而使用 CSF 處理表面張力項會在數值結果產生速度震盪的 spurious currents 問題。這是目前學界與計算軟體極力解決的問題。目前學術界處理雙相流界面 spurious currents 的問題主要開發出能有效的降低 spurious currents，又期望能有如 CSF 簡化數值程式撰寫特性。肖教授認為目前的研究成果雖然在測試階段能夠有效的得到令人滿意的結果，然而將此方法實際應用於求解兩相流之時，卻無法獲得正確的解答，也就此議題與肖鋒教授討論合作開發協議。

核研所是目前國內唯一具有設計及系統整合技術能力的國家級研究實驗室。而因應未來科技部能源國家型科技計畫之離岸風力主軸計畫，核研所目前主要將負責離岸風機設計驗證技術與風能預報及風場營運技術的開發，以協助離岸風力主軸技術團隊。離岸風電場具有較陸域風電場更優質之風力來源包括更高的平均風速及較低的紊流。然而，離岸風機則需面對比陸上風機更嚴苛的環境狀況如颱風、海波流及地震等之影響。目前國外多數的離岸風機系統廠家及經驗主要以北歐國家為主包括英國、丹麥及德國等，其對於位於亞熱帶多颱風及地震帶之台灣的特殊地理環境並無實際的經驗。因此，為確保未來國內離岸風機的運轉安全及可靠性，以針對台灣特定的環境狀況包括颱風等極端風況、海波流及地震，實際進行分析。因此本次拜訪東京工業大學肖鋒教授亦討論離岸分析等相關技術，並技術交流國際大型風機模擬技術與最佳化佈置，可協助與提供未來離岸風電場建置的參考。 本次參訪也針對本次國際研討會所發表核研所 150kW 風機模擬計算並尋求未來雙方的合作機會並建立國內自主化的離岸風機設計技術。

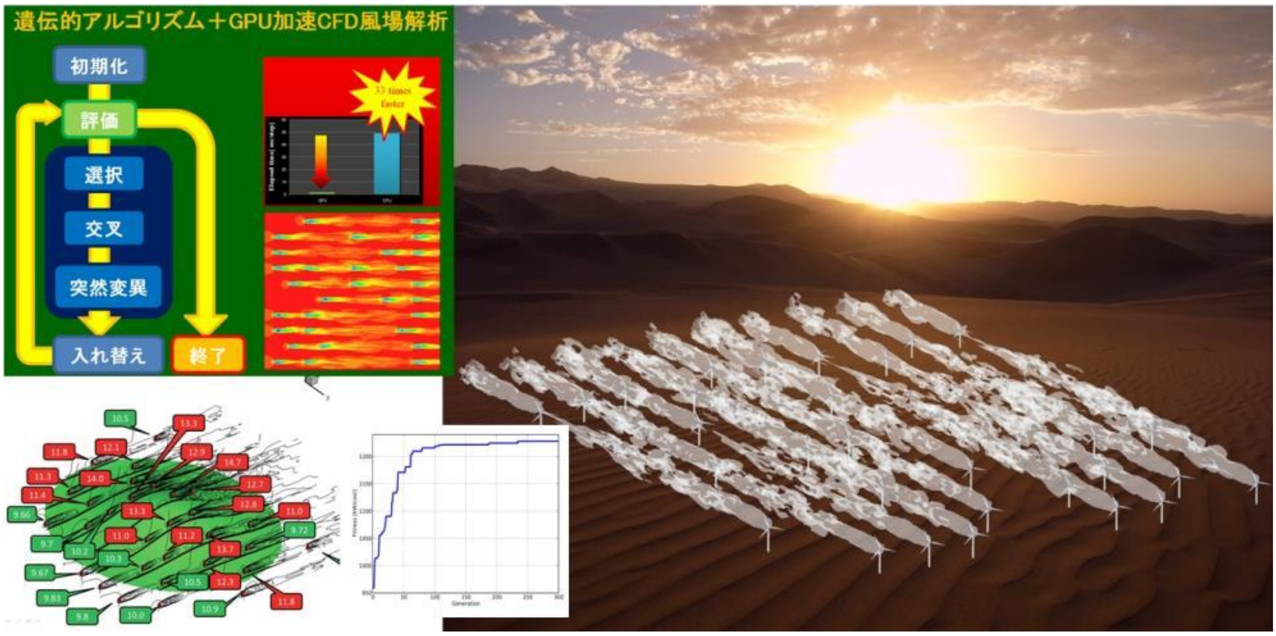

圖 12，離岸風機最佳化位置布置模擬示意圖

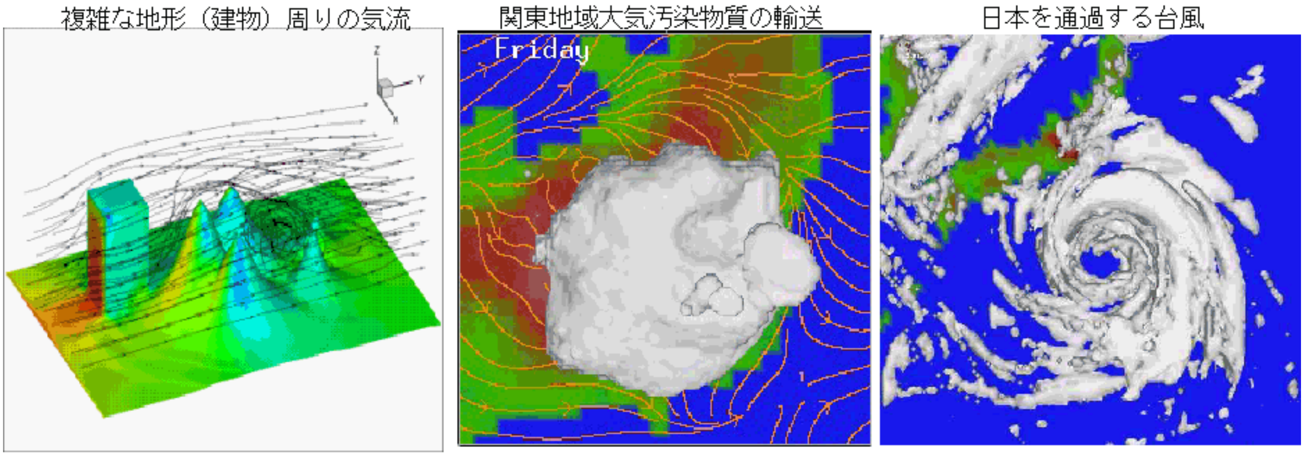

圖 13，離岸風機最佳化位置布置模擬示意圖

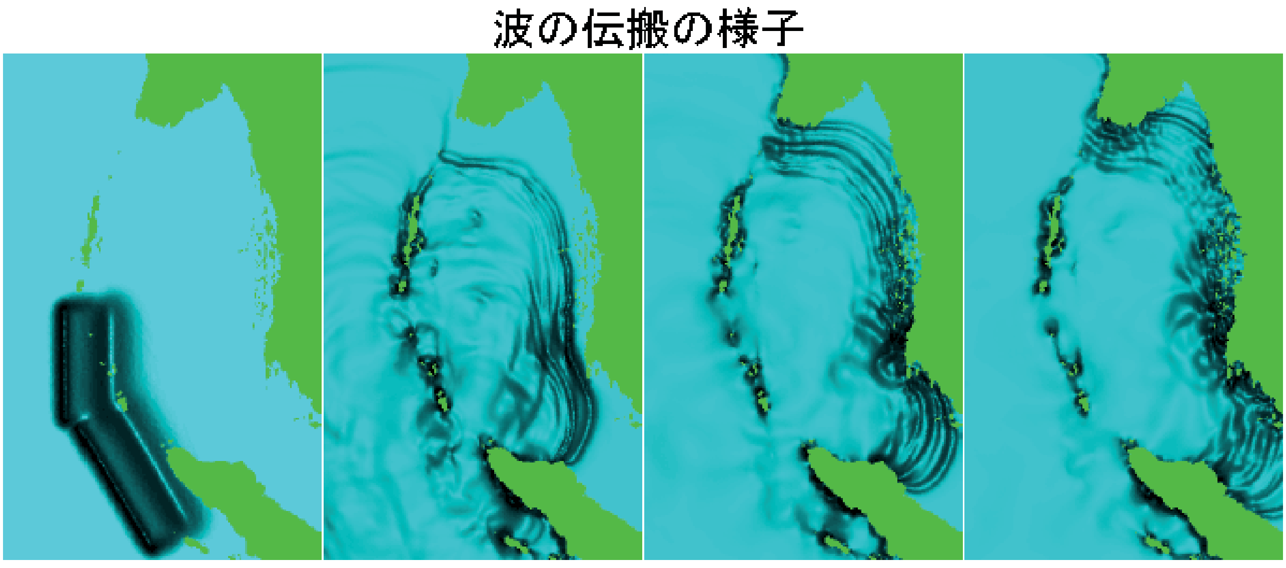

圖 14，海床地震之海嘯模擬示意圖

圖 15，與肖鋒教授於研究成果海報前合影

三、心　得

(一) AICFM13亞洲國際流體機械研討會本次在日本東京早稻田大學舉辦，參與大會的專家學者皆是該領域學有專精。本次大會研討會的發表流程恰當，皆安排相近或主題相當的研究在同一討論室。日本國內之重型機械廠家也在現場提供諮詢服務以及相關的量測設備廠家或分析模擬技術服務也在現場展示設備。以風機研究來說，日本參展的流體機械設備廠家已可以提供各類風機製作開發、量測服務與計算分析，透過現場的諮詢可幫助研究人員了解日本的業界與學界研發能力。

(二)大阪大學所研究的風機設計以及九州大學地形風場模擬與驗證研究等研究皆與核研所風機小組目前所開發的方向相符，代表國內關於風機的研究主題與國際研究同步，但值得借鏡的是日本有強力的量測設備廠家作為後盾，所有的相關量測設備幾乎皆是國產化，國產化的設備可直接與有效的幫助國內研究人員。此外日本業界幾乎大量開發雷射或是影像擷取量測系統，且已大量應用於風機與風況模擬驗證，此量測方向值得我們跟進。

(三) 依據研討會主辦單位邀請來的Ebara公司所報告的流體機械渦輪設計技術可知，該公司已完成相關自動化設計程式可加速與確保各類工程設計需求。尤其是以中小型風力機之開發需應用於不同風場與陣風，因此最佳化渦輪外型程式設計應為風機開發主題之一。

(四)日本東京電力公司電氣史料館幾乎涵蓋了日本重要歷史電器設備與發電機組的介紹。相關的歷史文件也藉由史料館公開給大眾閱覽查詢，對於311等公共安全事件也透過史料館將後續過程呈列於展區。JFE鋼鐵公司-東日本鋼鐵廠之現場營運狀況落實工安所要求的5S現場管理法。　5S：整理（SEIRI）、整頓（SEITON）、清掃（SEISO）、清潔（SEIKETSU）、素養（SHITSUKE），又被稱為“五常法則”或“五常法”，東日本鋼鐵廠不論是內部作業區或是外部廠區皆呈現井然有序與整潔的態樣，並沒有呈現廠區可能出現的混亂與雜亂問題，所有現場工程人員不論是員工或是包商皆穿著完整且清潔工安服裝與安全裝備，值得學習借鏡。

(五)東京工業大學肖鋒教授已與日本海洋開發研究機構、中國氣象科學研究院、中國大陸氣象局合作開發大氣數值模擬程式，用於分析複雜地形地貌或城市風場以及洋流、海嘯與颱風等大氣分析。且肖教授已與日本海洋開發研究機構開發出離岸風機最佳化布置與風機葉片流固耦合分析程式，目前該實驗室也有中國大陸氣象局人員派員參與研究。對於台灣目前積極發展離岸風電所需的氣象陣風、颱風氣動力等分析技術以及洋流與海波浪等對離岸塔架的衝擊分析，肖教授也認為或許兩方可以擬定共同開發計畫以幫助台灣開發離岸風場分析。

(六) 日本已成功開發離岸漂浮式風機且已成功運轉於福島外海，而成功的離岸風電之海象與氣象分析技術須建立在充足的大氣環境歷史資訊，精確且可靠的分析也需透過軟體開發模擬，尤其是分析離岸基座的流固現象之應力分析。肖鋒教授目前已同意先期參與核研所150kW二代風機之流固耦合氣動力分析比對，並共同開發離岸風電塔架之兩相流波浪模擬分析。

四、建　議　事　項

(一)核研所目前執行能源國家型相關計畫主要以國產風機自組研發技術與離岸風電及其支撐結構的驗證計算為主，本次前往參加AICFM13國際研討會透過論文發表參與國際學者的共同研究討論可提升研究人員的視野與推廣核研所自製風機與研發技術。建議政府與綠能產業應持續支持風力機技術研發與離岸風機工程技術以幫助國內能源產業發展。

(二)日本國產的輕工業與重工業設備上下游皆提供完整供應鏈，尤其在風機開發所需的製造設備與量測設備，日本皆有對應的廠家可提供技術服務。建議台灣各風能研究團隊可以加入日本相關風能研發單位，共同研究共享資源，不僅可有效提升台灣在國際風機研發能見度也可提升國內風機相關技術的研究能力。

(三)日本JFE鋼鐵公司之東日本鋼鐵所現場工作環境之整潔令人印象深刻，建議台灣不論在實驗室或是現場施工領域皆應確實執行，尤其是施工人員與現場人員之服裝儀容、安全裝備與清潔程度皆須落實工安所要求的5S現場管理法。

(四)日本在發生311核災事件之後積極發展再生能源計畫。以離岸風電為例，日本經濟產業省透過離岸浮動風電計畫委託三菱重工、丸紅公司、東京大學、新日鐵住金、清水建設、三井造船等11家公司組成聯合團體並投資188億日圓，已成功開發出各類離岸浮台機組(http://www.nippon.com/hk/views/b01506/)。台灣目前應加速發展離岸國產技術以跟上國際腳步。

(五)東京工業大學肖鋒建議核研所可積極與日本各研究單位與學界合作，擴大研究範疇與在國際間的影響力，尤其在風機技術與離岸風能工程分析技術。因台灣特殊且嚴苛的地形與氣候條件，任何國際上的案例分析皆無法滿足國內設計要求，台灣應積極開發自主分析軟體與程序以成功開發離岸風電與風機技術。

五、附　錄

附件 1，參與 AICFM13 研討會人員彙整表與研討會議程

Participants The 13th Asian International Conference on Fluid Machinery (AICFM13), 7-10 September 2015, Tokyo

Prefix	*Family Name*	*First Name*	*Middle Name*	*Country*	*Company/Institution/Organization Name*
Mr.	ABADI	GHOLAMREZA BAMOROVAT		Korea	Pusan National University
Prof.	ABDUL WAHID	MAZLAN		Malaysia	UNIVERSITI TEKNOLOGI MALAYSIA
Mr.	Abe	Kento		Japan	Osaka Prefecture University
Mr.	Aida	Takamitsu		Japan	Tanaka Hydropower Co., Ltd
Dr.	Alam	Miah	Md Ashraful	Japan	National Institute of technology, Matsue College
Mr.	Asai	Yuta		Japan	Oita university
Mr.	Asakura	Hiroshi		Japan	IHI Corporation
Dr.	Asvapoositkul	Wanchai		Thailand	King Mongkut's U. of Technology Thonburi
Prof.	Avellan	Francois		Switzerland	EPFL
Mr.	Bando	Yuji		Japan	Mitsubishi Heavy Industries Compressor Corporation
Prof.	Bhamidi	Prasad	V.S.S.S	India	Indian Institute of Technology Madras
Prof.	Bohn	Dieter	E.	Germany	RWTH Aachen
Ms.	Cai	Fang		China	Wuhan University
Mr.	CAI	ZhenWei		China	Shanghai Jiao Tong University
Ms.	Chen	Jia		China	Nation Research Centre of Pumps,Jiangsu University
Mr.	Chen	Zhenmu		Korea	Mokpo National University
Prof.	Chen	Qijuan		China	Wuhan University
Mr.	Chen	Qiang		China	Wuhan University
Prof.	Choi	Young-Do		Korea	Mokpo National University
Dr.	Choi	Young	Seok	Korea	KITECH(Korea Institute of Industrial Technology)
Ms.	Chung	Yunchen		Taiwan	National Pingtung University
Ms.	CUI	FEI		China	Xeca Turbo Technologies (Beijing) Co.,Ltd
Prof.	Dou	Huashu		Australia	Zhejiang Sci-Tech University
Mr.	Duan	Chongfei		Japan	Mitsubishi Hitachi Power Systems, Ltd
Mr.	Enomoto	Yasuyuki		Japan	TOSHIBA
Prof.	Fan	Honggang		China	Tsinghua University
Prof.	Feng	Ding		China	Yangtze University
Ms.	Feng	Yijing		China	
Prof.	Feng	Jianjun		China	Xi'an University of Technology
Mr.	Fujiyama	Keita		Japan	Software Cradle CO.,LTD.
Mr.	FUKUDA	HIROAKI		Japan	Tokushima University
Prof.	Fukutomi	Junichiro		Japan	Tokushima University
Prof.	Funazaki	Kenichi		Japan	Iwate University
Prof.	Furukawa	Akinori		Japan	National Institute of Technlogy, Oita College
Mr.	Furukawa	Daichi		Japan	Kyushu University
Prof.	FURUKAWA	MASATO		Japan	Kyushu University
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Dr.	GOTO	Akira		Japan	Ebara Corporation
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Dr.	GUO	Yang		Japan	Institute of Industrial Science, The University of Tokyo
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Mr.	Hiromatsu	Jun		Japan	Eagle Industry Co., Ltd.

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Dr.	Homma	Naohiko		Japan	Mitsubishi Electric
Mr.	HONG	HUI		China	Shanghai Jiao Tong University
Mr.	Horibe	Shinji		Japan	Doshisha university
Prof.	Horiguchi	Hironori		Japan	Osaka University
Prof.	Hsieh	Chiu-Fan		Taiwan	National Formosa University
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Dr.	Huang	Bin		Japan	Kyushu Institute of Technology
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Dr.	Iwase	Taku		Japan	Hitachi, Ltd.
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Mr.	Jacob	Joe		India	Indian Institute of Technology Madras
Dr.	Jang	Choon-Man		Korea	Korea Institute of Civil engineering and Building Technology
Mr.	Jeong	Huiseong		Korea	Korea maritime and ocean university
Ms.	Jeong	Sena		Korea	Korea Institute of Science and Technology
Dr.	JEONG	JONGHYUN		Korea	DNDE Inc.
Dr.	Jia	Weidong		China	Ministry of Education, Jiangsu University
Prof.	Jiang	Jin		China	School of Power and Mechanical Engineering, Wuhan University
Mr.	JO	IN	CHAN	Korea	Korea Institute of Science and Technology
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Mr.	Kaneko	Masanao		Japan	Hosei University
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Mr.	Kim	Incheol		Korea	Korea maritime and ocean university
Mr.	KIM	SUNG		Korea	Korea Institute of Industrial Technology

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Dr.	Kim	Jin	Hyuk	Korea	KITECH(Korea Institute of Industrial Technology)
Mr.	Kim	Byung	Ha	Korea	Korea Maritime University
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Dr.	Lee	Gi-Chun		Korea	Korea Institute of Machinery & Materials
Dr.	Lee	Sang-Moon		Korea	Korea Institute of Civil engineering and Building Technology
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Mr.	Lee	Nakjoong		Korea	Korea maritime and ocean university
Mr.	Li	Guoli		China	Anhui University
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Ms.	Liu	Wenchuan		China	Wuhan University
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Prof.	Luo	Xianwu		China	Tsinghua University
Mr.	MAJIMA	KANJI		Japan	IHI Corporation
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Prof.	MIYAGAWA	Kazuyoshi		Japan	WASEDA University
Mr.	Miyagi	Junpei		Japan	TOSHIBA Corporation
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Dr.	Muhamad Said	Mohd Farid		Malaysia	UNIVERSITI TEKNOLOGI MALAYSIA
Dr.	Munekata	Mizue		Japan	Kumamoto University
Prof.	Munisamy	Kannan		Malaysia	Universiti Tenaga Nasional
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Mr.	Nakai	Sunao		Japan	YONAGO STEEL Co., Ltd.
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Mr.	Nakamura	Hirokazu		Japan	KINKI METAL Co.,Ltd

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Dr.	NAKAMURA	TAKANORI		Japan	TOSHIBA Corporation
Prof.	Nakanishi	Yuji		Japan	Kanagawa University
Mr.	Nakashima	Takahiro		Japan	WASEDA University
Mr.	Nakashiro	Masashi		Japan	IHI Inspection&Instrumentation CO.,LTD.
Mr.	Nakatsuji	Mampei		Japan	Osaka Institute of Technology
Mr.	NASIR	MUHAMMAD TAUSEEF		Korea	Pusan National University
Dr.	Ni	Dan		China	Jiangsu University
Mr.	Niikura	Hisao		Japan	NUMECA Japan CO.,LTD.
Mr.	Nishida	Yoshifumi		Japan	Hitachi, Ltd.
Mr.	Nishimura	Katsuhiko		Japan	The University of Tokyo
Dr.	Nishioka	Takahiro		Japan	Hitachi, Ltd., Industrial Products Company
Mr.	Nobuhito	Oka		Japan	Kyushu University
Dr.	Nohmi	Motohiko		Japan	Ebara Corporation
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Mr.	Park	Jihoon		Korea	Korea maritime and ocean university
Prof.	Peng	Guoyi		Japan	Nihon University
Mr.	Pillala	Vital Kumar Yadav		India	IIT Madras
Dr.	Pin	Liu		China	Kyushu Institute of Technology
Mr.	Rakibuzzaman	MD		Bangladesh	Soongsil University
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Dr.	Renhui	Zhang		China	Lanzhou University of Technology
Mr.	Rong	Guo		China	Lanzhou University of Technology
Dr.	Rui	Cheng	Xiao	China	Lan Zhou University of Technology
Mr.	Sa	KwangJin		Korea	Inha University/Department of Mechanical Engineering
Dr.	Saito	Sumio		Japan	Waseda University
Mr.	Saito	Kosaku		Japan	PHOTRON LIMITED.
Prof.	Sakaguchi	Daisaku		Japan	Nagasaki University
Mr.	Sakaguchi	Masahiro		Japan	Tokushima University
Mr.	Sakaguchi	Junichi		Japan	Dresser-Rand
Mr.	Sakai	Fuma		Japan	Tokai University
Mr.	Sang	Le	Quang	Viet Nam	Mie university
Mr.	SANGHIRUN	WITTHAWAT		Thailand	King Mongkut's U. of Technology Thonburi
Prof.	Sang-Ho	Suh		Korea	Soongsil University
Dr.	Sasaki	Soichi		Japan	Nagasaki University
Mr.	SASAKI	Hirotoshi		Japan	Tohoku University
Mr.	Sasaki	Yoshihiro		Japan	Advanced Simulation Technology of Mechanics R&D,CO.,LTD
Prof.	Sato	Kotaro		Japan	Kogakuin University
Dr.	Sedlar	Milan		Czech	Centre of Hydraulic Research, Ltd.
Mr.	SEKINE	NORIAKI		Japan	Fuji-Techno Service CO.LTD.,
Ms.	Sekino	Yumiko		Japan	EBARA CORPORATION
Mr.	Seo	Jaewon		Korea	Inha University graduate school
Prof.	Setoguchi	Toshiaki		Japan	Saga University
Dr.	SHIGEMITSU	TORU		Japan	Tokushima University
Mr.	Shimizu	Shohei		Japan	Kogakuin University
Mr.	Shimizu	Hiroyoshi		Japan	Daiichi System Engineering CO.,LTD.
Mr.	Shimmei	Katsumasa		Japan	Hitachi Mitsubishi Hydro Corporation

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Mr.	Shrestha	Mausam		Korea	Korea Maritime and Ocean University
Mr.	Suganuma	Shunsuke		Japan	DITECT Corporation
Mr.	Sugaya	Takashi		Japan	Ebara corporation
Mr.	SUGIMOTO	TAKAYUKI		Japan	TOHOKU SMALL HYDROPOWER
Prof.	Sugiyama	Kazuyasu		Japan	Graduate School of Engineering Science, Osaka University
Mr.	Suh	Jun	Won	Korea	Yonsei University
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Dr.	Sutikno	Priyono		Indonesia	Institut Teknologi Bandung
Prof.	Suzuki	Masami		Japan	University of the Ryukyus
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Prof.	Takami	Toshihiro		Japan	Okayama University of Science
Prof.	Takao	Manabu		Japan	National Institute of Technology, Matsue College
Mr.	Takayama	Yasuhiro		Japan	Osaka University
Mr.	Takemura	Takashi		Japan	EBARA corporation
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Mr.	Tamura	Yuta		Japan	Hitachi Mitsubishi Hydro Corporation
Dr.	Tan	Lei		China	Tsinghua University
Prof.	TANAKA	Teiichi		Japan	National Institute of Technology, Kumamoto College
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Mr.	Wang	Zhao		China	Wuhan University
Dr.	Wang	Tong		China	Shanghai Jiaotong University
Dr.	Wang	Yuchuan		China	Northwest A & F University
Prof.	WANG	WeiZhe		China	Shanghai Jiao Tong University
Ms.	Wang	Yefang		China	National Research Centre of Pumps, Jiangsu University
Dr.	Wang	Baotong		Japan	IHI Corporation
Mr.	Wata	Joji	Vulibeci	Fiji	Korea maritime and ocean university
Mr.	Watabe	Keisuke		Japan	Osaka University
Prof.	WATANABE	SATOSHI		Japan	Kyushu University
Mr.	Watanabe	Hiroyoshi		Japan	Ebara corporation
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Prof.	Weng	Xiao	Hong	China	
Mr.	Wensi	Dong		Japan	Toshiba Corporation Power Systems Company
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Dr.	Wu	Guangkuan		China	Xi'an University of Technology
Prof.	Wu	Dazhuan		China	Zhejiang University
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Prof.	Xiong	Xue	Sheng	China	Hefei General Machinery Research Institute
Dr.	Xu	Maosen		China	Wuhan University

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Dr.	Xu	Yong		China	Sichuan University
Mr.	Yagyu	Satoshi		Japan	kinnkikinnzoku
Mr.	Yahagi	Yuichiro		Japan	Ibaraki University
Mr.	Yamada	Takuyoshi		Japan	Mitsubishi Heavy Industries, Ltd.
Dr.	Yamada	Kazutoyo		Japan	Kyushu University
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Mr.	YANG	DONG	UK	Korea	Korea Institute of Industrial Technology
Mr.	Yasuda	Masashi		Japan	JPower
Prof.	YOKOTA	Kazuhiko		Japan	Aoyama Gakuin University
Mr.	Yonemura	Atsushi		Japan	Hosei University
Dr.	Yonezawa	Koichi		Japan	Osaka university
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Dr.	Zhang	Ning		China	Jiangsu University
Mr.	Zhang	Mingxing		China	School of Power and Mechanical Engineering,Wuhan University
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Mr.	Zhu	Yaohua		China	National Research Centre of Pumps, Jiangsu University
Dr.	Zhuge	Weilin		China	Tsinghua University

Technical Program

7th September (Monday)

Time		
		Registration (15:00-19:00) at Rhiga Royal Hotel Tokyo
18:00	20:00	Welcome reception (Rhiga Royal Hotel Tokyo)

8th September (Tuesday)

Time						
		Registration (9:00-17:00)				
9:30	9:50	Opening celemony (Lecture hall)				
9:50	10:35	Plenary lecture 1 <Prof. Baek, Je Hyun (Republic of Korea)> (Lecture hall)				
10:35	11:20	Invited lecture 1 <Prof. Avellan, Francois (EPFL, Switzerland)> (Lecture hall)				
11:20	12:50	Lunch break				
		Room A	Room B	Room C	Room D	Room E
12:50	14:50	OS01	OS12	OS09-1	OS14-1	OS13-1
		AICFM13-009	AICFM13-132	AICFM13-006	AICFM13-037	AICFM13-063
		AICFM13-017	AICFM13-133	AICFM13-010	AICFM13-175	AICFM13-064
		AICFM13-019	AICFM13-166	AICFM13-071	AICFM13-188	AICFM13-065
		AICFM13-031	AICFM13-172	AICFM13-032	AICFM13-193	AICFM13-066
		AICFM13-208	AICFM13-187	AICFM13-160	AICFM13-194	AICFM13-070
120 minutes		AICFM13-216		AICFM13-154	AICFM13-205	AICFM13-125
14:50	15:20	Break				
		Room A	Room B	Room C	Room D	Room E
15:20	16:40	OS07-1	OS04-1	OS09-2	OS14-2	OS13-2
		AICFM13-023	AICFM13-022	AICFM13-142	AICFM13-209	AICFM13-093
		AICFM13-097	AICFM13-026	AICFM13-007	AICFM13-210	AICFM13-094
		AICFM13-113	AICFM13-041	AICFM13-046	AICFM13-217	AICFM13-096
80 minutes		AICFM13-165	AICFM13-061	AICFM13-083	AICFM13-218	AICFM13-181
16:40	16:50	Break				
		Room A	Room B	Room C	Room D	Room E
16:50	17:50	OS07-2	OS04-2	OS09-3	OS14-3	
		AICFM13-137	AICFM13-110	AICFM13-124	AICFM13-034	
		AICFM13-139	AICFM13-116	AICFM13-155	AICFM13-042	
60 minutes		AICFM13-156	AICFM13-203	AICFM13-174	AICFM13-130	

9th September (Wednesday)

Time							
		Registration (9:00-17:00)					
9:30	10:15	Plenary lecture 2 <Prof. Zhang, Yangjun (China) > (Lecture hall)					
10:15	11:00	Invited lecture 2 <Prof. Dr.-Ing. Bohn, Dieter (RWTH Aachen, Germany)> (Lecture hall)					
11:00	11:20	Break					
		Room A	**Room B**	**Room C**	**Room D**	**Room E**	**Lecture hall**
11:20	12:40	OS02-1	OS04-3	OS03-1	OS14-4	OS13-3	OS09-4
		AICFM13-040	AICFM13-215	[illegible]	AICFM13-145	AICFM13-108	AICFM13-128
		AICFM13-161	AICFM13-103	[illegible]	AICFM13-211	AICFM13-112	AICFM13-025
		AICFM13-144	AICFM13-101	[illegible]	AICFM13-219	AICFM13-159	AICFM13-057
80 minutes		AICFM13-153	AICFM13-138	[illegible]	AICFM13-170	AICFM13-198	AICFM13-080
12:40	14:10	Break					
		Room A	**Room B**	**Room C**	**Room D**	**Room E**	**Lecture hall**
14:10	15:50	OS02-2	OS04-4	OS03-2	OS10-1	OS11	OS09-5
		AICFM13-150	AICFM13-169	[illegible]	AICFM13-039	AICFM13-048	AICFM13-062
		AICFM13-068	AICFM13-090	[illegible]	AICFM13-043	AICFM13-106	AICFM13-008
		AICFM13-127	AICFM13-118	[illegible]	AICFM13-052	AICFM13-140	AICFM13-024
		AICFM13-002	AICFM13-069	[illegible]	AICFM13-182	AICFM13-141	AICFM13-100
100 minutes		AICFM13-109	AICFM13-005		AICFM13-183		AICFM13-117
15:50	16:10	Break					
16:10	16:55	Plenary lecture 3 <Dr. Goto, Akira (Japan)> (Lecture hall)					
16:55	17:40	Invited lecture 3 <Prof. Katz, Joseph (Johns Hopkins Univ., USA)> (Lecture hall)					
19:00	21:00	Banquet (Rhiga Royal Hotel Tokyo)					

10th September (Thursday)

Time						
		Registration (9:00-16:00)				
		Room A	Room B	Room C	Room D	Room E
9:30	10:50	OS02-3	OS04-5	OS09-6	OS10-2	OS08-1
		AICFM13-004	AICFM13-038	AICFM13-049	AICFM13-073	AICFM13-011
		AICFM13-164	AICFM13-088	AICFM13-147	AICFM13-178	AICFM13-082
		AICFM13-222	AICFM13-099	AICFM13-060	AICFM13-012	AICFM13-085
80 minutes		AICFM13-224	AICFM13-202	AICFM13-220	AICFM13-214	AICFM13-192
10:50	11:10	Break				
		Room A	Room B	Room C	Room D	Room E
11:10	12:30	OS02-4	OS09-8	OS09-7	OS10-3	OS08-2
		AICFM13-029	AICFM13-056	AICFM13-027	AICFM13-028	AICFM13-079
		AICFM13-030	AICFM13-115	AICFM13-105	AICFM13-067	AICFM13-050
		AICFM13-143	AICFM13-123	AICFM13-186	AICFM13-015	AICFM13-058
80 minutes		AICFM13-018	AICFM13-180	AICFM13-199	AICFM13-135	AICFM13-163
12:30	13:50	Lunch break				
		Room A	Room B	Room C	Room D	Room E
13:50	15:30	OS06-1	OS09-9	OS05	OS10-4	OS08-3
		AICFM13-020	AICFM13-157	AICFM13-107	AICFM13-076	AICFM13-044
		AICFM13-196	AICFM13-086	AICFM13-129	AICFM13-077	AICFM13-119
		AICFM13-200	AICFM13-035	AICFM13-134	AICFM13-162	AICFM13-158
		AICFM13-091	AICFM13-036	AICFM13-051	AICFM13-167	AICFM13-045
100 minutes		AICFM13-120	AICFM13-047	AICFM13-177	AICFM13-179	AICFM13-121
15:30	15:50	Break				
		Room A	Room B	Room C	Room D	Room E
15:50	16:50	OS06-2	OS09-10	GS-1	GS-2	GS-3
		AICFM13-212	AICFM13-122	AICFM13-054	AICFM13-014	AICFM13-072
		AICFM13-126	AICFM13-168	AICFM13-149	AICFM13-184	AICFM13-078
60 minutes		AICFM13-146	AICFM13-152	AICFM13-185	AICFM13-189	AICFM13-171
16:50	17:00	Break				
17:00	17:20	Closing celemony (Lecture hall)				

OS 1: Measurements and Experimental Fluid Dynamics	OS 8 : Renewable Energy (Wind, Tidal, Small, Hydro etc.)
OS 2: Computational Fluid Dynamics on Turbomachinery	OS 9: Pumps and Hydroturbines
OS 3: Design Optimization	OS 10: Fans and Compressors
OS 4: Cavitation and Multiphase Flows	OS 11: Steam Turbines
OS 5: Tribology and Rotordynamics	OS 12: Small Wind Turbines
OS 6: Unsteady Phenomena	OS 13: Organic Rankine Cycle Generation
OS 7: Noise and Vibration Problems of Turbomachinery	OS 14: Ocean Energy Machinery and Systems
	GS: General Session

SWTDEL
SMALL WIND TURBINE DESIGN EVALUATION LAB

Experimental and Numerical Investigation of a 150 kW Horizontal-axis Wind Turbine

Yan-Ting Lin*
Wei-Nian Su, Chin-Cheng Huang

Mechanical and System Engineering Program
Institute of Nuclear Energy Research

THE 13th Asian International Conference on FLUID MACHINERY,2015(AICFM13).
7th-10th September 2015.

INER

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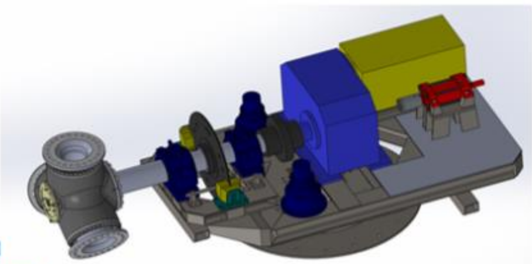
SMALL WIND TURBINE DESIGN EVALUATION LAB

Outline

- INTRODUCTION
- THEORETICAL MODEL
- BLADE DESIGN
- RESULTS AND DISCUSSION
  - Numerical results of power coefficient
  - Comparisons between CFD and Measurements
- CONCLUSIONS



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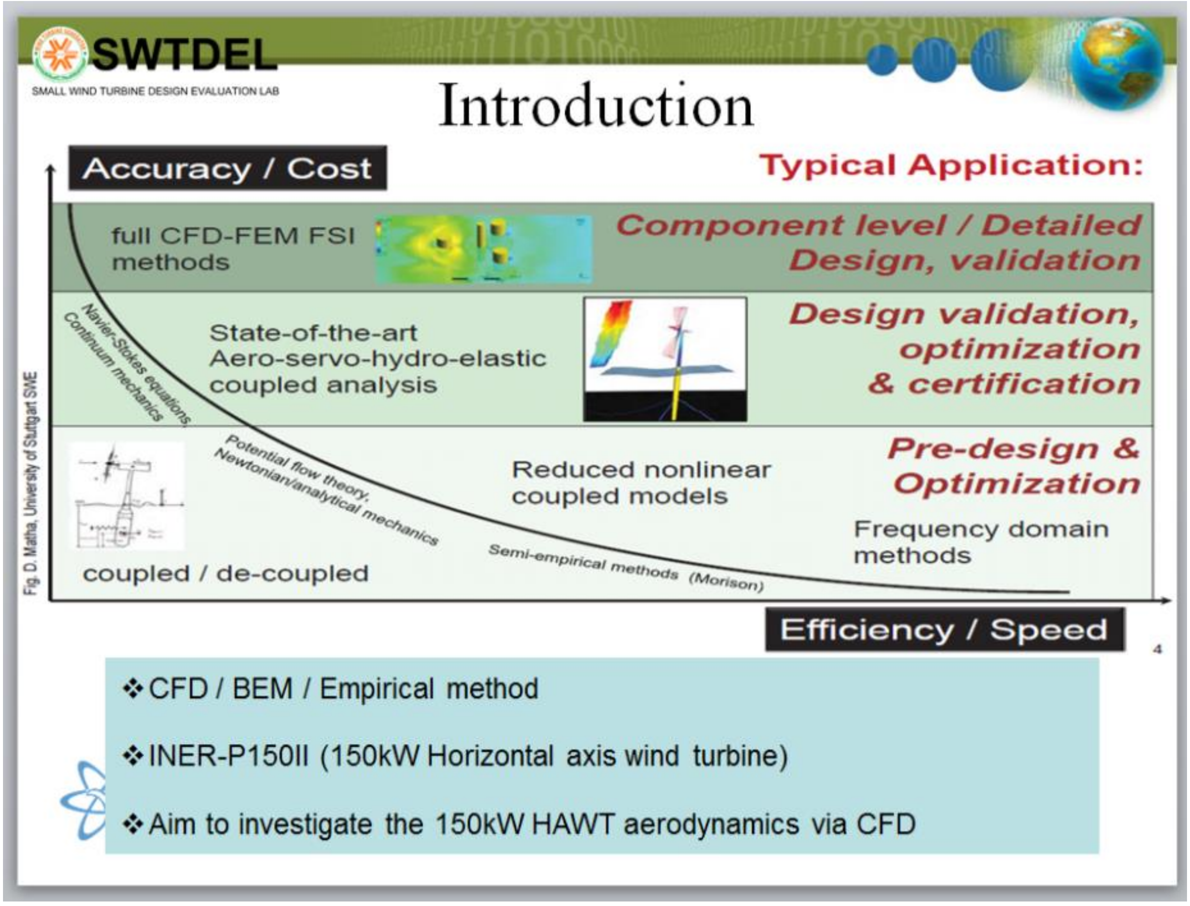
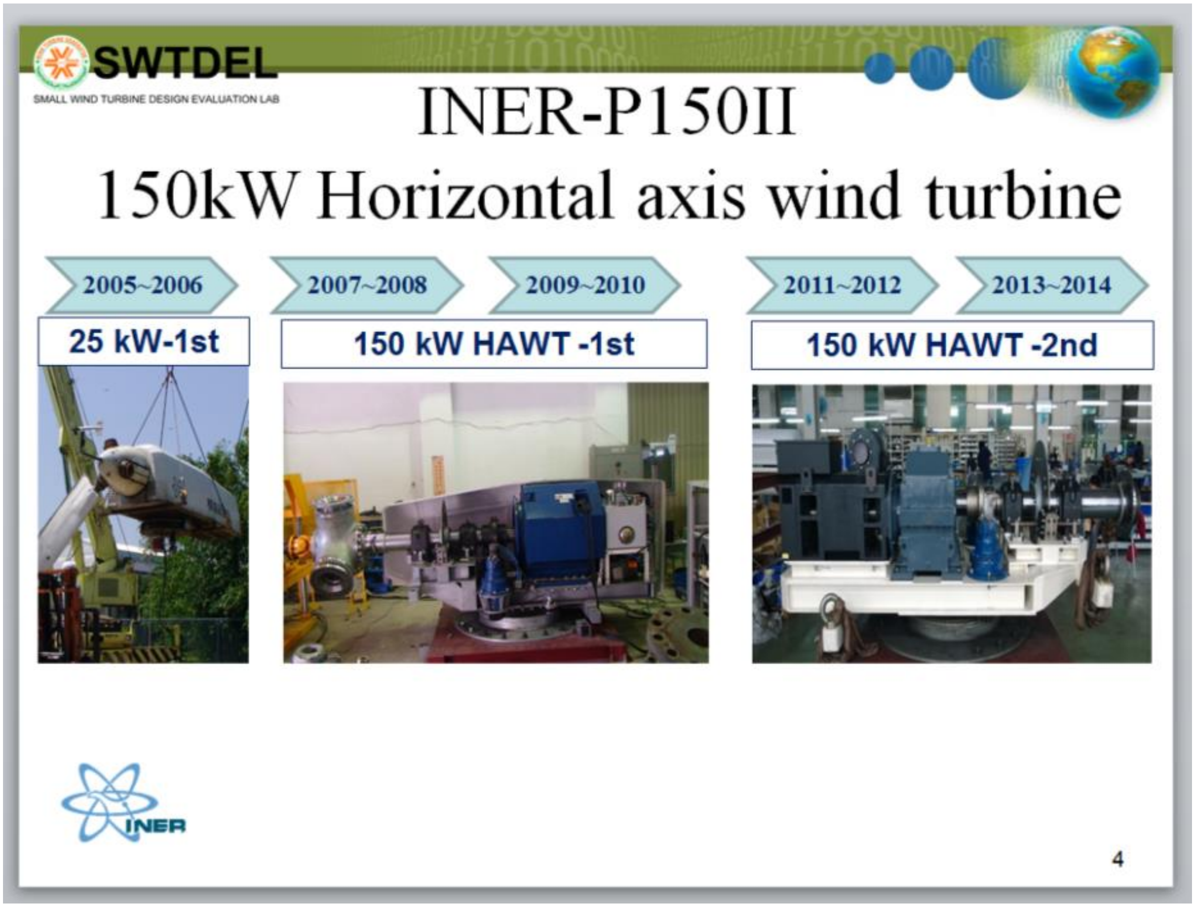
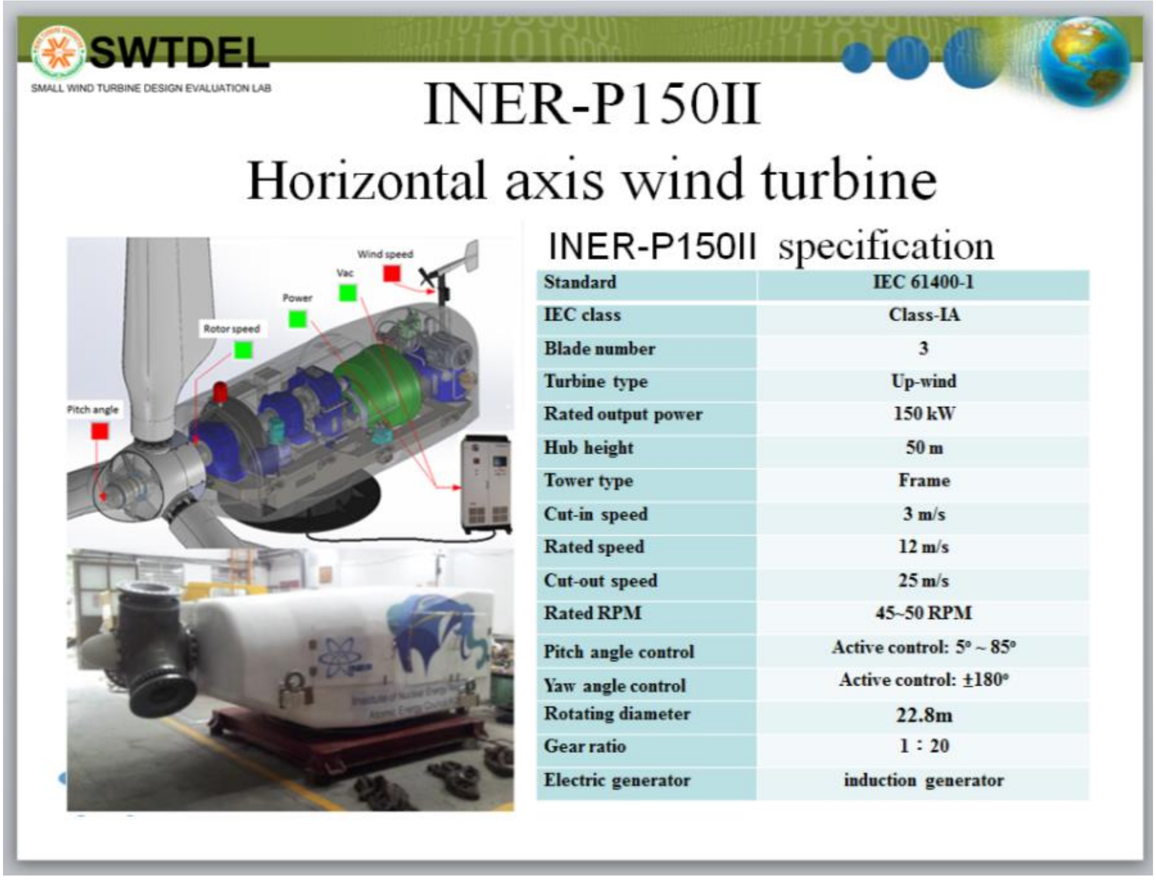
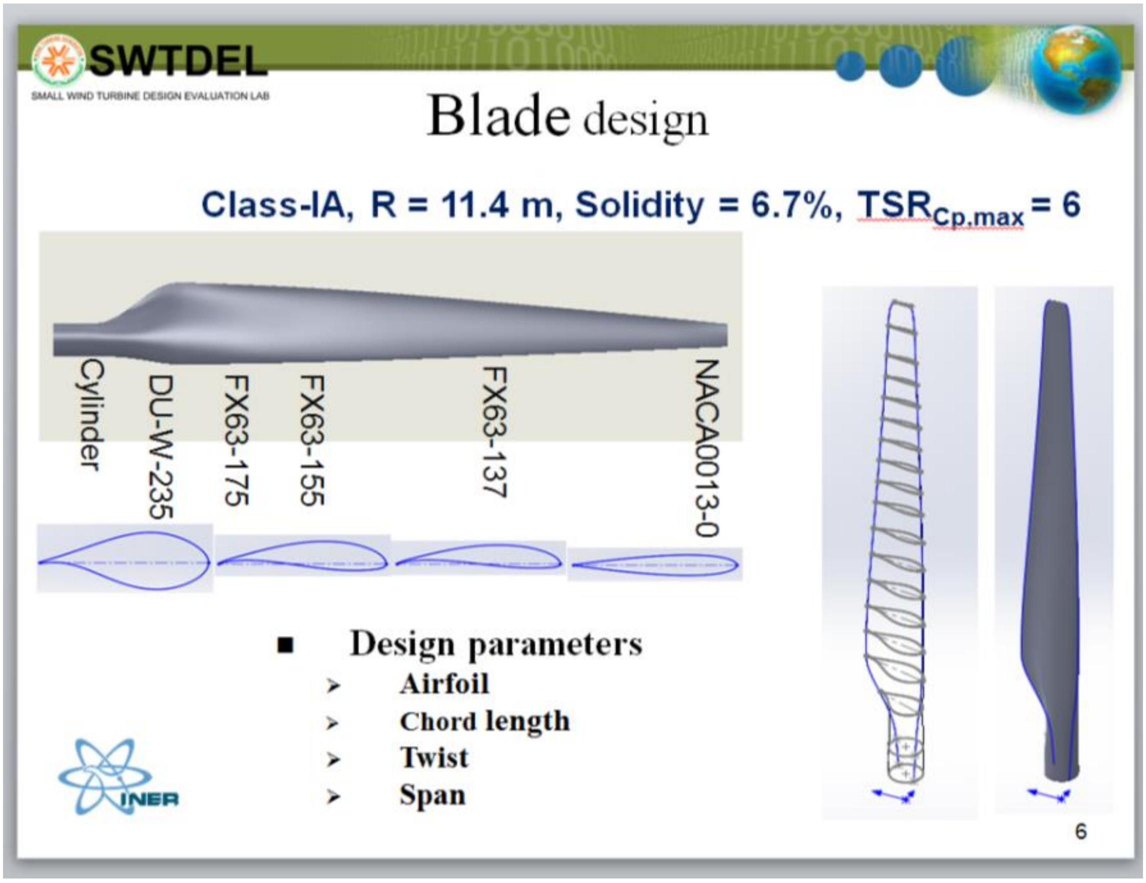

SWTDEL
SMALL WIND TURBINE DESIGN EVALUATION LAB
Introduction
Accuracy / Cost
Typical Application:
full CFD-FEM FSI methods
Component level / Detailed Design, validation
State-of-the-art Aero-servo-hydro-elastic coupled analysis
Navier-Stokes equations, Continuum mechanics
Design validation, optimization & certification
Potential flow theory, Newtonian/analytical mechanics
Reduced nonlinear coupled models
Pre-design & Optimization
Frequency domain methods
coupled / de-coupled
Semi-empirical methods (Morison)
Fig. D. Matha, University of Stuttgart SWE
Efficiency / Speed
4
❖CFD / BEM / Empirical method
❖INER-P150II (150kW Horizontal axis wind turbine)
❖Aim to investigate the 150kW HAWT aerodynamics via CFD


SWTDEL
SMALL WIND TURBINE DESIGN EVALUATION LAB
INER-P150II
150kW Horizontal axis wind turbine
2005~2006
2007~2008
2009~2010
2011~2012
2013~2014
25 kW-1st
150 kW HAWT -1st
150 kW HAWT -2nd
INER
4



Standard	IEC 61400-1
IEC class	Class-IA
Blade number	3
Turbine type	Up-wind
Rated output power	150 kW
Hub height	50 m
Tower type	Frame
Cut-in speed	3 m/s
Rated speed	12 m/s
Cut-out speed	25 m/s
Rated RPM	45~50 RPM
Pitch angle control	Active control: 5° ~ 85°
Yaw angle control	Active control: ±180°
Rotating diameter	22.8m
Gear ratio	1 : 20
Electric generator	induction generator



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SMALL WIND TURBINE DESIGN EVALUATION LAB

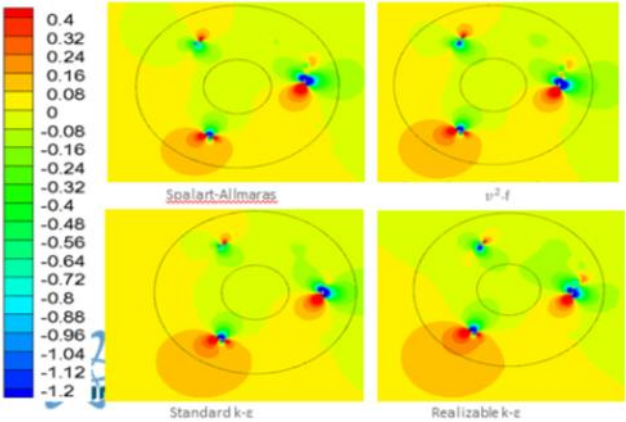
RANS-based turbulent model

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{V}) = 0$$

$$\frac{\partial \rho \vec{V}}{\partial t} + \nabla \cdot (\rho \vec{V} \vec{V}) = -\nabla p + \nabla \cdot \left(\mu_{eff} \left(\nabla \vec{V} + (\nabla \vec{V})^T \right) + \vec{g} \right)$$

$$\frac{\partial \rho k}{\partial t} + \nabla \cdot (\rho \vec{V} k) = \nabla \left[\left(\mu_L + \frac{\mu_T}{\sigma_k} \right) \nabla k \right] + P_k - \rho \varepsilon$$

$$\frac{\partial \rho \varepsilon}{\partial t} + \nabla \cdot (\rho \vec{V} \varepsilon) = \nabla \left[\left(\mu_L + \frac{\mu_T}{\sigma_k} \right) \nabla \varepsilon \right] + \frac{\varepsilon}{k} (C_{\varepsilon 1} P_k + C_{\varepsilon 2} P_\varepsilon)$$



Case	Free stream velocity (m/s)	TSR	Turbulence Model
1	10	TSR=2(63.66rpm)	Spalart-Allmaras
2	10	TSR=2(63.66rpm)	STD k-ε
3	10	TSR=2(63.66rpm)	Realizable k-ε
4	10	TSR=2(63.66rpm)	SST k-ω
5	10	TSR=2(63.66rpm)	v^2-f

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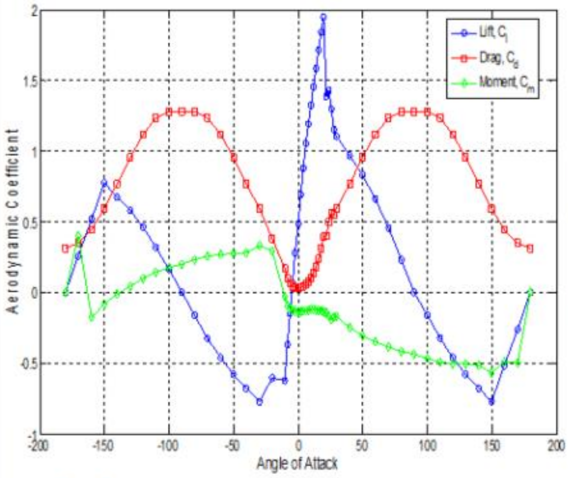
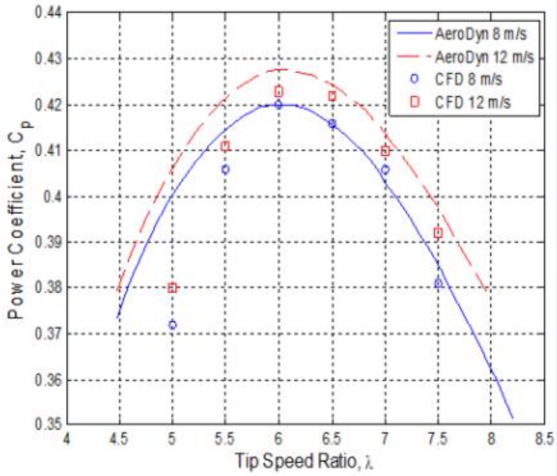
SMALL WIND TURBINE DESIGN EVALUATION LAB

Blade design -AoA

- **Aerodynamic coefficients**





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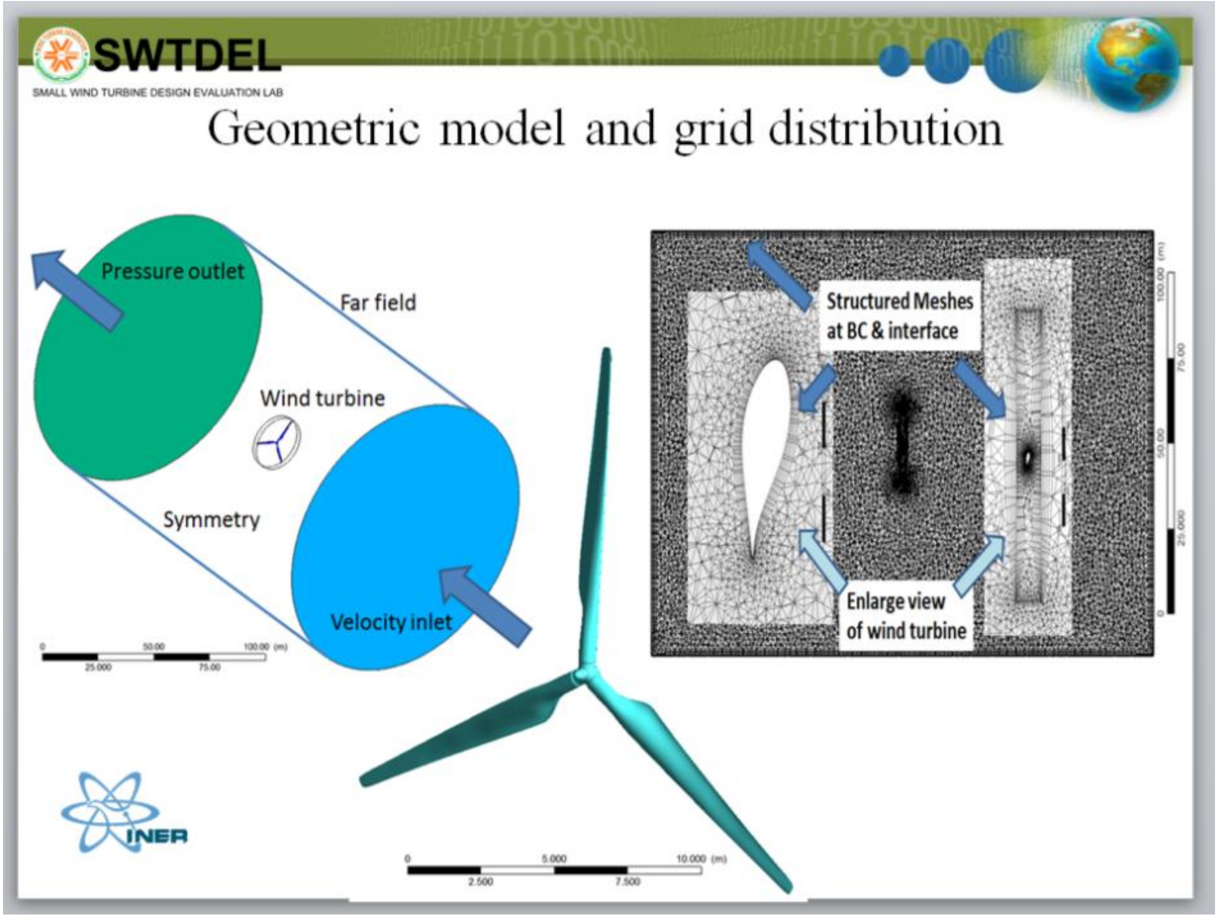
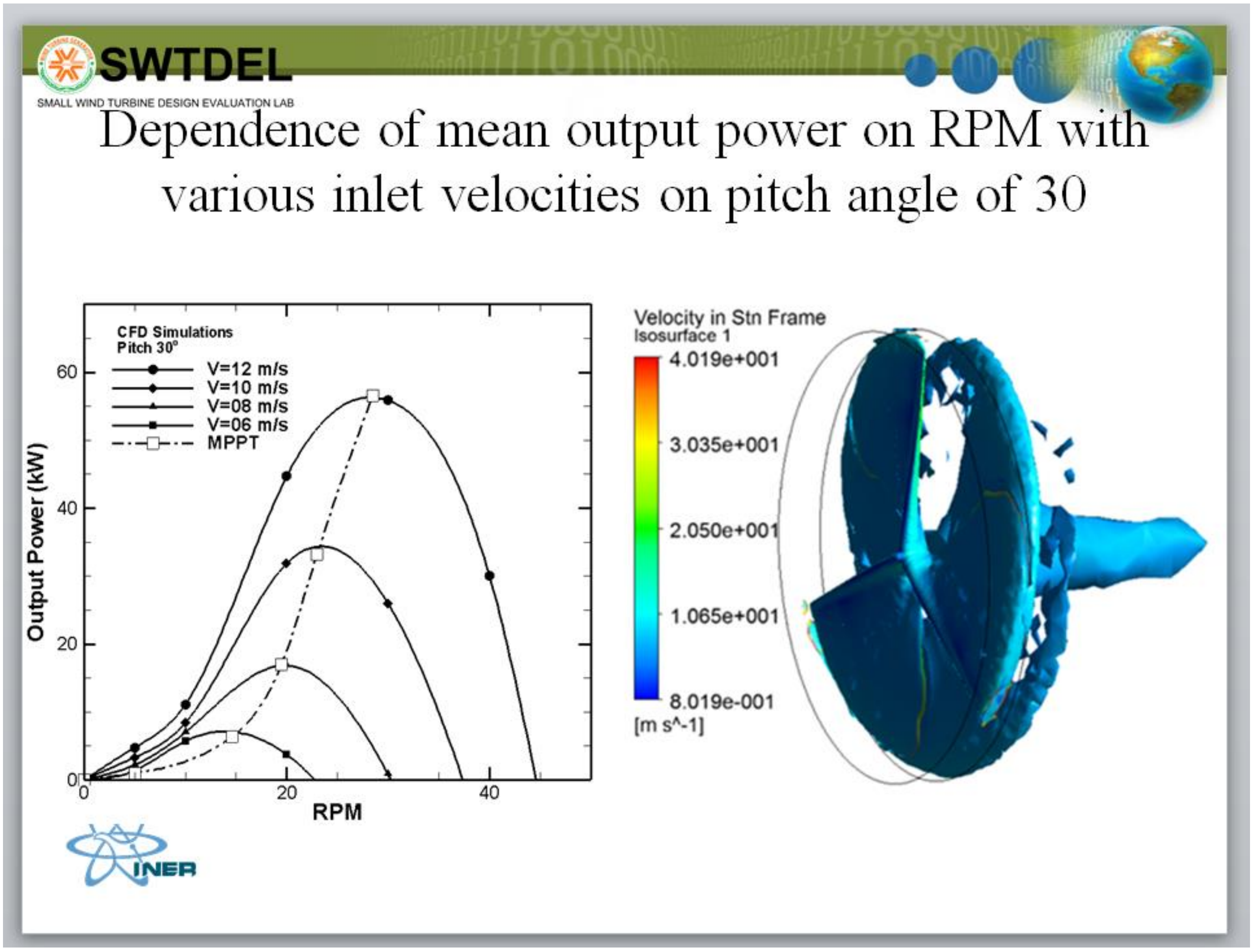
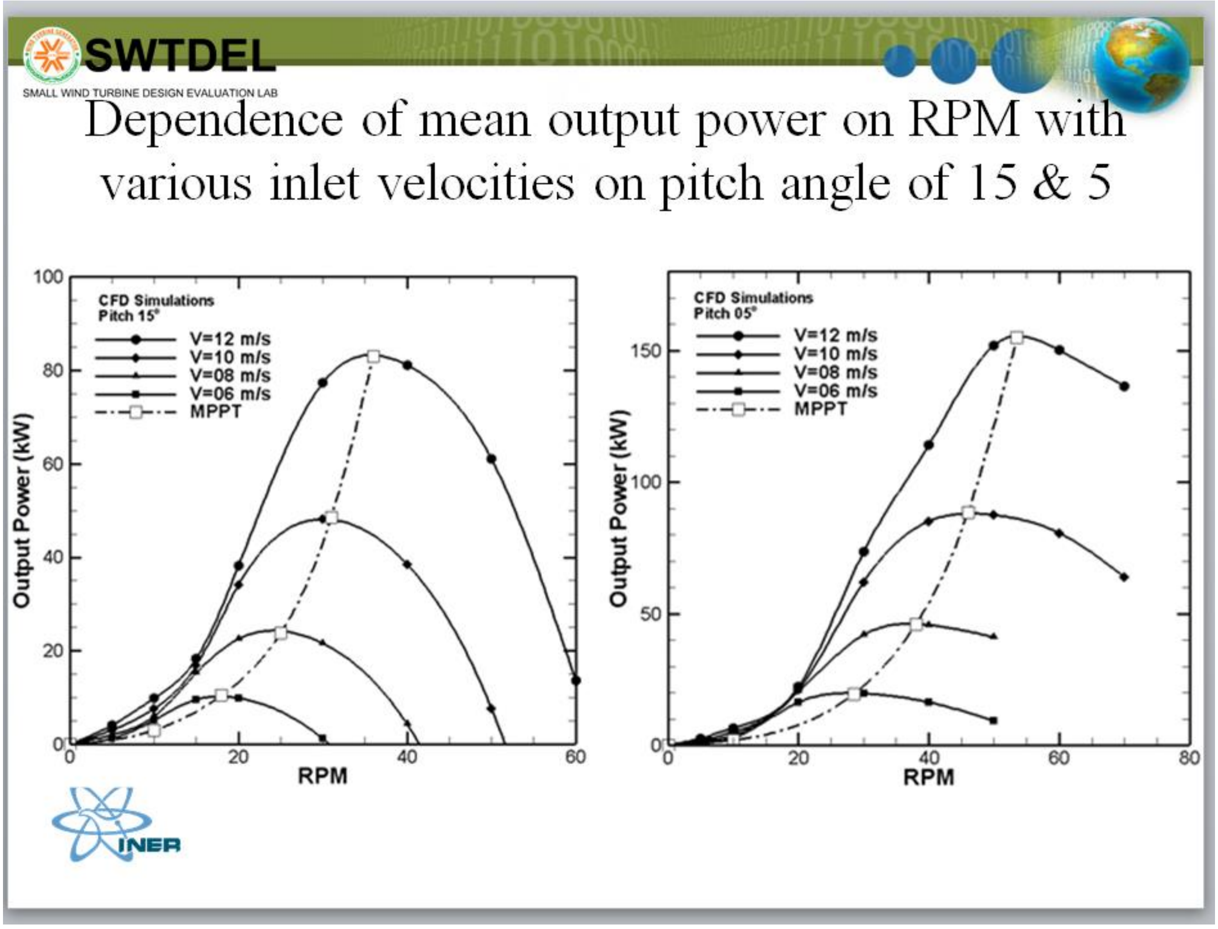
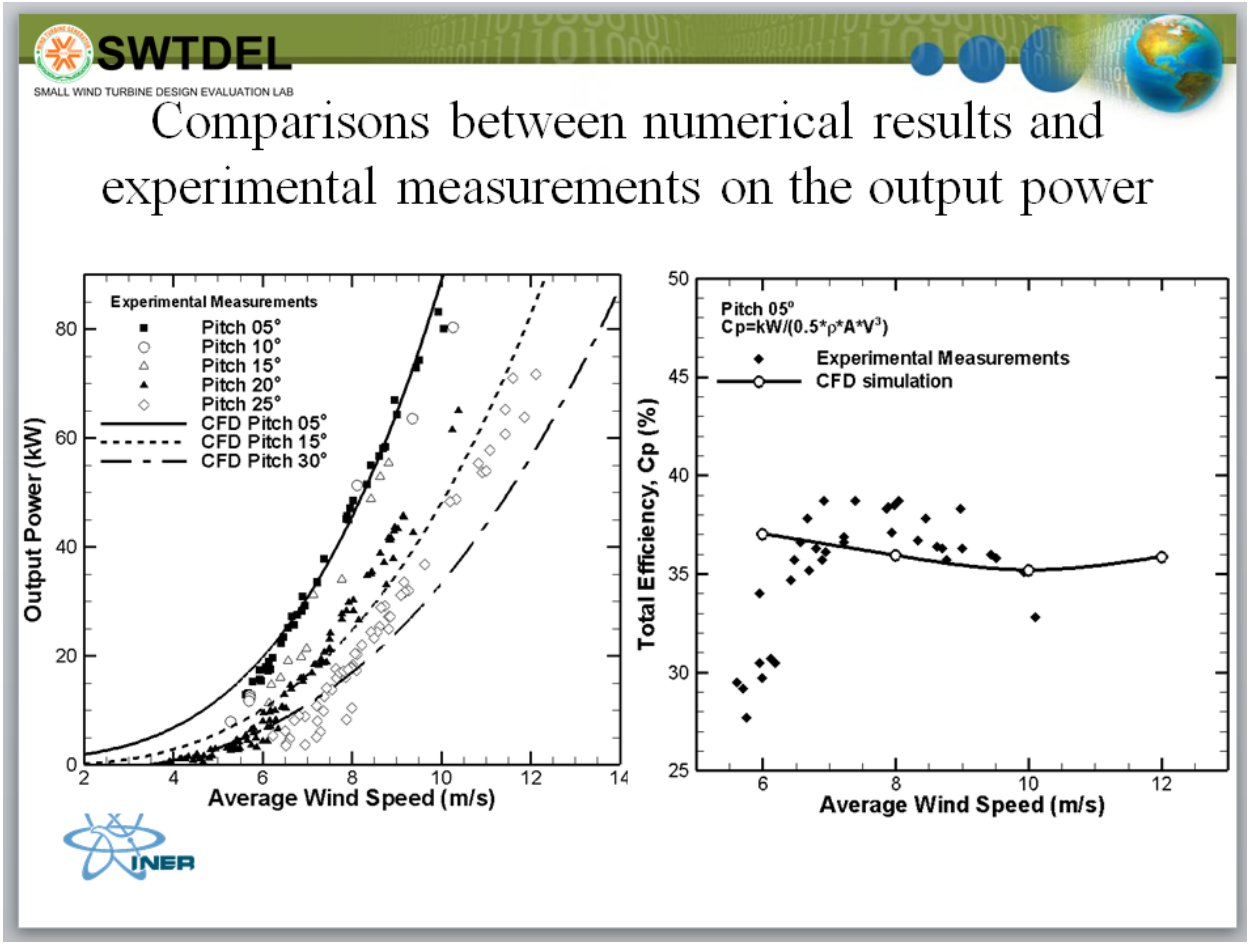
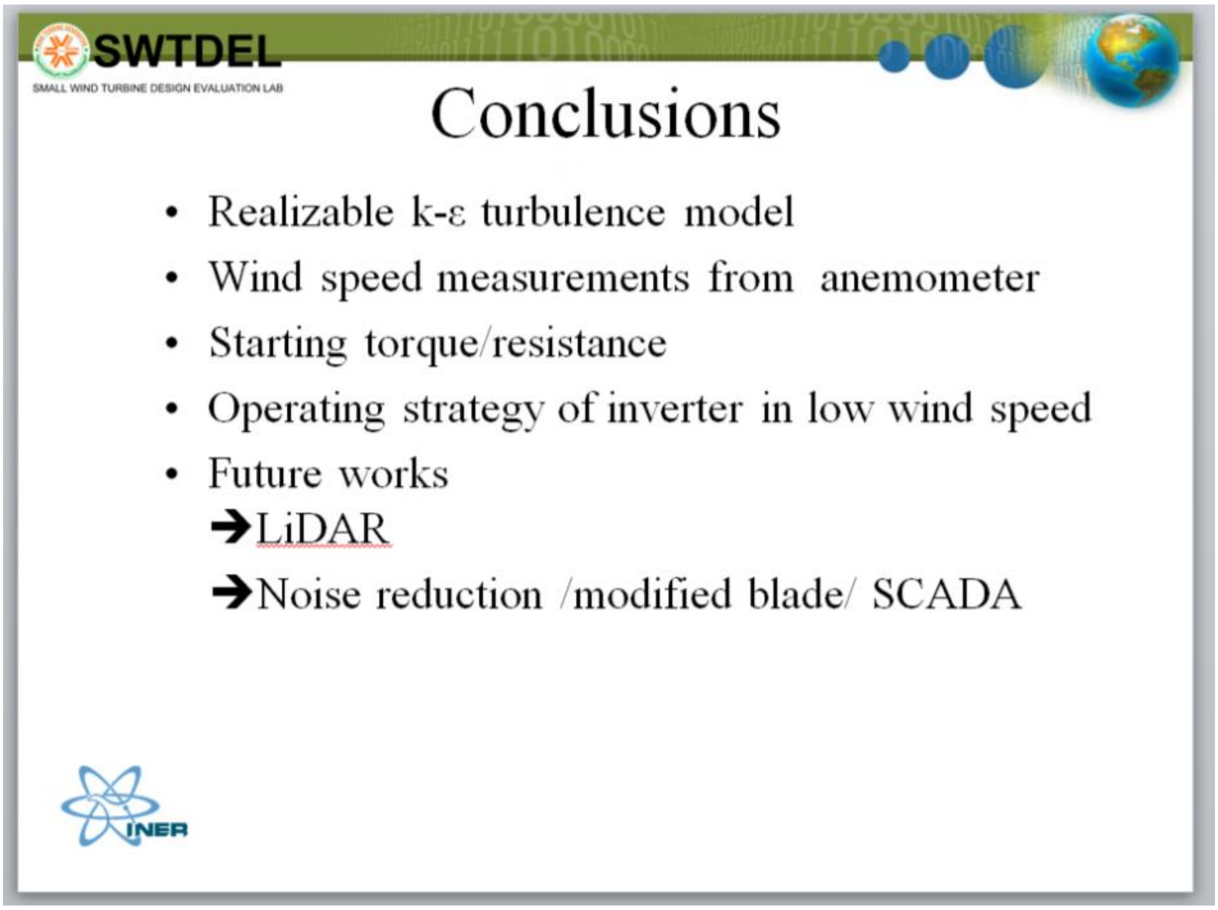
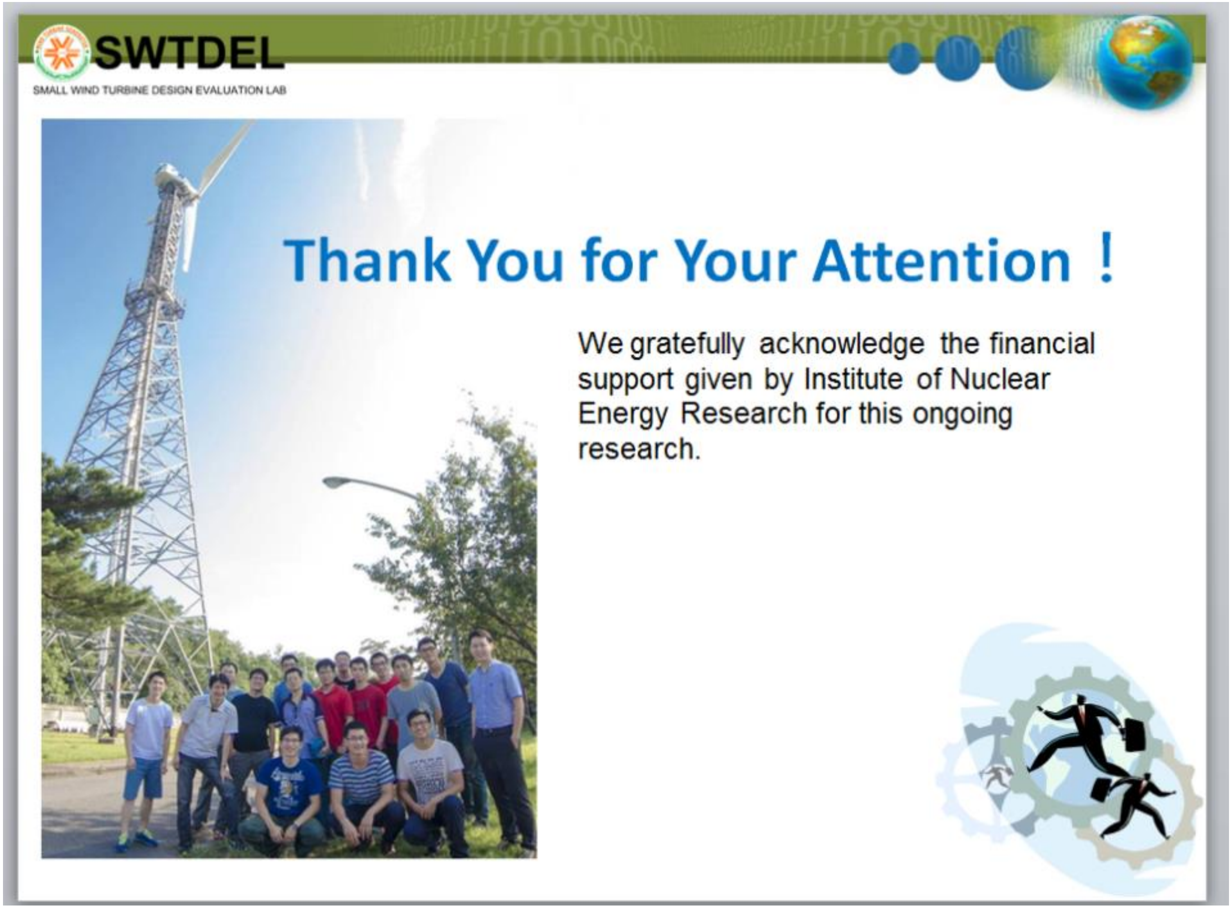

SWTDEL
SMALL WIND TURBINE DESIGN EVALUATION LAB
Geometric model and grid distribution
Pressure outlet
Far field
Wind turbine
Symmetry
Velocity inlet
Structured Meshes at BC & interface
Enlarge view of wind turbine
INER


SWTDEL
SMALL WIND TURBINE DESIGN EVALUATION LAB
Dependence of mean output power on RPM with various inlet velocities on pitch angle of 30
CFD Simulations
Pitch 30°
V=12 m/s
V=10 m/s
V=08 m/s
V=06 m/s
MPPT
Output Power (kW)
RPM
Velocity in Stn Frame
Isosurface 1
4.019e+001
3.035e+001
2.050e+001
1.065e+001
8.019e-001
[m s^-1]
INER

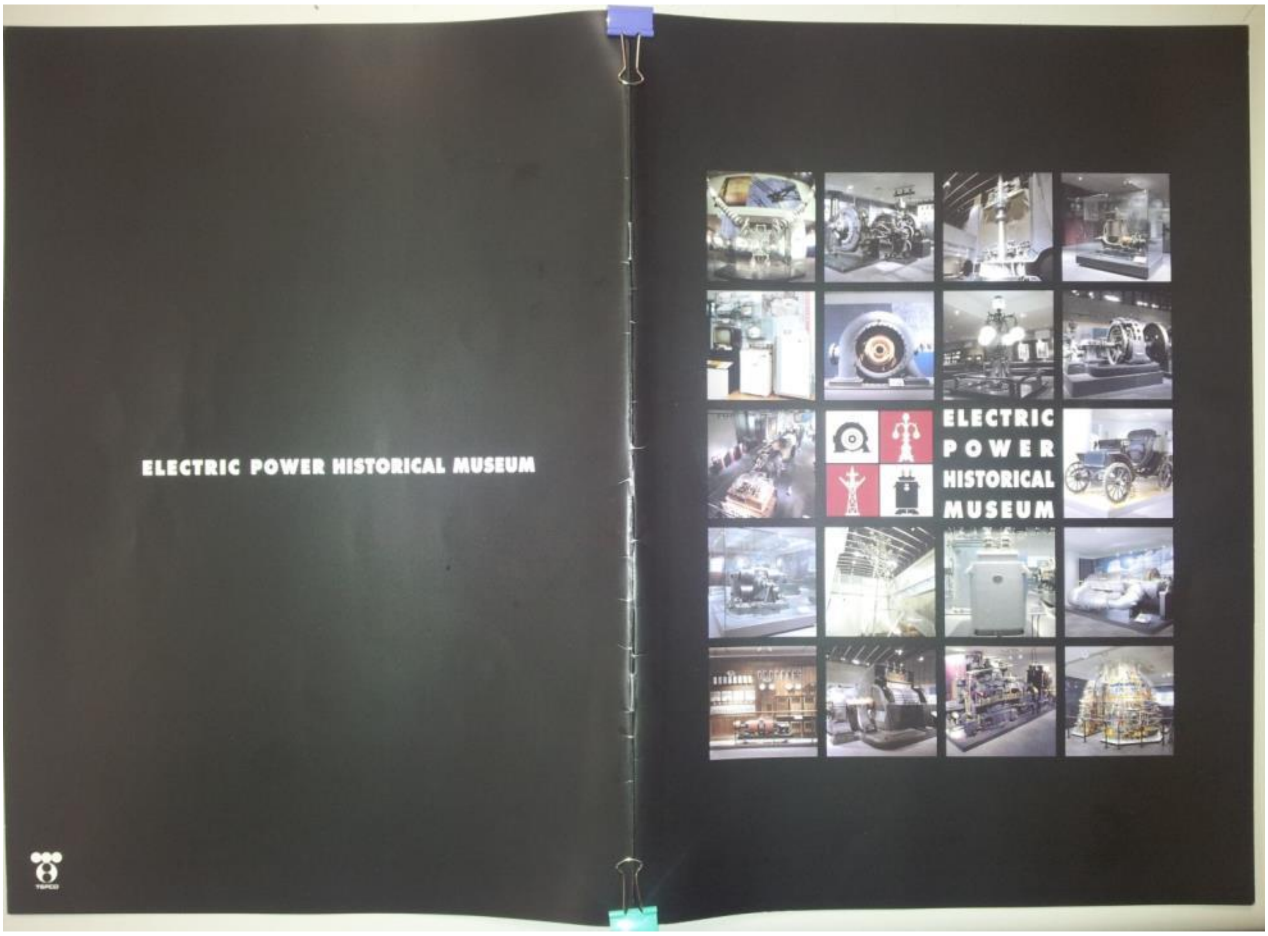

SWTDEL
SMALL WIND TURBINE DESIGN EVALUATION LAB
Dependence of mean output power on RPM with various inlet velocities on pitch angle of 15 & 5
CFD Simulations
Pitch 15°
V=12 m/s
V=10 m/s
V=08 m/s
V=06 m/s
MPPT
Output Power (kW)
RPM
CFD Simulations
Pitch 05°
V=12 m/s
V=10 m/s
V=08 m/s
V=06 m/s
MPPT
Output Power (kW)
RPM
INER

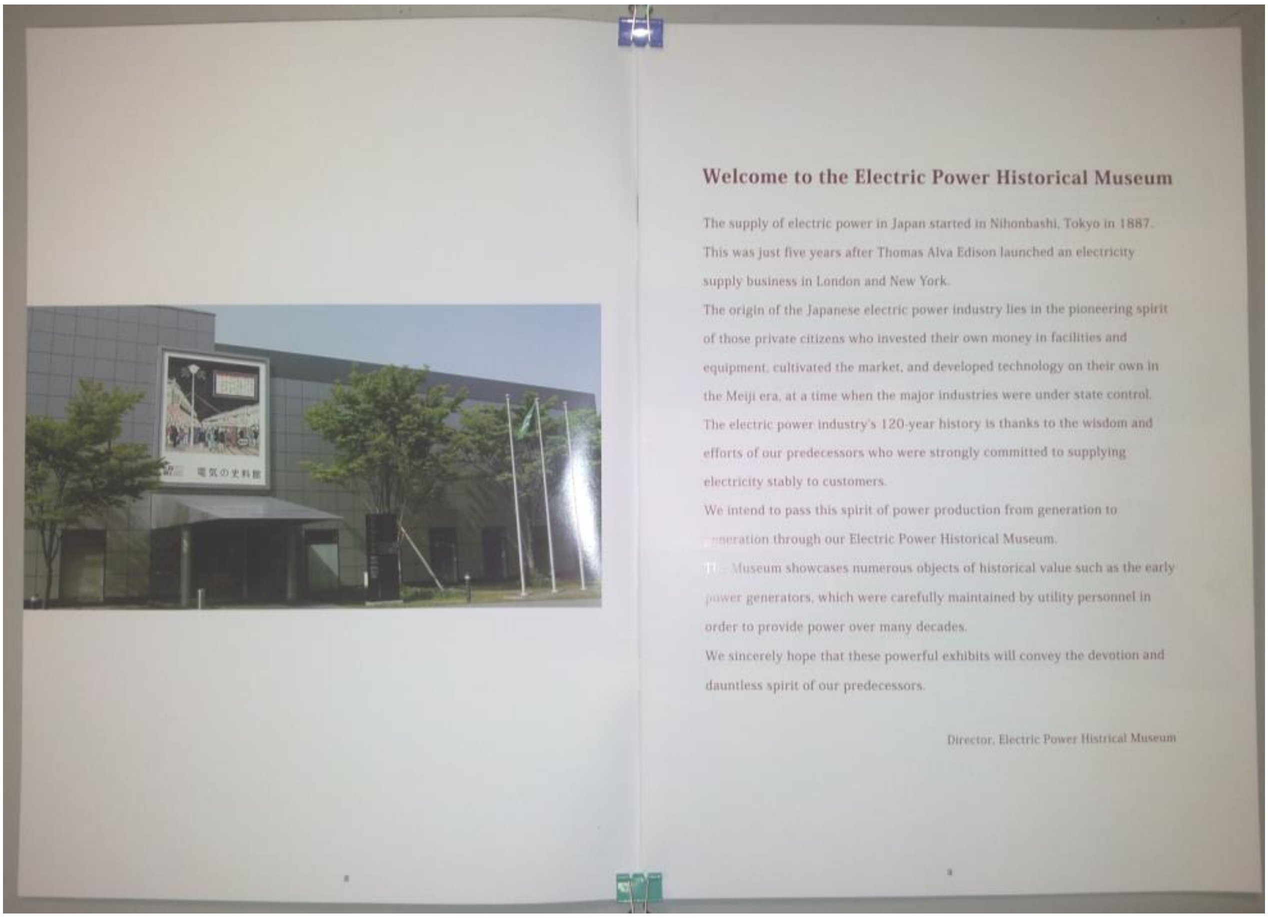

SWTDEL
SMALL WIND TURBINE DESIGN EVALUATION LAB
Comparisons between numerical results and experimental measurements on the output power
Experimental Measurements
Pitch 05°
Pitch 10°
Pitch 15°
Pitch 20°
Pitch 25°
CFD Pitch 05°
CFD Pitch 15°
CFD Pitch 30°
Output Power (kW)
Average Wind Speed (m/s)
Pitch 05°
Cp=kW/(0.5*ρ*A*V³)
Experimental Measurements
CFD simulation
Total Efficiency, Cp (%)
Average Wind Speed (m/s)
INER


SWTDEL
SMALL WIND TURBINE DESIGN EVALUATION LAB
Conclusions
• Realizable k-ε turbulence model
• Wind speed measurements from anemometer
• Starting torque/resistance
• Operating strategy of inverter in low wind speed
• Future works
➔LiDAR
➔Noise reduction /modified blade/ SCADA
INER


SWTDEL
SMALL WIND TURBINE DESIGN EVALUATION LAB
Thank You for Your Attention！
We gratefully acknowledge the financial support given by Institute of Nuclear Energy Research for this ongoing research.

附件 2，東京電力公司電氣史料館展示資料





Welcome to the Electric Power Historical Museum

The supply of electric power in Japan started in Nihonbashi, Tokyo in 1887. This was just five years after Thomas Alva Edison launched an electricity supply business in London and New York.

The origin of the Japanese electric power industry lies in the pioneering spirit of those private citizens who invested their own money in facilities and equipment, cultivated the market, and developed technology on their own in the Meiji era, at a time when the major industries were under state control.

The electric power industry's 120-year history is thanks to the wisdom and efforts of our predecessors who were strongly committed to supplying electricity stably to customers.

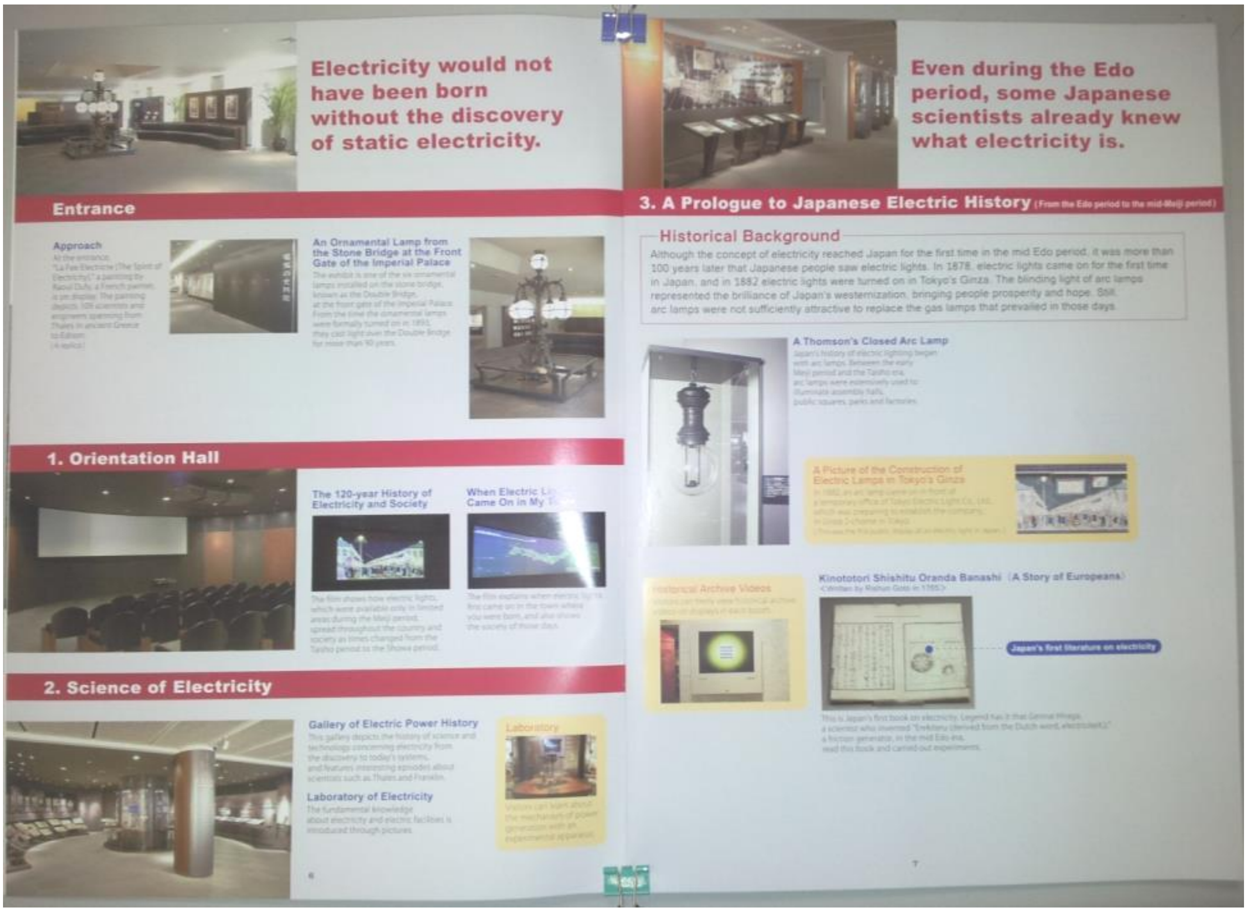
We intend to pass this spirit of power production from generation to generation through our Electric Power Historical Museum.

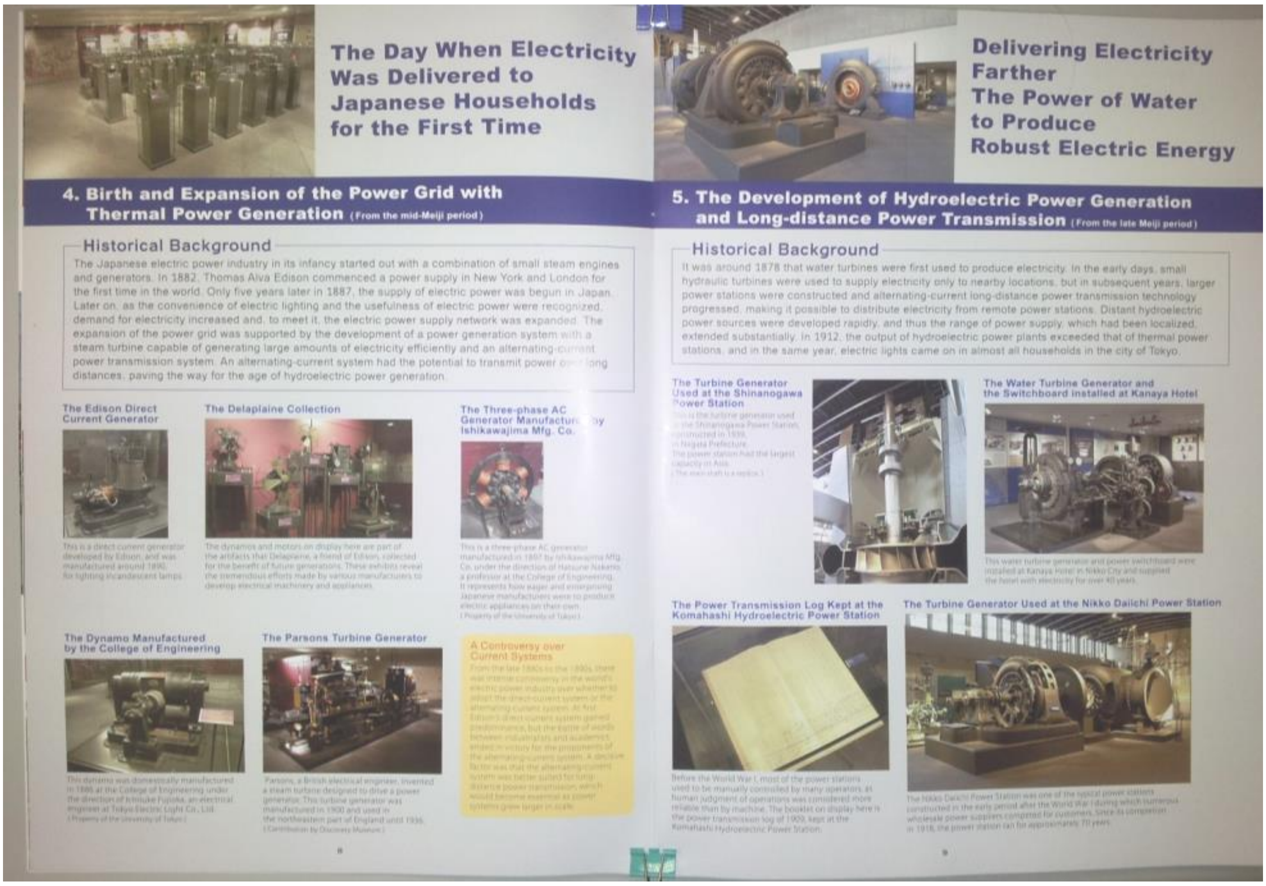
The Museum showcases numerous objects of historical value such as the early power generators, which were carefully maintained by utility personnel in order to provide power over many decades.

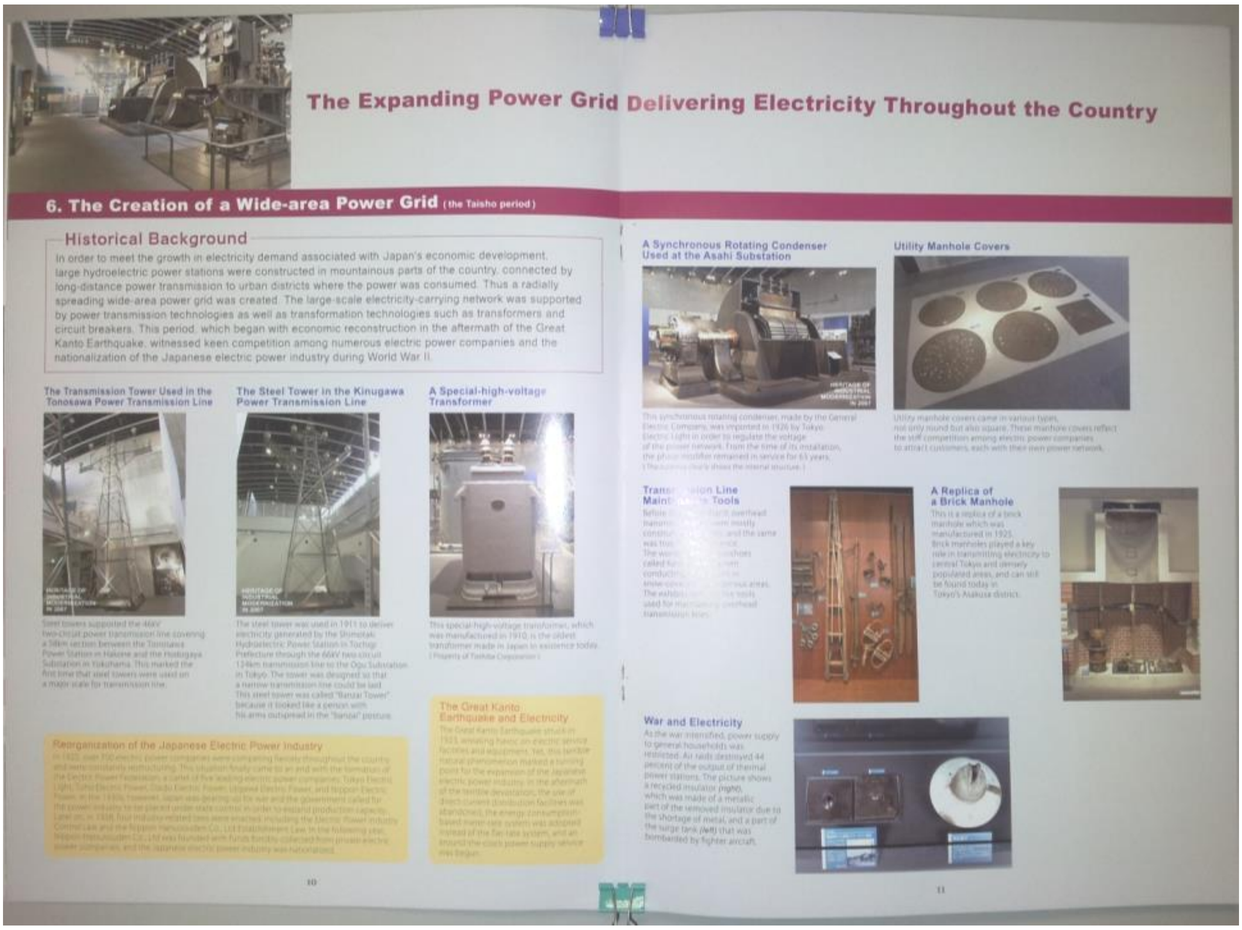
We sincerely hope that these powerful exhibits will convey the devotion and dauntless spirit of our predecessors.

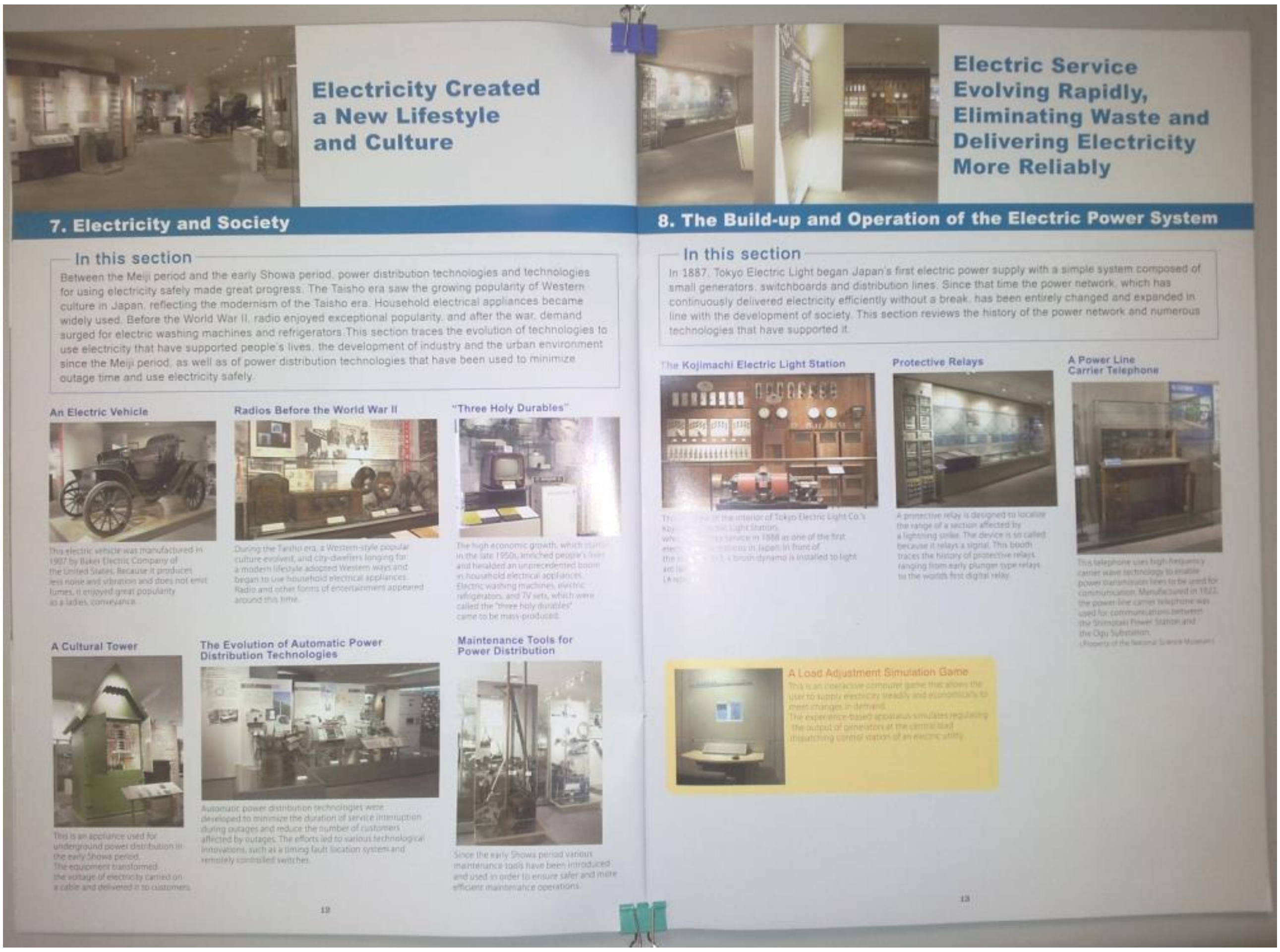
Director, Electric Power Histrical Museum


A Guide to the Floors of the Electric Power Historical Museum
The Electric Power Historical Museum has an exhibition floor space of approximately 4,000 square meters.
The museum exhibits approximately 700 objects that tell the 120-year history of the Japanese electric power industry.
Exhibition Booths on the Second Floor
Exhibition Booths on the First Floor
Museum Hall
Information
Elevator
Entrance
Museum Cafe
Coffee, tea and light meals are available.
〈TABLE OF CONTENTS〉
Message from Director •••3
A Guide to the Floors of the Electric Power Historical Museum •••4
Entrance, Orientation Hall, and Science of Electricity •••6
A Prologue to Japanese Electric History •••7
Birth and Expansion of the Power Grid with Thermal Power Generation •••8
The Development of Hydroelectric Power Generation and Long-distance Power Transmission •••9
The Creation of a Wide-area Power Grid •••10
Electricity and Society •••12
The Build-up and Operation of the Electric Power System •••13
Large-capacity and High-efficiency Power Stations •••14
The Promotion of Power Source Diversification and a Best Generating Mix •••15
Development of Nuclear Power Generation •••16
Electricity—The Product of Humankind's Wisdom and Effort •••17
A Guide to the Facilities •••18
FOR VISITORS •••19


Electricity would not have been born without the discovery of static electricity.
Entrance
Approach
An Ornamental Lamp from the Stone Bridge at the Front Gate of the Imperial Palace
1. Orientation Hall
The 120-year History of Electricity and Society
2. Science of Electricity
Gallery of Electric Power History
Laboratory of Electricity
Even during the Edo period, some Japanese scientists already knew what electricity is.
3. A Prologue to Japanese Electric History (From the Edo period to the mid-Meiji period)
Historical Background
Although the concept of electricity reached Japan for the first time in the mid Edo period, it was more than 100 years later that Japanese people saw electric lights. In 1878, electric lights came on for the first time in Japan, and in 1882 electric lights were turned on in Tokyo's Ginza. The blinding light of arc lamps represented the brilliance of Japan's westernization, bringing people prosperity and hope. Still, arc lamps were not sufficiently attractive to replace the gas lamps that prevailed in those days.
A Thomson's Closed Arc Lamp
Historical Archive Videos
Japan's first literature on electricity


The Day When Electricity Was Delivered to Japanese Households for the First Time
4. Birth and Expansion of the Power Grid with Thermal Power Generation (From the mid-Meiji period)
Historical Background
The Japanese electric power industry in its infancy started out with a combination of small steam engines and generators. In 1882, Thomas Alva Edison commenced a power supply in New York and London for the first time in the world. Only five years later in 1887, the supply of electric power was begun in Japan. Later on, as the convenience of electric lighting and the usefulness of electric power were recognized, demand for electricity increased and, to meet it, the electric power supply network was expanded. The expansion of the power grid was supported by the development of a power generation system with a steam turbine capable of generating large amounts of electricity efficiently and an alternating-current power transmission system. An alternating-current system had the potential to transmit power over long distances, paving the way for the age of hydroelectric power generation.
The Edison Direct Current Generator
The Delaplaine Collection
The Three-phase AC Generator Manufactured by Ishikawajima Mfg. Co.
The Dynamo Manufactured by the College of Engineering
The Parsons Turbine Generator
A Controversy over Current Systems
Delivering Electricity Farther
The Power of Water to Produce Robust Electric Energy
5. The Development of Hydroelectric Power Generation and Long-distance Power Transmission (From the late Meiji period)
Historical Background
It was around 1878 that water turbines were first used to produce electricity. In the early days, small hydraulic turbines were used to supply electricity only to nearby locations, but in subsequent years, larger power stations were constructed and alternating-current long-distance power transmission technology progressed, making it possible to distribute electricity from remote power stations. Distant hydroelectric power sources were developed rapidly, and thus the range of power supply, which had been localized, extended substantially. In 1912, the output of hydroelectric power plants exceeded that of thermal power stations, and in the same year, electric lights came on in almost all households in the city of Tokyo.
The Turbine Generator Used at the Shinanogawa Power Station
The Water Turbine Generator and the Switchboard installed at Kanaya Hotel
The Power Transmission Log Kept at the Komahashi Hydroelectric Power Station
The Turbine Generator Used at the Nikko Daiichi Power Station


The Expanding Power Grid Delivering Electricity Throughout the Country
6. The Creation of a Wide-area Power Grid (the Taisho period)
Historical Background
In order to meet the growth in electricity demand associated with Japan's economic development, large hydroelectric power stations were constructed in mountainous parts of the country, connected by long-distance power transmission to urban districts where the power was consumed. Thus a radially spreading wide-area power grid was created. The large-scale electricity-carrying network was supported by power transmission technologies as well as transformation technologies such as transformers and circuit breakers. This period, which began with economic reconstruction in the aftermath of the Great Kanto Earthquake, witnessed keen competition among numerous electric power companies and the nationalization of the Japanese electric power industry during World War II.
The Transmission Tower Used in the Tonosawa Power Transmission Line
The Steel Tower in the Kinugawa Power Transmission Line
A Special-high-voltage Transformer
A Synchronous Rotating Condenser Used at the Asahi Substation
Utility Manhole Covers
A Replica of a Brick Manhole
War and Electricity
The Great Kanto Earthquake and Electricity
Reorganization of the Japanese Electric Power Industry



Electricity Created a New Lifestyle and Culture

7. Electricity and Society

In this section

Between the Meiji period and the early Showa period, power distribution technologies and technologies for using electricity safely made great progress. The Taisho era saw the growing popularity of Western culture in Japan, reflecting the modernism of the Taisho era. Household electrical appliances became widely used. Before the World War II, radio enjoyed exceptional popularity, and after the war, demand surged for electric washing machines and refrigerators.This section traces the evolution of technologies to use electricity that have supported people's lives, the development of industry and the urban environment since the Meiji period, as well as of power distribution technologies that have been used to minimize outage time and use electricity safely.

An Electric Vehicle

This electric vehicle was manufactured in 1907 by Baker Electric Company of the United States. Because it produces less noise and vibration and does not emit fumes, it enjoyed great popularity as a ladies conveyance.

Radios Before the World War II

During the Taisho era, a Western-style popular culture evolved, and city-dwellers longing for a modern lifestyle adopted Western ways and began to use household electrical appliances. Radio and other forms of entertainment appeared around this time.

"Three Holy Durables"

The high economic growth, which started in the late 1950s, enriched people's lives and heralded an unprecedented boom in household electrical appliances. Electric washing machines, electric refrigerators, and TV sets, which were called the "three holy durables" came to be mass-produced.

A Cultural Tower

This is an appliance used for underground power distribution in the early Showa period. The equipment transformed the voltage of electricity carried on a cable and delivered it to customers.

The Evolution of Automatic Power Distribution Technologies

Automatic power distribution technologies were developed to minimize the duration of service interruption during outages and reduce the number of customers affected by outages. The efforts led to various technological innovations, such as a timing fault location system and remotely controlled switches.

Maintenance Tools for Power Distribution

Since the early Showa period various maintenance tools have been introduced and used in order to ensure safer and more efficient maintenance operations.

12

Electric Service Evolving Rapidly, Eliminating Waste and Delivering Electricity More Reliably

8. The Build-up and Operation of the Electric Power System

In this section

In 1887, Tokyo Electric Light began Japan's first electric power supply with a simple system composed of small generators, switchboards and distribution lines. Since that time the power network, which has continuously delivered electricity efficiently without a break, has been entirely changed and expanded in line with the development of society. This section reviews the history of the power network and numerous technologies that have supported it.

The Kojimachi Electric Light Station

Protective Relays

A protective relay is designed to localize the range of a section affected by a lightning strike. The device is so called because it relays a signal. This booth traces the history of protective relays ranging from early plunger type relays to the world's first digital relay.

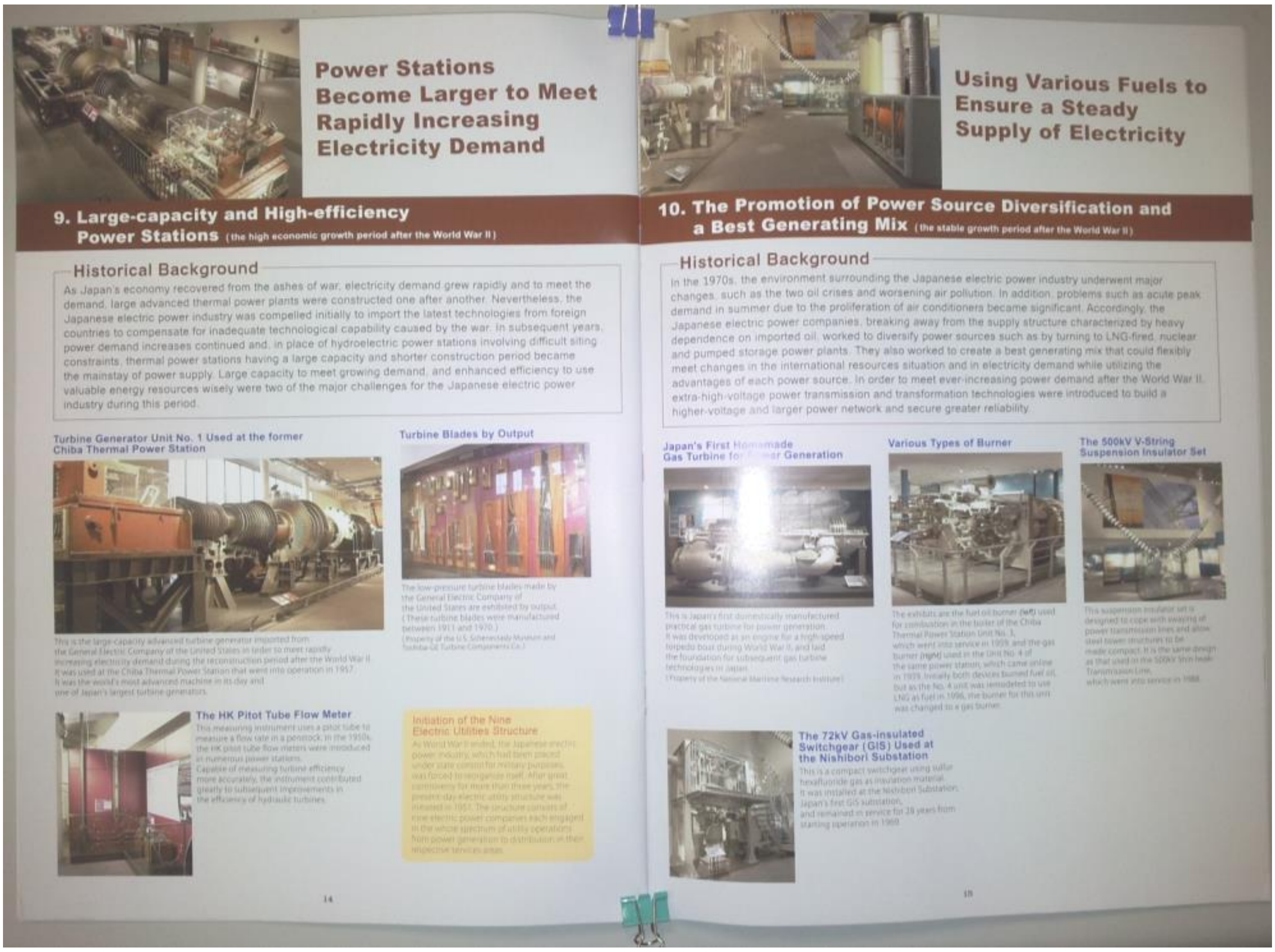
A Power Line Carrier Telephone

This telephone uses high frequency carrier wave technology to enable power transmission lines to be used for communication. Manufactured in 1922, the power line carrier telephone was used for communications between the Shimotaki Power Station and the Ogu Substation.
(Property of the National Science Museum)

A Load Adjustment Simulation Game

This is an interactive computer game that allows the user to supply electricity steadily and economically to meet changes in demand.
The experience-based apparatus simulates regulating the output of generators at the central load dispatching control station of an electric utility.

13



Power Stations Become Larger to Meet Rapidly Increasing Electricity Demand

9. Large-capacity and High-efficiency Power Stations (the high economic growth period after the World War II)

Historical Background

As Japan's economy recovered from the ashes of war, electricity demand grew rapidly and to meet the demand, large advanced thermal power plants were constructed one after another. Nevertheless, the Japanese electric power industry was compelled initially to import the latest technologies from foreign countries to compensate for inadequate technological capability caused by the war. In subsequent years, power demand increases continued and, in place of hydroelectric power stations involving difficult siting constraints, thermal power stations having a large capacity and shorter construction period became the mainstay of power supply. Large capacity to meet growing demand, and enhanced efficiency to use valuable energy resources wisely were two of the major challenges for the Japanese electric power industry during this period.

Turbine Generator Unit No. 1 Used at the former Chiba Thermal Power Station

This is the large-capacity advanced turbine generator imported from the General Electric Company of the United States in order to meet rapidly increasing electricity demand during the reconstruction period after the World War II. It was used at the Chiba Thermal Power Station that went into operation in 1957. It was the world's most advanced machine in its day and one of Japan's largest turbine generators.

Turbine Blades by Output

The low-pressure turbine blades made by the General Electric Company of the United States are exhibited by output. (These turbine blades were manufactured between 1911 and 1970.)
(Property of the U.S. Schenectady Museum and Toshiba GE Turbine Components Co.)

The HK Pitot Tube Flow Meter

This measuring instrument uses a pitot tube to measure a flow rate in a penstock. In the 1950s, the HK pitot tube flow meters were introduced in numerous power stations. Capable of measuring turbine efficiency more accurately, the instrument contributed greatly to subsequent improvements in the efficiency of hydraulic turbines.

Initiation of the Nine Electric Utilities Structure

As World War II ended, the Japanese electric power industry, which had been placed under state control for military purposes, was forced to reorganize itself. After great controversy for more than three years, the present-day electric utility structure was initiated in 1951. The structure consists of nine electric power companies each engaged in the whole spectrum of utility operations from power generation to distribution in their respective services areas.

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Using Various Fuels to Ensure a Steady Supply of Electricity

10. The Promotion of Power Source Diversification and a Best Generating Mix (the stable growth period after the World War II)

Historical Background

In the 1970s, the environment surrounding the Japanese electric power industry underwent major changes, such as the two oil crises and worsening air pollution. In addition, problems such as acute peak demand in summer due to the proliferation of air conditioners became significant. Accordingly, the Japanese electric power companies, breaking away from the supply structure characterized by heavy dependence on imported oil, worked to diversify power sources such as by turning to LNG-fired, nuclear and pumped storage power plants. They also worked to create a best generating mix that could flexibly meet changes in the international resources situation and in electricity demand while utilizing the advantages of each power source. In order to meet ever-increasing power demand after the World War II, extra-high-voltage power transmission and transformation technologies were introduced to build a higher-voltage and larger power network and secure greater reliability.

Japan's First Homemade Gas Turbine for Power Generation

This is Japan's first domestically manufactured practical gas turbine for power generation. It was developed as an engine for a high-speed torpedo boat during World War II, and laid the foundation for subsequent gas turbine technologies in Japan.
(Property of the National Maritime Research Institute)

Various Types of Burner

The exhibits are the fuel oil burner (left) used for combustion in the boiler of the Chiba Thermal Power Station Unit No. 3, which went into service in 1959, and the gas burner (right) used in the Unit No. 4 of the same power station, which came online in 1959. Initially both devices burned fuel oil, but as the No. 4 unit was remodeled to use LNG as fuel in 1996, the burner for this unit was changed to a gas burner.

The 500kV V-String Suspension Insulator Set

This suspension insulator set is designed to cope with swaying of power transmission lines and allow steel tower structures to be made compact. It is the same design as that used in the 500kV Shin ... Transmission Line, which went into service in 1988.

The 72kV Gas-insulated Switchgear (GIS) Used at the Nishibori Substation

This is a compact switchgear using sulfur hexafluoride gas as insulation material. It was installed at the Nishibori Substation, Japan's first GIS substation, and remained in service for 28 years from starting operation in 1969.

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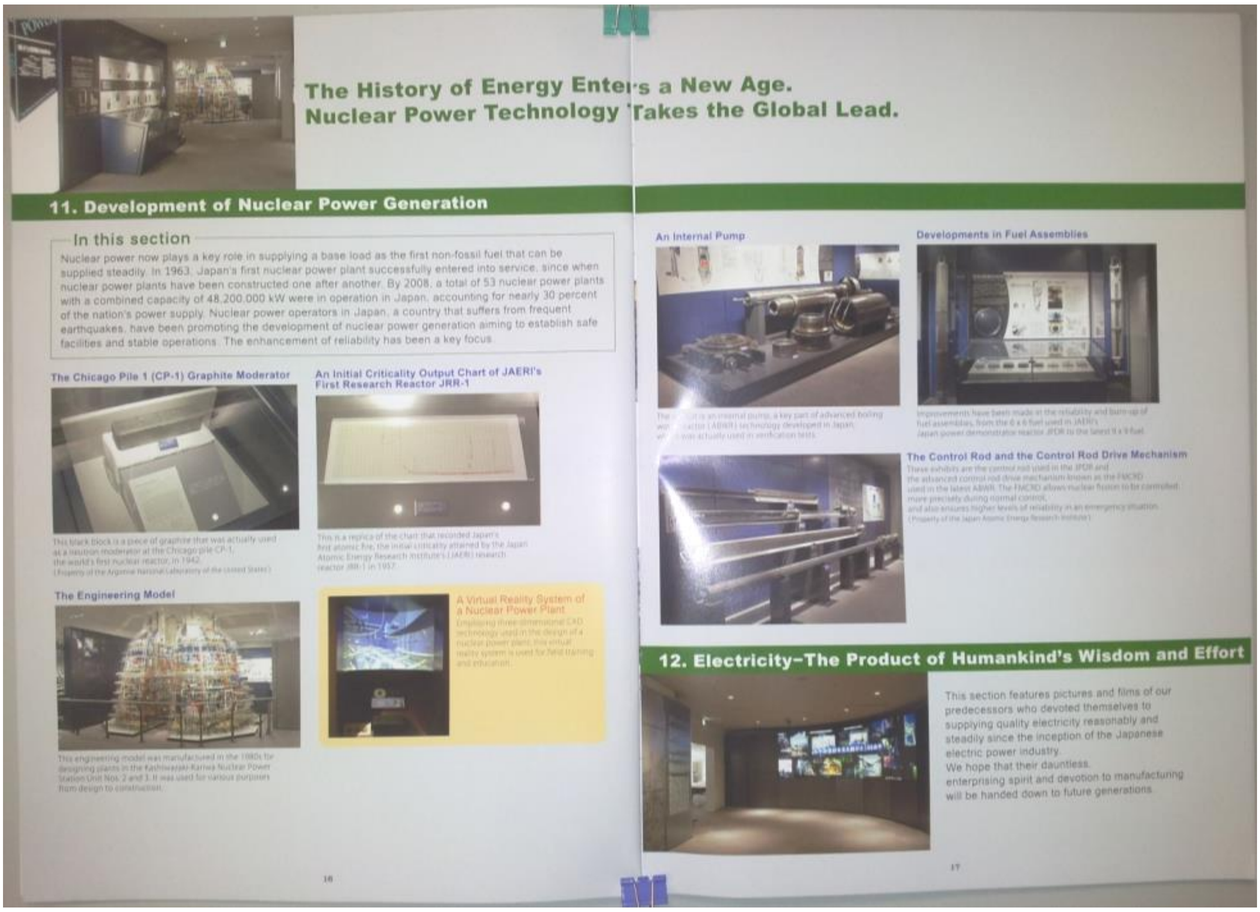


The History of Energy Enters a New Age. Nuclear Power Technology Takes the Global Lead.

11. Development of Nuclear Power Generation

In this section

Nuclear power now plays a key role in supplying a base load as the first non-fossil fuel that can be supplied steadily. In 1963, Japan's first nuclear power plant successfully entered into service, since when nuclear power plants have been constructed one after another. By 2008, a total of 53 nuclear power plants with a combined capacity of 48,200,000 kW were in operation in Japan, accounting for nearly 30 percent of the nation's power supply. Nuclear power operators in Japan, a country that suffers from frequent earthquakes, have been promoting the development of nuclear power generation aiming to establish safe facilities and stable operations. The enhancement of reliability has been a key focus.

The Chicago Pile 1 (CP-1) Graphite Moderator

An Initial Criticality Output Chart of JAERI's First Research Reactor JRR-1

The Engineering Model

A Virtual Reality System of a Nuclear Power Plant

An Internal Pump

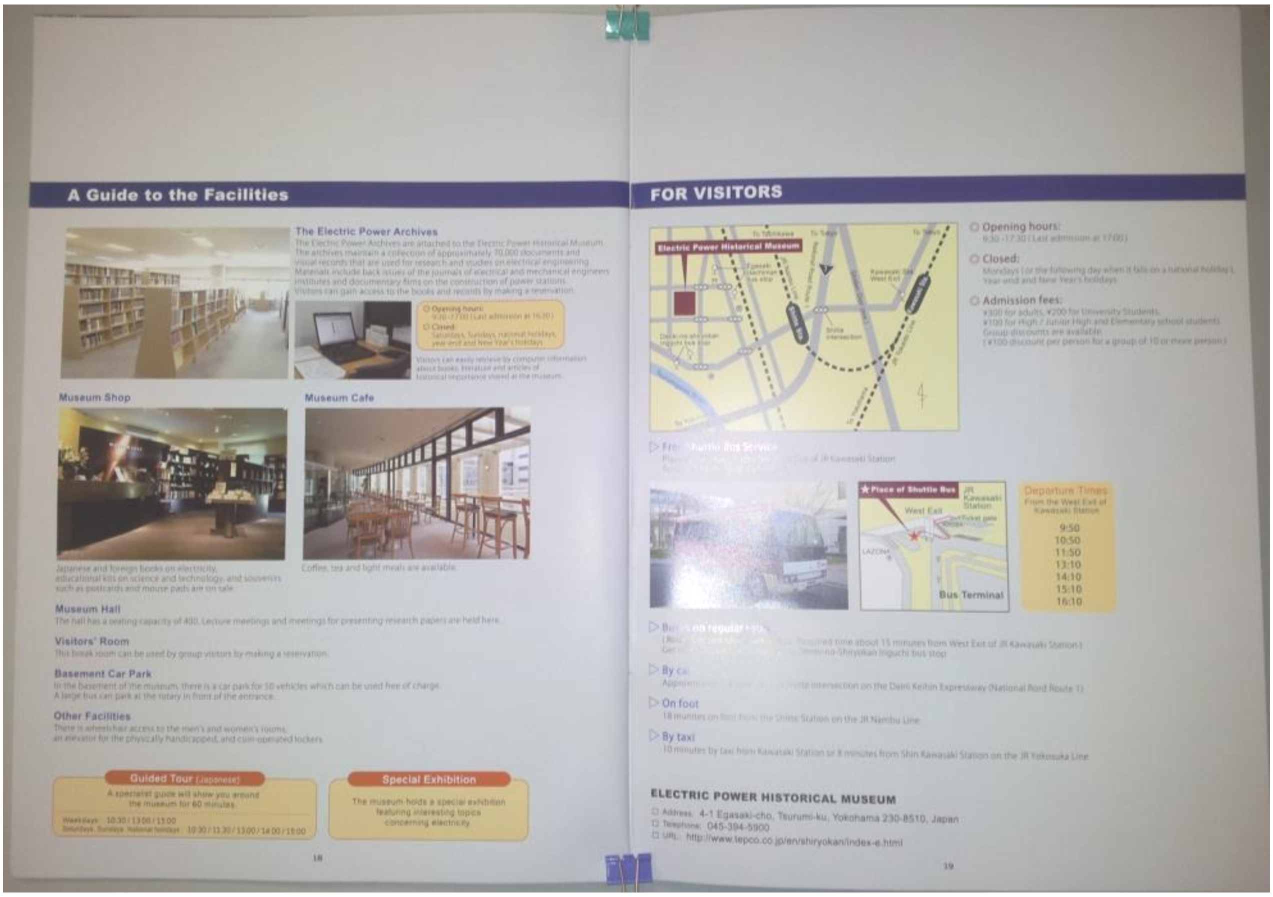
Developments in Fuel Assemblies

The Control Rod and the Control Rod Drive Mechanism

12. Electricity–The Product of Humankind's Wisdom and Effort

This section features pictures and films of our predecessors who devoted themselves to supplying quality electricity reasonably and steadily since the inception of the Japanese electric power industry.
We hope that their dauntless enterprising spirit and devotion to manufacturing will be handed down to future generations.

16 17



A Guide to the Facilities

The Electric Power Archives

Museum Shop

Museum Cafe

Museum Hall

Visitors' Room

Basement Car Park

Other Facilities

Guided Tour (Japanese)

Special Exhibition

The museum holds a special exhibition featuring interesting topics concerning electricity.

FOR VISITORS

Opening hours:
Closed:
Admission fees:

Free Shuttle Bus Service

Departure Times
From the West Exit of Kawasaki Station
9:50
10:50
11:50
13:10
14:10
15:10
16:10

By car

On foot

By taxi

ELECTRIC POWER HISTORICAL MUSEUM

Address: 4-1 Egasaki-cho, Tsurumi-ku, Yokohama 230-8510, Japan
Telephone: 045-394-5900
URL: http://www.tepco.co.jp/en/shiryokan/index-e.html

18 19

JFE East Japan Works, JFE Steel

Main History of Keihin District

1912 NKK Corporation is established.
1914 Tapping is conducted at No.1 open-hearth furnace.
The company starts manufacturing seamless steel pipes.
1940 The company merges with Tsurumi Ironmaking and Shipbuilding Corporation
1958 Two new LD converters are established at the Kawasaki Steel Mill
1959 New blooming, hot rolling and cold rolling equipment is established at the Mizue Steel Mill
1968 The Keihin Steel Mill is launched.
(Three steel mills at Kawasaki, Tsurumi and Mizue are integrated.)
1971 The construction of Ohgishima starts.
1976 No.1 blast furnace is initially fired.
1979 No.2 blast furnace is initially fired.
1988 Corporate names are integrated into "NKK" on the occasion of the anniversary of the founding.
1989 High-tech sheet manufacturing equipment starts operations.
1990 The single blast furnace system is established.
1993 The manufacturing line of 6.5%silicon steel sheet starts operations.
1996 The company starts the integrated recycling system to use waste plastic as blast furnace feed.
1999 Surface treatment operations are spun off into a separate company.
1999 Welded pipe operations are spun off into a separate company.
2000 Seamless steel pipe operations are made into an amalgamated company.

Main History of Chiba District

1950 Kawasaki Steel Corporation is established.
1951 The Chiba Steel Mill is launched.
1953 No.1 blast furnace is initially fired.
1958 No.2 blast furnace is initially fired, and No.1 cold rolling plant starts operations.
(An integrated system to make pig iron and steel is established.)
1962 No.1 converter starts operations.
1965 No.5 blast furnace is initially fired.
1969 Landfill starts at the west plant.
1977 No.3 steelmaking plant starts operations.
(Q-BOP)
No.6 blast furnace is initially fired.
1991 Renovation construction starts in the Chiba district
1994 No.4 steelmaking plant starts operations.
1995 No.3 hot rolling plant starts operations.
1996 No.3 hot rolling plant starts the world's first endless rolling process.
1998 No.6 blast furnace achieves the world's longest operating life (at that time) and undergoes very short-term repair work.
2000 The Kawasaki Steel thermoselect waste gasification and melting furnace starts industrial waste treatment operations.
2002 Kawatetsu Chiba Clean Power Station starts operations.

2003
The East Japan Works of JFE Steel Corporation is launched.

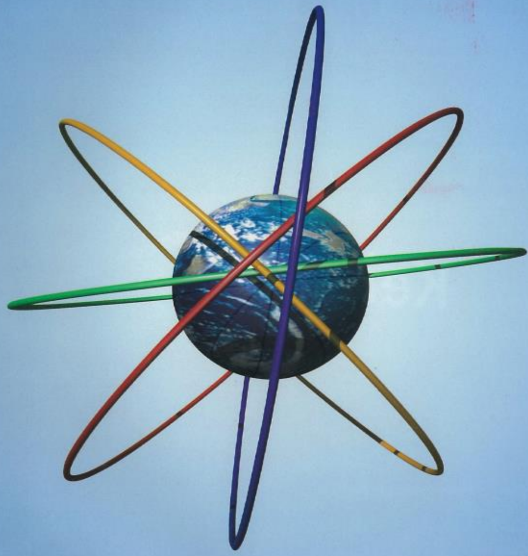
JFE

East Japan Works, JFE Steel

[Keihin District] 1-1, Ohgishima, Kawasaki-ku, Kawasaki-shi, Kanagawa, 210-0868 TEL. (81)-44-322-1119
[Chiba District] 1, Kawasaki-cho, Chuo-ku, Chiba-shi, Chiba, 260-0835 TEL. (81)-43-262-2024

JFE Steel

JFE Steel Corporation



JFE

East Japan Works (Keihin), JFE Steel

Two Places for "Steelmaking" Meet by Connecting both Sides of Tokyo Bay with a Straight Line

East Japan Works, JFE Steel

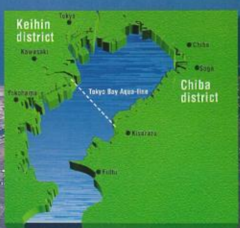
Two major waterfront industrial areas, Keiyo and Keihin, continue to make progress in the 21st century.
The East Japan Works of JFE Steel has "steelmaking" bases on the east and west sides of Tokyo Bay.

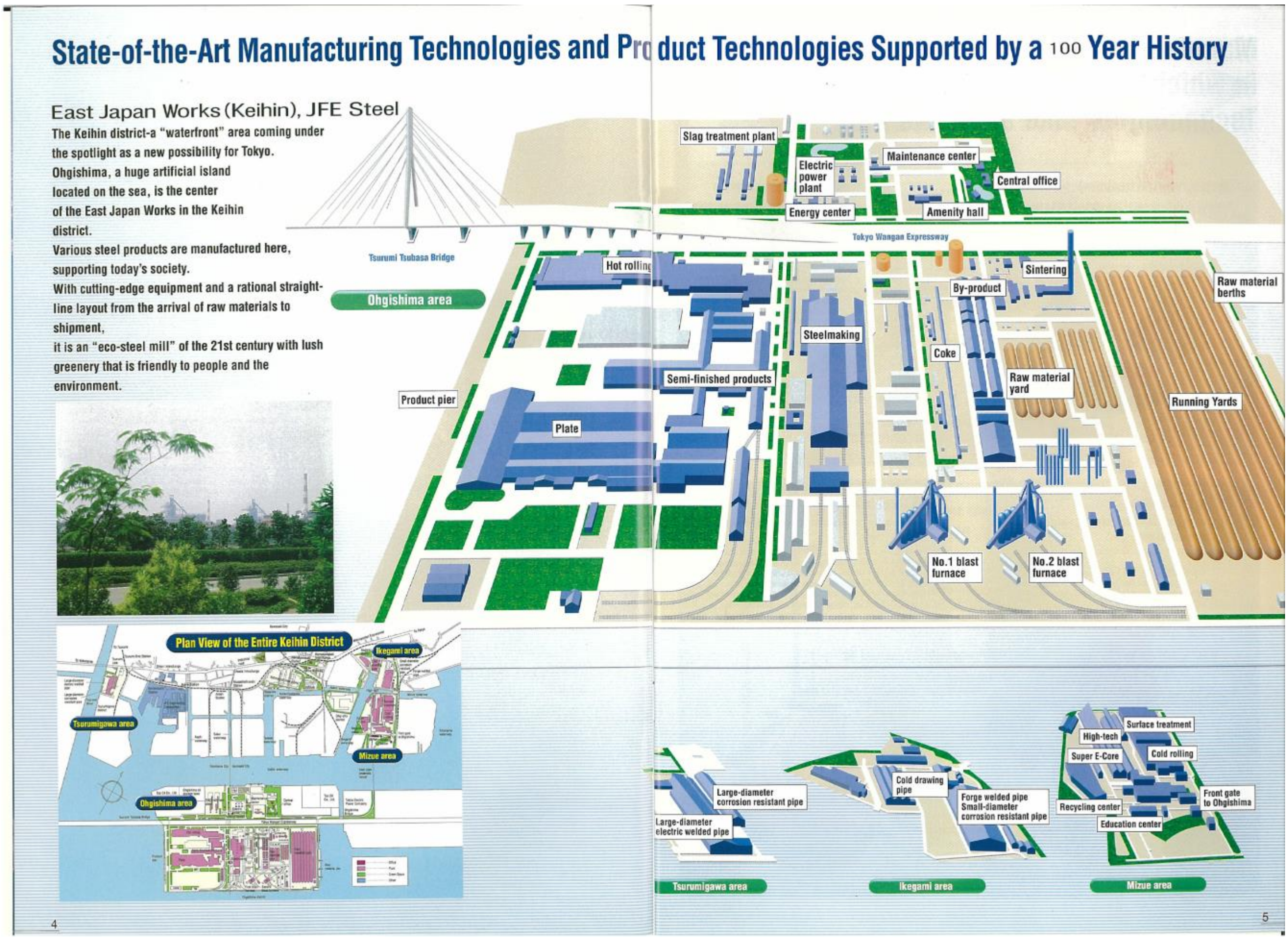
With cutting-edge equipment and state-of-the-art technologies, an urban steel mill abounding in smiling workers and lush greenery

Here is a base for the transmission of new "steel" culture, which always meets the needs of society and the confidence of consumers through creation of the world's highest-quality steel products.
That is the East Japan Works, JFE Steel.

Chiba

Keihin



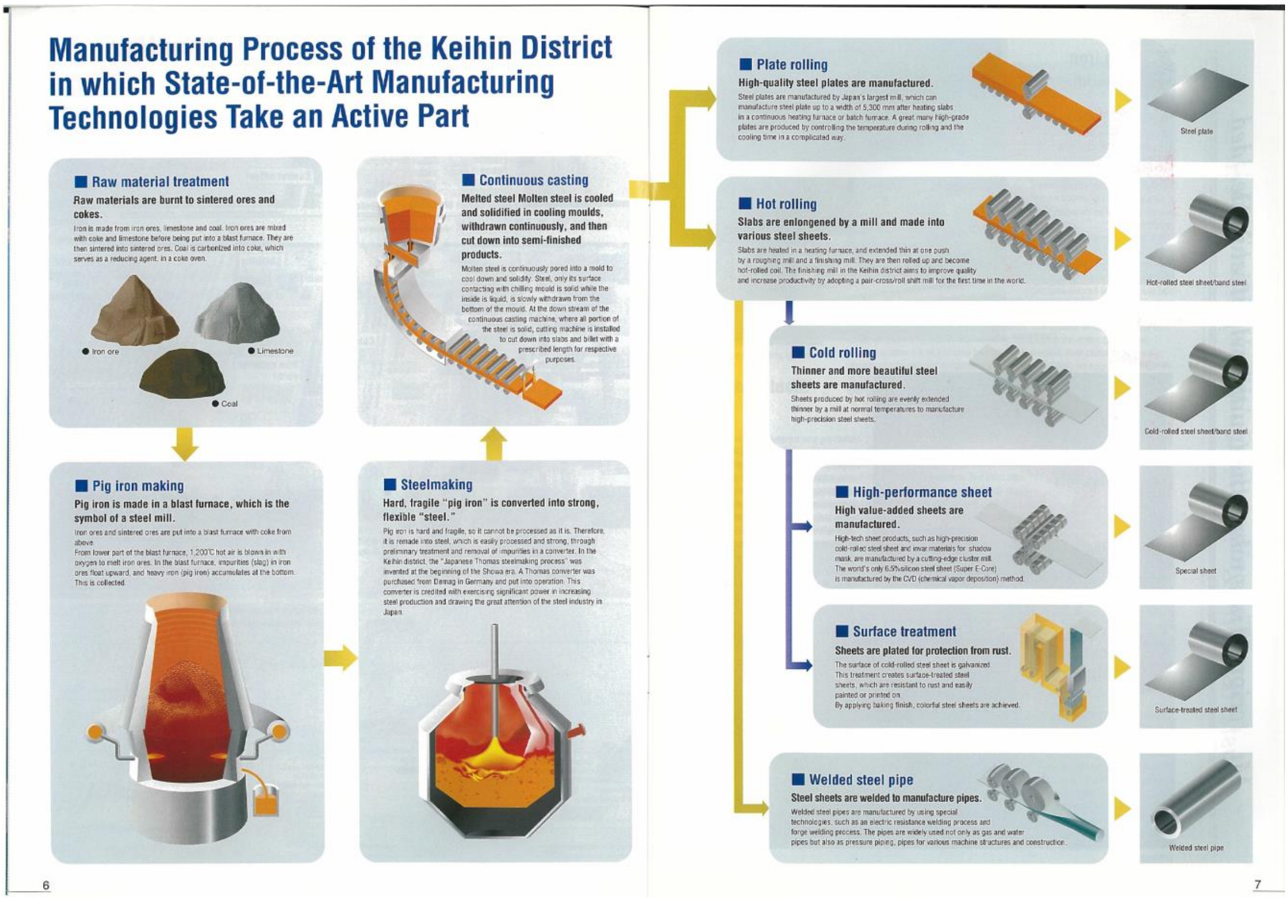


State-of-the-Art Manufacturing Technologies and Product Technologies Supported by a 100 Year History

East Japan Works (Keihin), JFE Steel

The Keihin district-a "waterfront" area coming under the spotlight as a new possibility for Tokyo.
Ohgishima, a huge artificial island located on the sea, is the center of the East Japan Works in the Keihin district.
Various steel products are manufactured here, supporting today's society.
With cutting-edge equipment and a rational straight-line layout from the arrival of raw materials to shipment,
it is an "eco-steel mill" of the 21st century with lush greenery that is friendly to people and the environment.

4 5



Manufacturing Process of the Keihin District in which State-of-the-Art Manufacturing Technologies Take an Active Part

Raw material treatment

Raw materials are burnt to sintered ores and cokes.

Iron is made from iron ores, limestone and coal. Iron ores are mixed with coke and limestone before being put into a blast furnace. They are then sintered into sintered ores. Coal is carbonized into coke, which serves as a reducing agent, in a coke oven.

Pig iron making

Pig iron is made in a blast furnace, which is the symbol of a steel mill.

Iron ores and sintered ores are put into a blast furnace with coke from above.
From lower part of the blast furnace, 1,200℃ hot air is blown in with oxygen to melt iron ores. In the blast furnace, impurities (slag) in iron ores float upward, and heavy iron (pig iron) accumulates at the bottom. This is collected.

Steelmaking

Hard, fragile "pig iron" is converted into strong, flexible "steel."

Pig iron is hard and fragile, so it cannot be processed as it is. Therefore, it is remade into steel, which is easily processed and strong, through preliminary treatment and removal of impurities in a converter. In the Keihin district, the "Japanese Thomas steelmaking process" was invented at the beginning of the Showa era. A Thomas converter was purchased from Demag in Germany and put into operation. This converter is credited with exercising significant power in increasing steel production and drawing the great attention of the steel industry in Japan.

Continuous casting

Melted steel Molten steel is cooled and solidified in cooling moulds, withdrawn continuously, and then cut down into semi-finished products.

Molten steel is continuously pored into a mold to cool down and solidify. Steel, only its surface contacting with chilling mould is solid while the inside is liquid, is slowly withdrawn from the bottom of the mould. At the down stream of the continuous casting machine, where all portion of the steel is solid, cutting machine is installed to cut down into slabs and billet with a prescribed length for respective purposes.

Plate rolling

High-quality steel plates are manufactured.

Steel plates are manufactured by Japan's largest mill, which can manufacture steel plate up to a width of 5,300 mm after heating slabs in a continuous heating furnace or batch furnace. A great many high-grade plates are produced by controlling the temperature during rolling and the cooling time in a complicated way.

Steel plate

Hot rolling

Slabs are enlongened by a mill and made into various steel sheets.

Slabs are heated in a heating furnace, and extended thin at one push by a roughing mill and a finishing mill. They are then rolled up and become hot-rolled coil. The finishing mill in the Keihin district aims to improve quality and increase productivity by adopting a pair-cross/roll shift mill for the first time in the world.

Hot-rolled steel sheet/band steel

Cold rolling

Thinner and more beautiful steel sheets are manufactured.

Sheets produced by hot rolling are evenly extended thinner by a mill at normal temperatures to manufacture high-precision steel sheets.

Cold-rolled steel sheet/band steel

High-performance sheet

High value-added sheets are manufactured.

High-tech sheet products, such as high-precision cold-rolled steel sheet and invar materials for shadow mask, are manufactured by a cutting-edge cluster mill.
The world's only 6.5%silicon steel sheet (Super E-Core) is manufactured by the CVD (chemical vapor deposition) method.

Special sheet

Surface treatment

Sheets are plated for protection from rust.

The surface of cold-rolled steel sheet is galvanized.
This treatment creates surface-treated steel sheets, which are resistant to rust and easily painted or printed on.
By applying baking finish, colorful steel sheets are achieved.

Surface-treated steel sheet

Welded steel pipe

Steel sheets are welded to manufacture pipes.

Welded steel pipes are manufactured by using special technologies, such as an electric resistance welding process and forge welding process. The pipes are widely used not only as gas and water pipes but also as pressure piping, pipes for various machine structures and construction.

Welded steel pipe

6 7

Mysterious Time when the Quality of Steel is Decided

Pig iron making

The mission of a blast furnace is to continue supplying stable-quality pig iron. The latest computer technology is introduced to permanently conduct stable operations. Pig iron is produced in a cutting-edge blast furnace where excellent control technologies are concentrated.
The Keihin district aims to recycle waste plastic, and the world's first integrated system to sort out, crush and graduate waste plastic and use it as blast furnace feed can be found there.


Blast furnace

Converter


Steel making

Molten pig iron transferred from blast furnace is charged into a converter, and is refined by pure oxygen blowing for the control of the carbon content and removal of impurities. This process converts pig iron into steel with controlled composition for respective purposes, and supply molten steel to continuous casting machine. The Keihin district adopts and innovative "zero slag steelmaking process," which realizes significant rationalization and quality improvement by differentiating the process of removing impurities and nulling the amount of slag generated in dephosphorization in the converter.

Continuous casting

Molten steel of which ingredients were adjusted to fit specific purposes is transferred to a continuous-casting machine. It is infused from a container called tundish into a mold, continuously drawn out while being hardened, cut into a prescribed length, made into semi-finished products such as slabs and billets, and transferred to each rolling process.


Continuous-casting machine

Unlimited Variations according to Usages

Plate rolling


Super online accelerated cooling system (*Super*-OLAC)

Plate mill


Keihin plate mill can make wide range types of products with world leading technologies and extensive experience. It is designed with reasonable layout for automatically computer-controlled operation. It is capable of manufacturing one of the largest size plates in the world. By introducing the online accelerated cooling system (OLAC) to cool and quench hot-rolled steel plates online, we increased strength and toughness significantly. In 2004, we upgraded the system to the *Super*-OLAC to achieve more precise control over the cooling temperature, and succeeded in manufacturing plates of much higher quality.

Hot rolling

The hot rolling plant in the Keihin district is a cutting-edge plant that can manufacture the nation's widest hot-rolled steel sheets. This plant manufactures steel sheets that are used for automobiles, materials for line pipes, and all other kinds of purposes. The plant also became able to manufacture high-strength, highly processable steel sheets, which could not be manufactured by conventional technologies, by using unique cooling control technologies, including the world's first pair-cross/roll shift mill. Therefore, the plant is highly valued by automobile manufacturers.


Hot strip mill

Manufacturing Higher Value-Added Products by Concentrating Excellent Technologies

Cold rolling

Cold-rolled steel sheets are manufactured by washing hot-rolled steel sheets with acid and removing oxide on the surface, and then extending them thinner in a mill at normal temperatures. "Cold" means applying no special heat.


Cold strip mill


High-tech cluster mill

High-performance steel sheets

This is the production line of high-performance sheets in the Keihin district. In the line, a cutting-edge 12-tiered cluster mill and annealing furnaces are highly controlled by computers. Among various high-performance products produced there, demand for invar materials for shadow masks has been rapidly increasing in recent years due to the dissemination of large-sized televisions and personal computer displays.

The world's only CVD (chemical vapor deposition) line is also in full-fledged operation at present. The production line is proceeding with manufacturing 6.5%silicon steel sheets (Super E-Core) through its own development.


Super E-Core manufacturing equipment

First-Class Products Produced by Making Full Use of Cutting-Edge Equipment and Technologies

Surface treatment

Cold-rolled steel sheets are used as materials, and the surface of the sheets is galvanized. Surface-treated steel sheets with excellent corrosion resistance are achieved through this treatment. Surface-treated steel sheets are used in various fields, such as automobiles, civil engineering and construction as well as home electric appliances. In addition, colored steel sheets, to which a baking finish is applied, are not only excellently designed and functional but also increasingly important from the standpoint of the rationalization of processing and environment resistance.


Line of coloring


Line of continuous galvanizing

Welded steel pipe

Various high-performance steel pipes manufactured at the welded pipe plant in the Keihin district have been widely used for diversified purposes, such as for establishing social infrastructure and for high-performance automobiles. In order to meet the new needs of the next generation, the plant developed various high-performance line pipes, steel pipes for civil engineering and construction and steel pipes that fit the hydroforming process. The Keihin district will continue to meet various needs for pipes in the future.


Electric welded pipe manufacturing machine


Molding and forge welding machine

Toward Environment-Friendly Steel Mill

Steel Mill-Based Recycling!

There are various recycling facilities using state-of-the-art technologies in the Keihin district. Within "JFE-a group of companies advanced in recycling," the East Japan Works (Keihin district) is taking a central role. Taking advantage of being a steel mill located in the metropolitan area, the East Japan Works will contribute to the local community as the "urban infrastructure of the 21st century" under the keywords "environment" and "recycling."

World's First Integrated Recycling System

System to Use Waste Plastic as Blast Furnace Feed

In October 1996, the blowing of industrial waste plastic into a blast furnace was begun in the Ohgishima area in the Keihin district. Previously, there was no integrated recycling system in the world that was equipped with the facility to make plastic into feed by crushing and granulating it. Plastic works as a reducer within a furnace in substitution for coke. The exhaust gas is recycled as energy for use within the steel mill. In addition, the system contributes to restraining carbon dioxide emission in the manufacturing process. In April 2000, the East Japan Works started operations to use municipal waste plastic as blast furnace feed along with the complete enforcement of the Containers and Packaging Recycling Law.

Plant equipped with facility to use plastic as blast furnace feed (Ohgishima area)

Plant equipped with facility to use plastic as blast furnace feed (Mizue area)

Integrated Treatment from Decomposition to Recycling

Recycling System for Used Home Electric Appliances

The Electric Home Appliance Recycling Law started the full-fledged recycling of electric home appliances, starting with refrigerators, washing machines, televisions and air conditioners. The JFE invests in an electric home appliance recycling business located in the steel mill, as well as recycling, in its own steelmaking process, iron, nonferrous metal and other metals, which were well decomposed, and almost all plastic. The JFE is willing to offer help in the field of recycling used electric home appliances, in order to become a steel mill which serves as an infrastructure required in the community.

Used electric home appliance recycling plant

Realization of Complete Pet Bottle Recycling

Kawasaki Pet Bottle Recycling Plant

In April 2002, a pet bottle recycling plant based on the Containers and Packaging Recycling Law was completed in the Mizue area of the Keihin district, and started operations. This is an operation to recycle pet bottles into polyethylene terephthalate resin flakes. Recycled flakes are sold to textile manufacturers and sheet manufacturers, and are recycled into clothing, egg containers, repacking bottles, hangers and other various products. The plant is also characterized in that it can realize zero emission since labels and caps can be used as raw materials for steelmaking.

Pet bottle recycling plant

Manufacturing Environment-Friendly Products by Reusing Recycled Plastic

Manufacturing Plant of Boards for Concrete Formwork (NF Board)

At present, 100 million sheets of wooden plywood are used for concrete formwork every year. However, reduction in the use of lumber from southeast Asia has been requested from the standpoint of reducing carbon dioxide and protecting rainforests. Our company developed "board for concrete formwork (NF board)," which is made by using waste plastic, as an alternative to wooden plywood. A plant was constructed in the Mizue area of the Keihin district and started its operations in September 2002. Used boards are collected and recycled as materials for steelmaking. NF board is a new type of environment-friendly recycled product.

NF board manufacturing plant

Excellent Steel Products of the Keihin District Made Using State-of-the-Art Technologies and Cutting-Edge Equipment

JFE Steel meets consumers' globalization and requests for high-quality products by making full use of its own world-class technical capabilities and cost competitiveness. JFE Steel has many technologies and products of the world's highest level, which cut out unexplored areas and are significantly valued by all consumers. Here we will introduce some of the products that the East Japan Works (Keihin district) is providing to the world using state-of-the-art technologies and cutting-edge equipment.

6.5%Silicon Steel Sheet (Super E-Core)

This is the world's only 6.5%silicon steel sheet, manufactured only in the Keihin district. Because of its low iron loss in the high frequency region, the sheet is greatly effective in downsizing electric equipment and increasing the efficiency thereof. In addition, the sheet emits almost no magnetostriction, which causes noise and vibration, and has excellent magnetic property. JFE Steel made it possible to manufacture 6.5%silicon steel sheet, which was impossible in the past, by using the CVD (chemical vapor deposition) method. The use of the sheets has been expanding in various high-tech fields such as small spindle motors for hard disk drives of personal computers and distributed power sources.

Example of using 6.5%silicon steel sheet

NANO HITEN

NANO HITEN is a new HITEN (high-strength steel sheet), which was developed by JFE Steel, using nanotechnology for the first time in the world. In the world of steel sheets for automobiles, high-strength is the most important issue. However, the balance between high-strength and formability was an extremely difficult issue. In order to solve this problem, JFE Steel developed a breakthrough technology by which nano-size (1 nanometer equals one-billionth of 1 meter) precipitates are uniformly dispersed in steel. By this method, JFE Steel achieved a balance between high-strength and high-formability, which was unachievable in the past. JFE Steel is constantly trying new possibilities such as the application of nanotechnology to steel products.

White automobile body using HITEN (high-strength steel sheet)

CUPTEN COAT M

CUPTEN COAT M is a rust stabilizer for weather-resistant steel. Weather-resistant steel, which is often used for bridges, is steel sheet of which the surface is covered by rust to prevent further corrosion. However, there were problems such as bad appearance until the rust stabilized, and the pollution of surrounding areas. Consequently, CUPTEN COAT M was developed. It condensed functions fulfilled by two layers of conventional products into one layer, and achieved a great improvement in workability and economical efficiency, as well as the mitigation of bad appearance due to rust streams (photo). In addition, CUPTEN COAT M is an earth-friendly technology that does not make use of chrome or lead compounds.

■Exposure Test Result of Actual Structure
(Tsu city, Mie prefecture / 0.3mdc two years)

EAST JAPAN WORKS (Chiba), JFE Steel

The East Japan Works (Chiba district) was the nation's first integrated waterfront steel mill established after World War II. It is located in the Keiyo industrial area close to the metropolitan area. It has a large scale with an area of about 8.32 million square meters, which is around 176 times the size of Tokyo Dome. In 1991, renovation construction was started to meet the gentrification of steel products and the diversification of needs. By inputting ¥260 billion in capital investment and spending four years, the Chiba district was reincarnated in 1995 as an "urban steel mill of the 21st century" which achieved complete resource saving and labor saving. The third hot rolling plant, which was newly established within the west plant, introduced a history-making innovative technology-the endless rolling process-in an actual machine.

The fourth steelmaking plant developed and introduced a dissolution and reduction process that was far beyond the common practice of conventional stainless refining. The East Japan Works in Chiba district is an internationally competitive steel mill focusing on manufacturing of high-grade steel sheets, with its center on the new steelmaking plant and hot rolling plant.

[Major product varieties]

Hot-rolled steel sheet/band, cold-rolled steel sheet/band, stainless steel sheet/band, surface-treated steel sheet/band, UOE pipe, iron powder and hot charge

East Japan Works (Nishinomiya plant), JFE Steel

As a stainless steel manufacturing plant, the East Japan Works (Nishinomiya plant) carries materials from the Chiba district and produces high-grade products and special products.

附件 4，JFE 鋼鐵-東日本鋼鐵廠能源中心展示資料

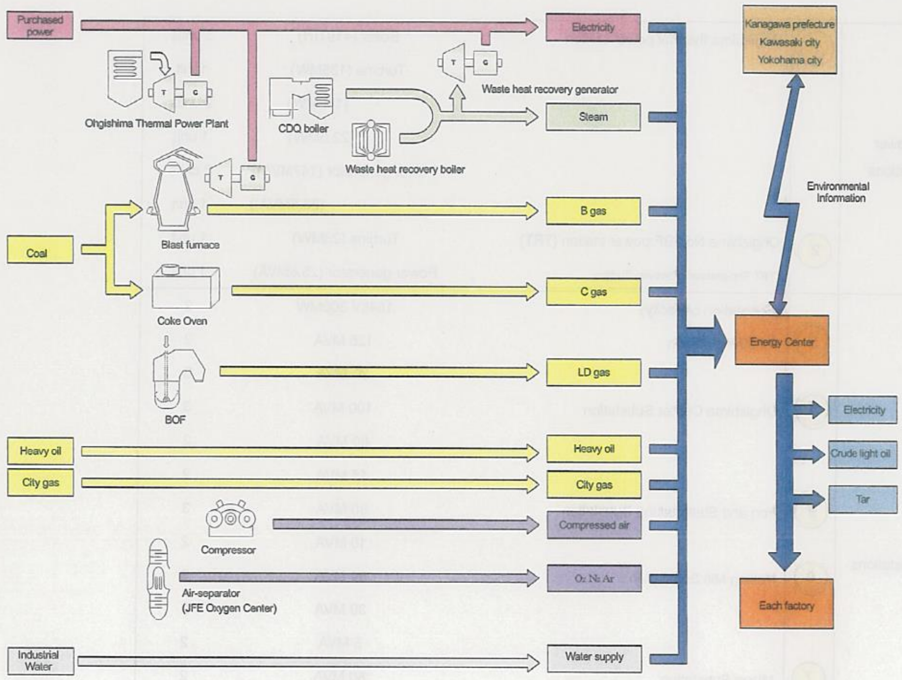
Role of the Energy Center

At the JFE EAST JAPAN WORKS Keihin District, we strive for full-fledged energy conservation and resource conservation and the Energy Center plays a central role in these activities. The Energy Center manages in a centralized manner the energy generated and utilized at the Keihin District.

Most of the energy needs of the Keihin District are covered by by-product energy generated in the ironmaking and steelmaking processes. The generation and utilization of energy vary greatly depending on plant operations and therefore one of the most important tasks of energy management is to achieve good balance between generation and utilization of energy and to ensure slim and efficient use.

Most of the water utilized at the Keihin District is recycled using the water purifying facilities operated by the Energy Center, and discharge water is first cleaned and then disposed of, while monitoring its quality. Monitoring of atmospheric data is also implemented. Thus, the Energy Center plays an extremely important role for the protection of environment, too.

How energies are used



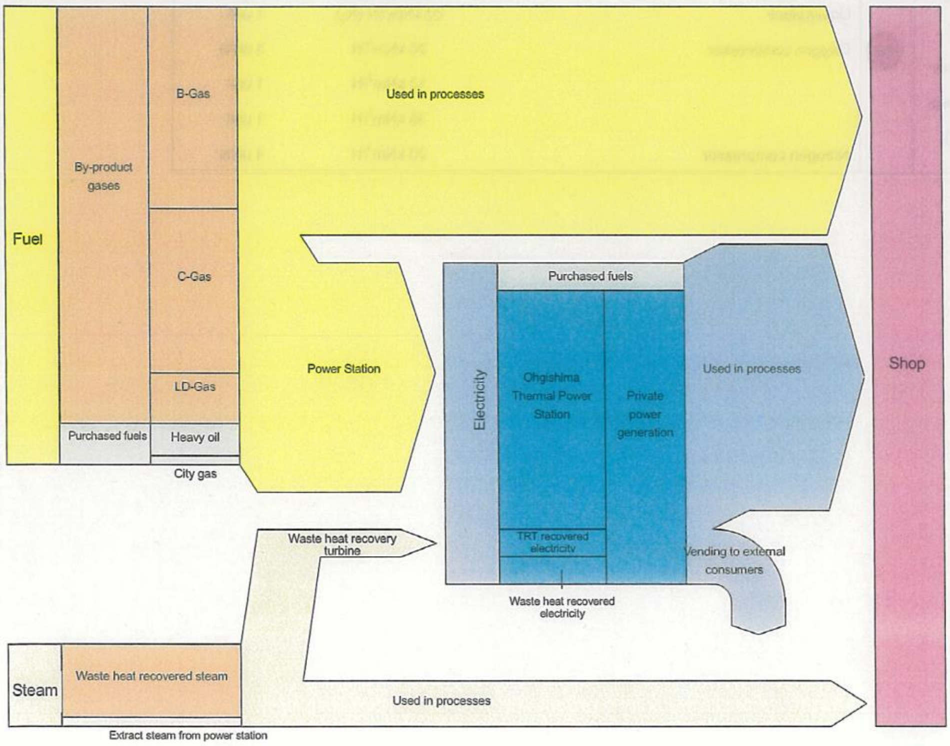
Summary of energy equipment

Power Stations	1	Ohgishima thermal power station	Boiler (410T/H)	3 units
			Turbine (135MW)	1unit
			(142MW)	2 units
			(22.5MW)	1 unit
			Power generator (147MVA)	3 units
			(23.5MVA))	1 unit
	2	Ohgishima No.2BF power station (TRT)	Turbine (23MW)	1 unit
		*TRT: Top-pressure Recovery Turbine	Power generator (25.6MVA)	1 unit
Substations		(Substation capacity)	154kV 300MW	2
	3	Switching station	125 MVA	2
			30 MVA	3
	4	Ohgishima Center Substation	100 MVA	3
			80 MVA	2
			15 MVA	2
	5	Iron and Steelmaking Substation	80 MVA	3
			10 MVA	2
	6	Rolling Mill Substation	80 MVA	3
			30 MVA	2
			5 MVA	2
	7	Mizue Substation	80 MVA	2
			15 MVA	2
	8	Watarida Substation	30 MVA	2
			10 MVA	2
	9	Other substations		
Fuel plants	10	B-gas Holder	150 km^3	1
	11	C-gas Holder	50 km^3	1
	12	LP-gas Holder	80 km^3	1
	13	Multiple gas Holder	200 km^3	1
	14	Heavy oil tank	7,830 kl	2
	15	Ohgishima C gas tank	4,000m^3 (0.9 MPa)	1
	16	Ikegami C gas tank	2,000m^3 (0.9 MPa)	1
	17	Gas Mixer	150 kNm^3/H	1
Water plants	18	Water purification plant		39 locations
Air compressors	19	Ohgishima Area Medium pressure (0.6MPa)	35 kNm^3/H	4 units
		Low pressure (0.2MPa)	26 kNm^3/H	1 units
	20	Other Areas Midium pressure (0.6MPa)	11 kNm^3/H	5 units

			2.6 kNm^3/H	2 units
		Low pressure (0.49Mpa)	12 kNm^3/H	1 unit
			11 kNm^3/H	1 unit
	21	Steam Power Recovery Compressor	9.3 kNm^3/H	1 unit
Blast furnace blowers	22	Blower	8.5 kNm^3/minute	2 units
Oxygen/ nitrogen/ argon equipment	23	Oxygen accumulator	1000 m^3 (2.5Mpa)	3 units
			800 m^3 (2.5Mpa)	2 units
		Nitrogen accumulator	2000 m^3 (0.6Mpa)	2 units
	24	Nitrogen accumulator	150 m^3 (3.7Mpa)	1 unit
		Argon accumulator	150 m^3 (3.7Mpa)	3 units
Oxygen/ nitrogen/ argon equipment (JFE Sanso Center)	25	Air Separator	20 kNm^3/H (O_2)	3 units
			65 kNm^3/H (O_2)	1 unit
		Liquid plant	20 kNm^3/H (N_2)	1 unit
		Oxygen compressor	20 kNm^3/H	3 units
			12 kNm^3/H	1 unit
			38 kNm^3/H	1 unit
		Nitrogen compressor	20 kNm^3/H	4 units

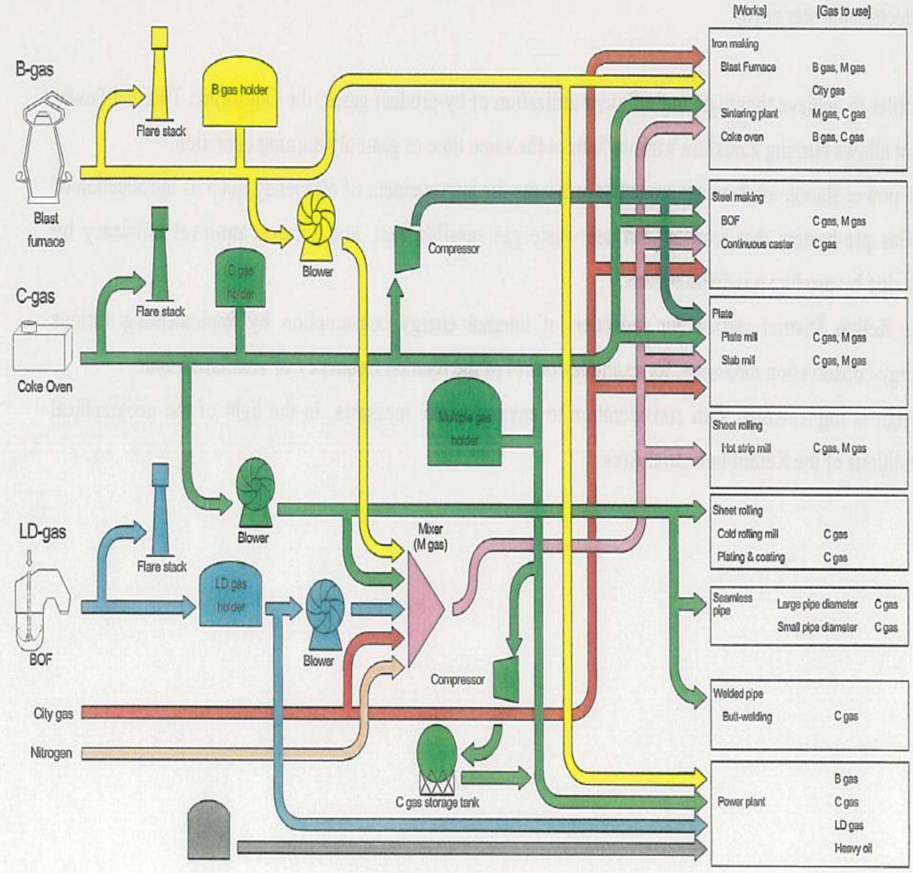
Use of Energy (Fuel, Steam and Electricity)

Part of the coal, which is the raw material used in steelmaking, is converted into the following by-product gases: B Gas in the blast furnace, C Gas in the coke oven and LD Gas in the BOF. Almost half of these by-product gases are utilized separately or as a mixed gas (M Gas) in the heating furnaces of each plant, and the remaining half is efficiently utilized as boiler fuel in power stations and converted into electrical power or steam. Most of the steam is produced through waste heat recovery. When the recovery facilities are not operating, steam extraction is carried out from power stations, and when excess steam is produced, it is converted into electrical power using heat recovery turbines. Most of the electrical power is generated at internal power stations owned by the Keihin Works and is supplied to each plant. It is also used for production and operation of energy generated using oxygen, compressed air, service water and others, and some of the surplus electrical power is sold to external organizations.



(1) Fuel gas operation

1. Almost all fuel needs of each plant and power station are covered using by-product gases generated within the Keihin District. Heavy oil and city gas may be used as necessary.
2. Each plant in Ohgishima uses M Gas adjusted as standard gas. M gas is produced by mixing B Gas, C Gas and LD Gas – by-products with differing calorific values.
3. Information about generation and use of by-product gases is fed into a computer, thus ensuring efficient utilization of each gas holder and C Gas storage tanks.

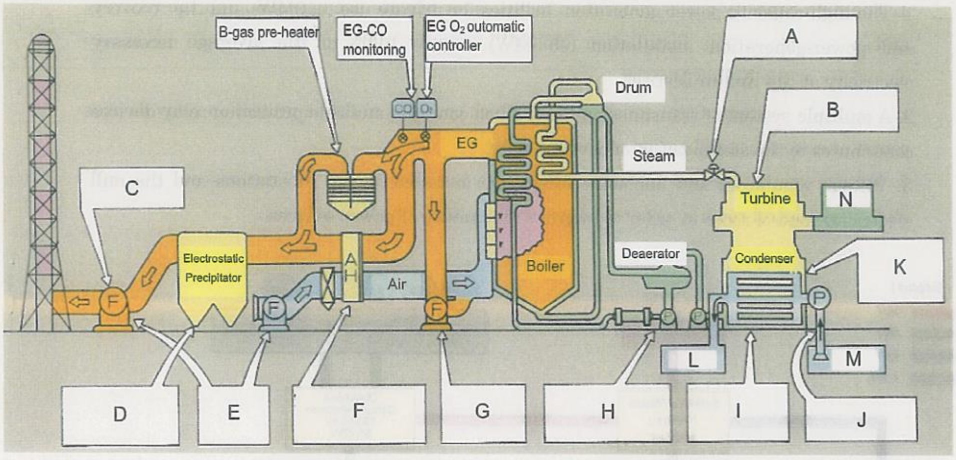


(2) Ohgishima Thermal Power Station

The Ohgishima Thermal Power Station is one of the largest company-owned power generation facilities in Japan, and its purpose is to minimize energy costs by making good use of by-product gases and producing electricity flexibility when storages of electricity occur.

Also, (Keihin) has the Top-pressure Recovery Turbine (TRT), a recovery generation system that utilizes the blast furnace top pressure, and an waste heat recovery steam power generator, and covers approximately 10% of the electrical power needs.

1. In order to achieve thorough and efficient utilization of by-product gases, the Ohgishima Thermal Power Plant allows burning a mixture various fuels at the same time or gas-only burning operation.
2. The power station implements proactive measures for improvement of efficiency, such as introduction of B Gas pre-heaters that recover and use waste gas sensible heat, and secures top-level efficiency by utilizing by-product-gas-fired boilers.
3. The Keihin District strives for reduction of internal energy consumption by implementing various energy-conservation measures, for example control of the rotation frequency of ventilation fans.
4. Design is implemented with consideration to environmental measures, in the light of the geographical conditions of the Keihin Industrial Area.



[Legend]

EG = Exhaust gas

A: Turbine initial pressure control
Boiler master control by C-gas

B: Use of blades of higher efficiency
Variable pressure operation

C: Moving blade variable pitch axial fan

D: Change-over of steams used in the premises
(steam for waste heat recuperation)

E: Rotation control of fans (VVVF)

F: Energy saving for air pre-heater
- Reduction of leakage air
- High-efficient element

G: Pole change of gas recirculation fan

H: Boiler feeding pump
- Pulling out an impeller
- Rotation control (VVVF)

I: Condenser
- Installation of vacuum pump instead of steam ejector
- atomization of cleaning

J: Optimization of pumps in operation for circulation water

K: Vacuum type stream ejector

L: Outlet port

M: Water-intake port

N: Power generator

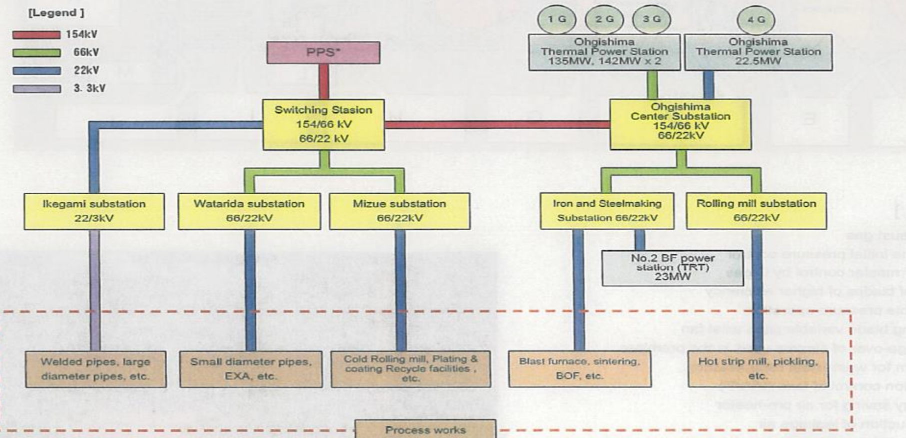
Ohgishima Thermal Power Station

(3) Electrical power operations

1. The high-capacity power generation facilities for private use (419MW) and the recovery ~~and~~ power-generation installation (45.5MW) supply 100% of the average necessary electricity at the Keihin District.

2. A multiple system of transmission lines which contains multiple protection relay devices contributes to the stabilization of power supply.

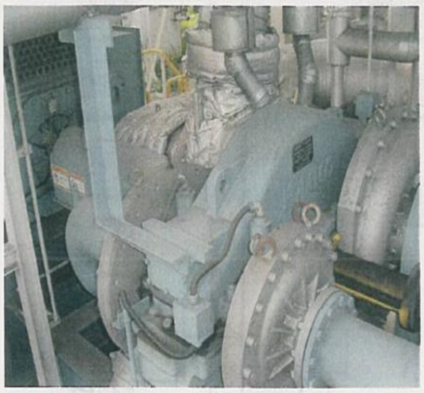
3. Voltage regulators and harmonic filters are installed at the substations and the mill electricity control room in order to improve the quality of power sources.

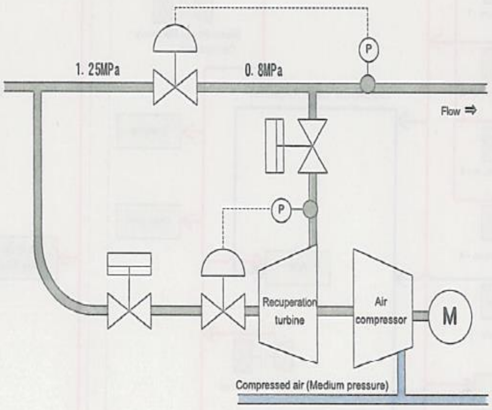


* Power Producer and Supplier

(4) Steam operation

1. The needs for steam at the Keihin District are almost completely covered using steam generated through exhaust heat recovery. (CDQ, sintering, hot rolling exhaust heat boilers)
2. Excess steam is converted into electricity by waste heat recovery steam turbines.
3. When steam shortages occur, it is possible to secure steam from the Ohgishima Thermal Power Station (Extract steam).
4. The Steam Power Recovery Compressor is installed and compressed air is produced in order to secure efficient utilization of pressure reduction loss.

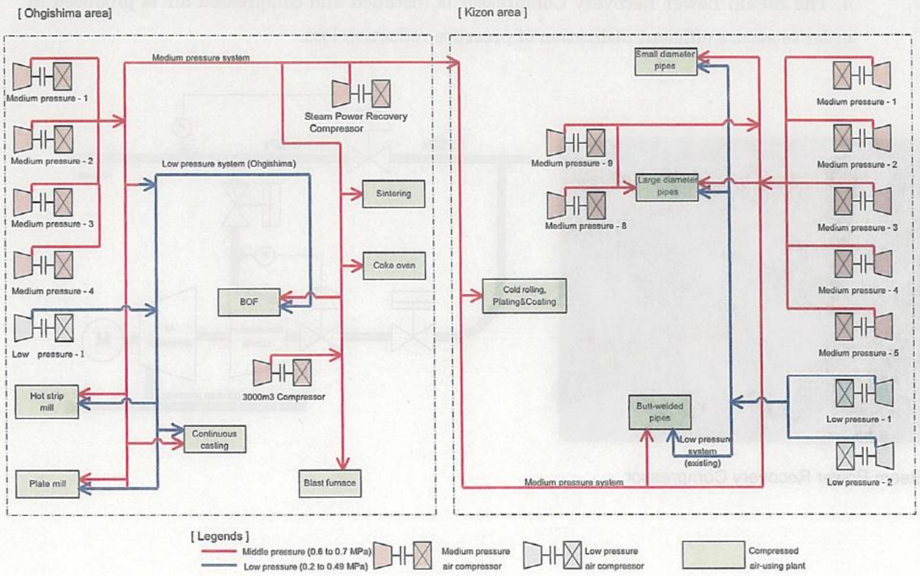




Steam Power Recovery Compressor

(5) Compressed air operation

1. Compressed air is supplied through two channels, one is medium pressure (0.6MPa) and the other is low-pressure (0.2MPa) for the purpose of energy saving.
2. The installation is equipped with backup supply functions from medium to low pressure.
3. Compressed air is supplied by using the connection stretches around Keihin District, and it is operated efficiently.

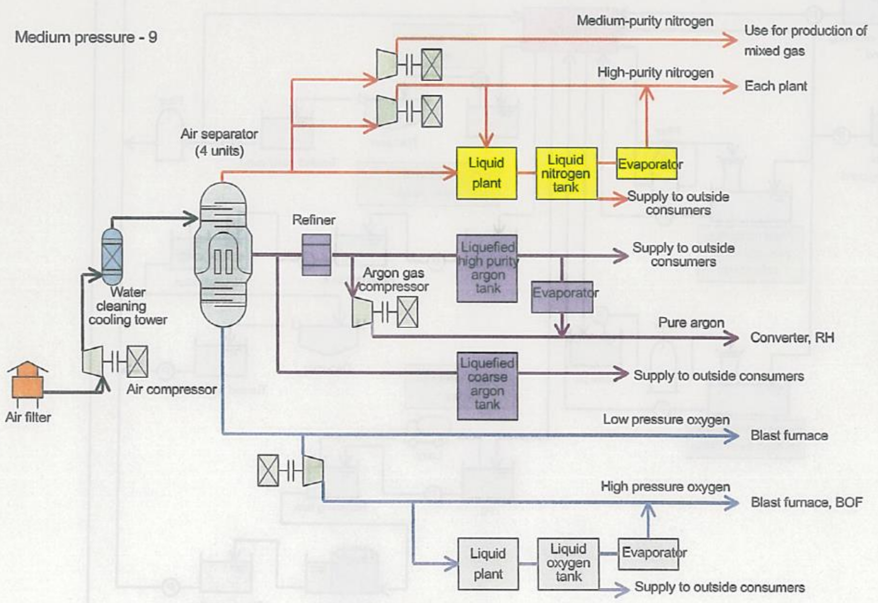


(6) Industrial gas operation

1. Industrial gas is supplied by JFE SANSO CENTER CORPORATION which has the installations located within the Keihin District.

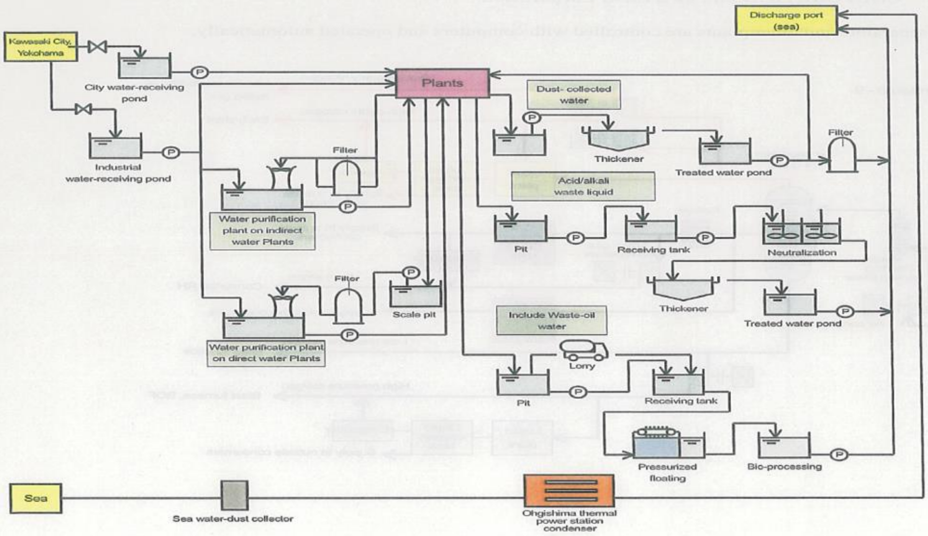
   *JFE SANSO CENTER CORPORATION is a joint company of TAIYO NIPPON SANSO CORPORATION and JFE Steel Corporation.

2. Air separators and other plants are controlled with computers and operated automatically.



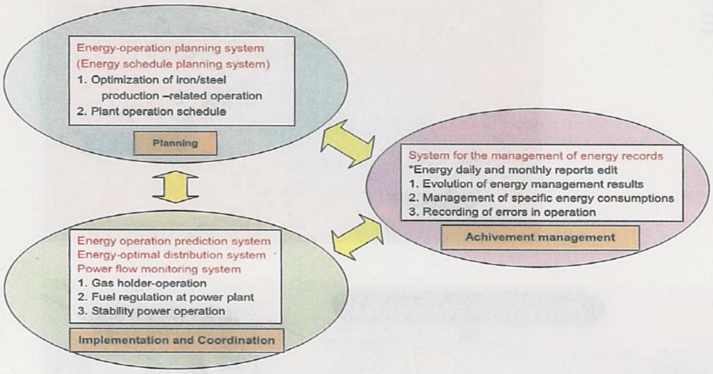
(7) Water operation

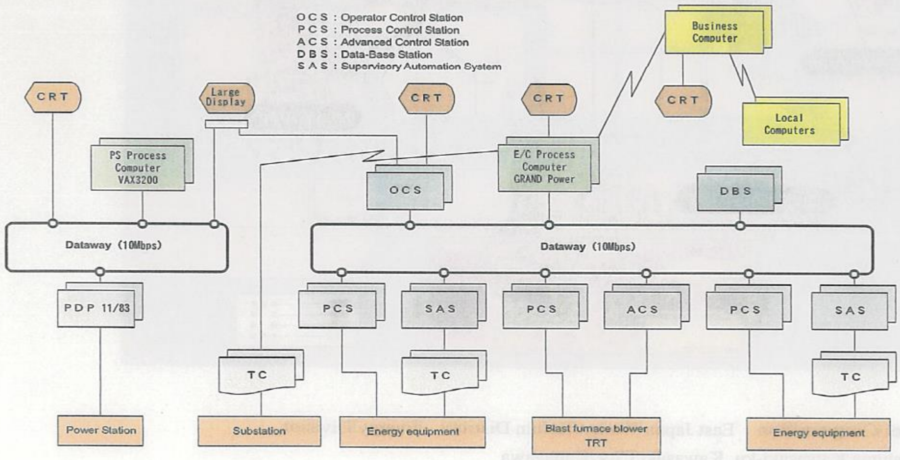
1. Water is effectively circulated through the plants to decrease purchased water and industrial waste water
2. Optimum water supplying systems which meet operating conditions of plants have been introduced for the purpose of saving electricity.

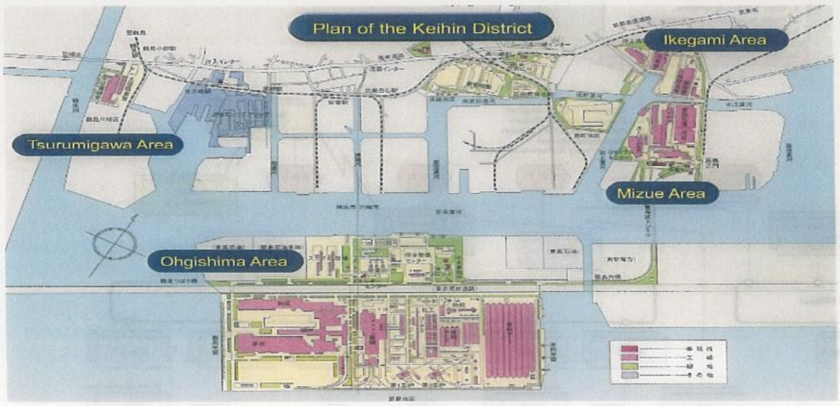


Energy Control System

The generation and utilization of energy are closely and diversely related to the steel production activities, and therefore slim and efficient operation needs to analyze large amounts of data speedily. To this end, systematization of energy management is essential. The energy management system comprises the following three elements: planning, implementation and coordination, and achievement management. By using these three systems as one management cycle, we efficiently utilize them for optimization of short, middle and long term energy performance.







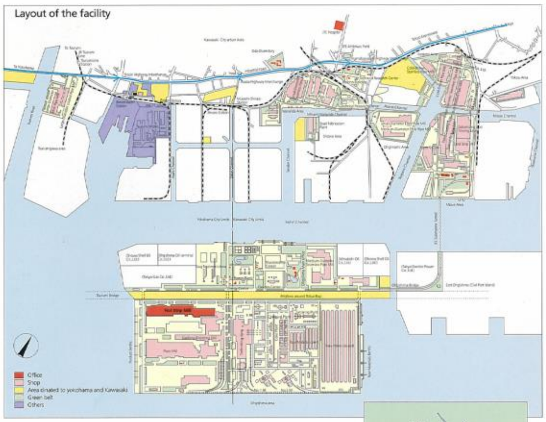
JFE Steel Corporation East Japan Works (Keihin District) Energy Division
1-1 Ohgishima Kawasaki-ku, Kawasaki City, Kanagawa
Tel. 044-322-1601 Fax. 044-322-1539

Head Office : 2-2-3 Uchisaiwaicho, Chiyoda-ku, Tokyo (Hibiya Kokusai Building)

JFE

Layout of Keihin Works

Layout of the facility



JFE スチール 株式会社

東日本製鉄所（京浜地区）薄板部 熱延工場
〒210-0868 川崎市川崎区扇町1丁目1番
TEL 044(322)1375

本　社 〒100-0011
〒100-0011 東京都千代田区内幸町2丁目2番3号（日比谷国際ビル）
TEL 03(3597)3111

JFE Steel Corporation EASTJAPAN WORKS

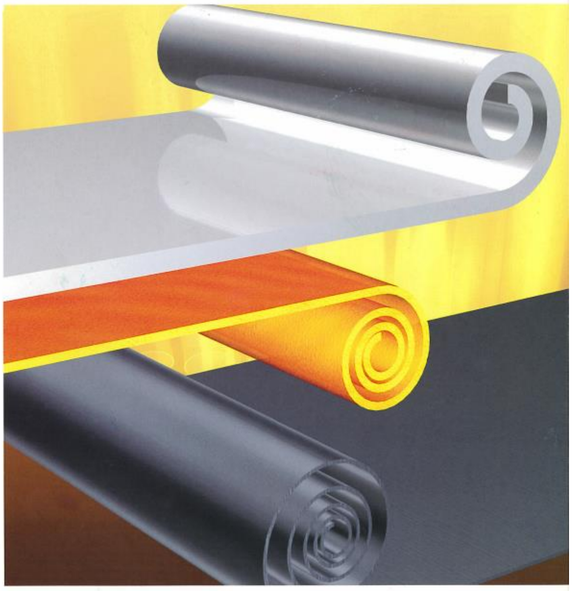
Sheet and Strip Dept. East Japan, Keihin District
1-1 Ogishima, Kawasaki-ku, Kawasaki, Kanagawa 210-0868, Japan
Phone : 81-44-322-1375

Head Office
Hibiya Kokusai Building, 2-3 Uchisaiwaicho 2-chome, Chiyodaku, Tokyo 100-0011, Japan
Phone : 81-3-3597-3111

Printed in Japan

Hot Strip Mill

JFE



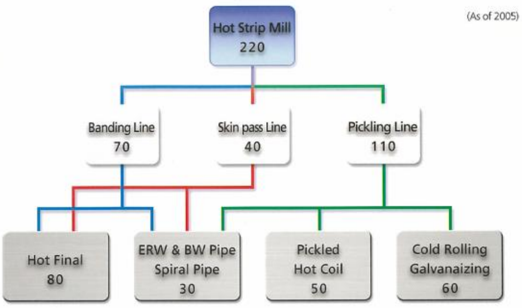
JFE Steel Corporation
東日本製鉄所 京浜地区 熱延工場

Brief History

1978.07 (S53.07)	H.S.M started Up
1979.03 (S54.03)	H.S.M operational
1979.04 (S54.04)	PKL started Up
	SKP started Up
1983.01 (S58.01)	PKL No.2 Pay-off Reel installed
1984.01 (S59.01)	F5 WRS installed
1988.04 (S63.04)	F4-F6 Hydraulic AGC installed
1988.04 (S63.04)	Hot Run Spray revamped
1988.11 (S63.11)	F4-F6 PCS installed
1989.08 (H01.08)	Bar Edge Heater installed
1989.10 (H01.10)	F7 Stand added (PCS & Hyd. AGC)
	E4 Hyd. AWC installed
	Process Control System revamped
	Profile Meter installed
1992.10 (H04.10)	Hot Run Spray revamped
1994.04 (H06.04)	PKL Process Control System revamped
1997.07 (H09.07)	Inter-Stand Thicknessmeter installed
2000.05 (H12.05)	Finisher and Coiler Process Control System revamped
2001.05 (H14.05)	Rougher Process Control System revamped
2005.04 (H17.04)	PKL Flying Shear installed

Production Flow Chart

(As of 2005)



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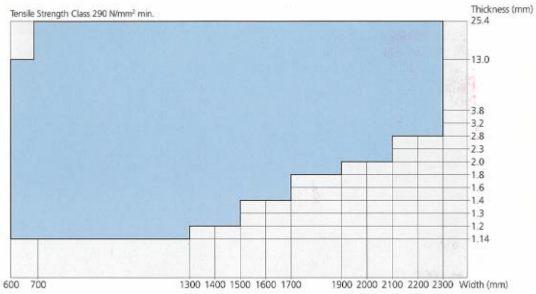
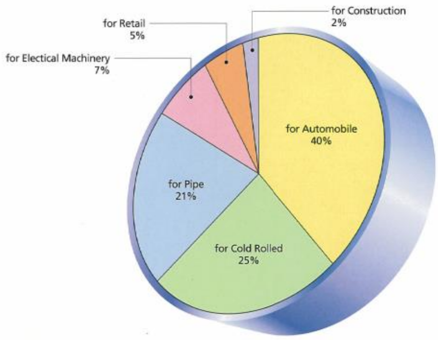


Uses of Hot Coils



Specification of Finshing Plant

Item	Pickling Line		Skinpass Mill	Banding Line
Mill Type	4 Hi, Hyd. (In-line Skinpass)		4 Hi, Hyd.	-
WR Dia. (mm)	650 ø (in-line Skinpass)		650 ø	-
Thickness (mm)	1.2 ~ 6.9		1.2 ~ 6.9	-
Width (mm)	600 ~ 1,630		600 ~ 2,300	600 ~ 2,300
Max. Wight (Ton)	36 (In) 43 (Out)		36	36
Max. Dia. (mm)	2,810		2,050	2,050
Line Speed (mpm)	300 Max. (Line Center)		500 Max.	-
Number of Tank	Pickling	5		
	Hot Rinse	5		
	Pre-Heating	1		

Pair Cross

F4 ~ 7 Stand

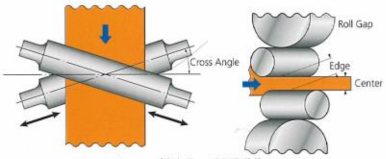
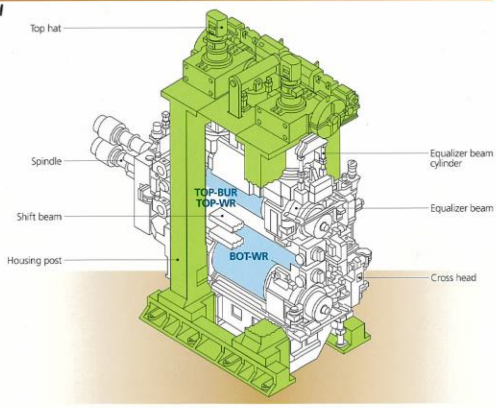


Image of Pair Cross & WR Shift

Shift Mill



Specification of Hot Strip Mill

Equipment	Specification					
Reheating Furnace	8-Zones Walking-Beam Type					
	T/H		300 T/H×2			
	Effective Length		57m			
	Furnace Width		9.8m			
Roughing Mill	HSB	Hydraulic Pressure 1530MPa(150kgf/cm²)				
		WR Dia.	Moter Power		Type	
	R2	1,160 ø	DC 5,000 kW×2		4 High Rev.	
	R4	1,160 ø	AC10,000 kW×1		4 High	
Edger		WR Dia.	Moter Power		AWC	
	E2A	930 ø	AC1,120 kW×2		Elec.	
	E2B	930 ø	AC1,120 kW×2		Elec.	
	E4	930 ø	AC 410 kW×2		Hyd.	
Edger Heater	Induction Heater Type					
	Power Supply		High Frequency Inverter 2,000 kW×2 ; 1,800V			
Crop Shear	4-Crank Type					
	Moter Power		DC 1,200kW×2			
Finishing Mill		WR Dia.	Moter Power	WR Shift	Cross Angle	AGC
	F1	815 ø	DC 4,200 kW×2			Elec.
	F2	815 ø	DC 4,200 kW×2			Elec.
	F3	815 ø	DC 4,200 kW×2			Elec.
	F4	800 ø	DC 4,200 kW×2	±213mm	0 -1.2 Deg.	Hyd. & Elec.
	F5	800 ø	DC 4,200 kW×2	±213mm	0 -1.2 Deg.	Hyd. & Elec.
	F6	800 ø	DC 2,800 kW×3	±213mm	0 -1.2 Deg.	Hyd. & Elec.
	F7	800 ø	AC 8,400 kW×1	±213mm	0 -1.2 Deg.	Hyd. & Elec.
	F7 Speed		Max. 1159mpm			
Run-out Table	Cooling Equiment	Pipe Lamina	Pipe Lamina or Soft Cooling		Soft Cooling	
		13 Banks	2 Banks		1 Banks	
Coiler	3-Unit Flame Type					
		Moter Power	Pinch Roll			
	No.1 & No.2	DC 260kW×3	440kW×2			

Specification of Yard

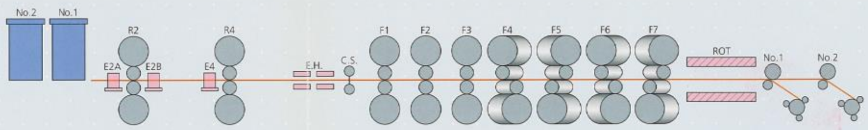
Computed control system utilizing automatic cranes and carriages.

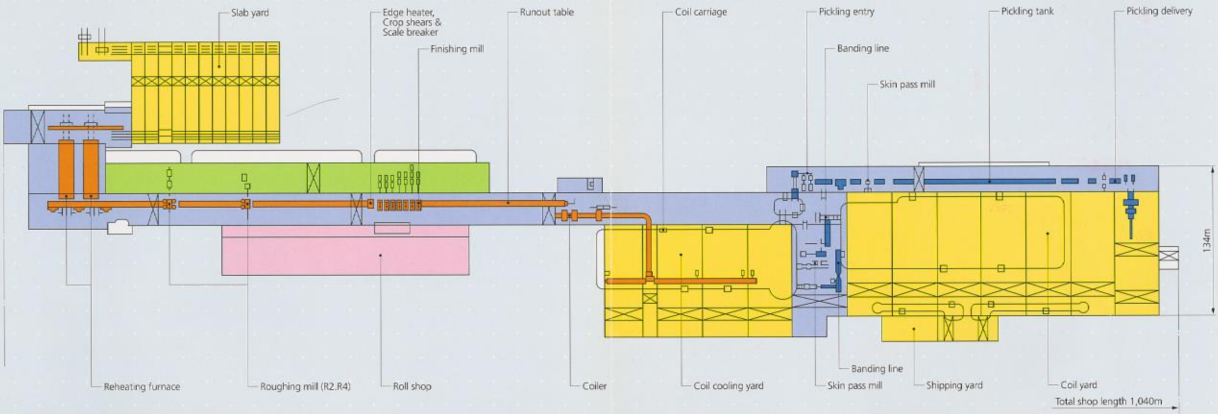
		Capacity	Operation	Crane	Carriage
Slab Yard	Cold Charge	50,000Ton (11Yard)	Auto.	1 / Yards	4
	Hot Charge	4,000Ton (11Yard)	Auto.	1 / Yards	1
Cooling Yard		545 Coils×4 Yard	Auto.	1 / Yards	7
Coil Yard	No.1 ~ No.6	606 Coils×6 Yard	Auto.	1 / Yards	15
	No.7	295 Coils	Manual	2	-

Production Capacity : 300,000 T / M

Slab and Coil Dimension

	Slab	Coil
Thickness (mm)	160 ~ 250	1.2 ~ 25.4
Width (mm)	600 ~ 2,300	600 ~ 2,300
Length (mm)	5,000 ~ 9,100	-
Weight (Ton)	Max.36	Max.36





Finishing Mill

Coil Yard

Pickling Line