The 2010 Shanghai World Expo: The Challenge for Distributed Energy

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Ernest Orlando Lawrence Berkeley National Laboratory, USA
Brief Introduction of My Laboratory

http://gao.env.kitakyu-u.ac.jp/

Welcome to Gao Weijun Laboratory

- Distributed Energy Resource and Network
- Environmental Evaluation
- China Energy
- Building Recycle

2006

Ph.D candidates: Four
Master Candidates: Three
Bachalor: Four
Research: Four
Visiting Professor: Five
Distributed Energy Resource and Network
Design and Management Support System for Promoting the Local
Distributed Energy Resources (2005-2007)

It is time from an era of making products to an era how to manager them. The long social value with a life cycle evaluation has been added in the present economical value. We need a “soft” technology to support the “hard” technology in order to realize this value.

In this study, we have developed a comprehensive computerized simulation tool to give an optimal decision making in using the distributed energy resources as well as to help the operation to reach its better mode in energy, money saving and environmental concern

**DER-CAM**

Planning, design and management tool for distributed energy resources
Field study on the effects of introducing a distributed district energy system (2002-2004)

Research on safety and backup of heat supply by networking heat resources (2003)

China Energy

- Planning an Energy Infrastructure with a low environmental load in Shanghai World Expo (2004-2005)
- Shanghai Energy Saving Situation and the Entry Possibility of ESCO enterprise into Shanghai Market (2005)
- Feasibility Study In relation to Methane Gas CDM Project In China (2005-2007)
- Research on district heat supply system with a low environment load in North-east area of China (Changchun) (2002)
- Investigation on Energy Consumption in Dalian, China (2001)
- Energy Consumption and its Impacts on Environment in Shanghai, China (2000)
- Investigation of City Environment and Energy Consumption in Yangtze Delta Area (1999)
Environmental Evaluation
Mitigating the heat island in Tokyo Metropolitan area with a Numerical Simulation (1999)

Effects of introducing distributed energy system on the local environment (1997)

LBNL-43955 Mitigation of urban heat islands: meteorology, energy, and air quality impacts 09/30/1999 Taha, Haider; Meier, Alan; Gao, Weijun; Ojima, Toshio
Research on Building Recycle

Recycle process of building materials in the detached houses (2005)

• Lifecycle resource and energy consumption evaluation in residential house with steel construction (2005)

• Lifecycle resource evaluation system for building material Recycle (2004-2005)

• Evaluation on decreasing the resource and energy consumption in environmental residential buildings (2003-2004)

• Research on disassemble and recycling energy consumption in collective residential buildings of Kitakyushu (2003)

• Lifecycle energy consumption for building material recycles in residential buildings (2002)

• Investigation on energy consumption of building material recycles in residential buildings (2002)


LBNL-46020 Energy impacts of recycling disassembly material in residential buildings.02/01/2000, Gao, Weijun; Ariyama, Takahiro; Ojima, Toshio; Meier, Alan
Design and Planning Works

Dalian Port Eastern Coastal Park Planning (2005) with Nikken Sekkei

International Consultancy for the Urban Design of Shenzhen City Center and Comprehensive Planning of the Underground Spaces (2000)

Comprehensive planning and design of Guiming garden houses (2002)

International Consultation for Integrated Planning Proposal of Luohu Land Port/Railway Station Area, Shenzhen(2000)
Why do we need the *Distributed Energy*?

In China

In USA

In Japan

In the World
The urbanization will be speeded in Asia in the next twenty years.
Monitoring in World Cities

Figure 2: Built area around 50km

Figure 3: Population scale

Figure 4: CO2 recharge in Shanghai

Figure 5: Population and city area in Shanghai

Figure 6: Energy consumption and air pollution
National energy consumption

Oil Kg/year

Canada

USA

Formal USSR

Germany

France and United Kingdom

Japan

Italy

Mexico

Korea

Brazil

Philippine

Thailand

Indonesia

Pakistan

Vienna

Myanmar

Ethiopia

Nepal

Average energy consumption of world

China

India

Population

Hundred Million People
Comparison of area between Tokyo and Shanghai

Tokyo

Shanghai

上海市和东京首都圈（一市两县）130km²的比较
（内区为50km²）
The city warming phenomenon due to sudden urbanization

<table>
<thead>
<tr>
<th>Urbanization of Shanghai (25km × 19km)</th>
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</thead>
<tbody>
<tr>
<td>1845年</td>
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</tbody>
</table>

1.5 ⁰C during 150 years
Increase of urban air temperature due to urbanization in Shanghai (height at 1.5m)

Simulation by Weijun GAO, Haifeng LI and Toshio OJIMA
Over the past century, the average temperature in Shanghai has increased by $1.5^{\circ}C$/year, more than three times of the global average. The temperature increase in recent ten years is at a rate of $0.11^{\circ}C$/year.
Huangpu River Bridge

Three-dimensional traffic system of Shanghai

Subway of Shanghai

linear motor car
Change of generation capacity and electricity consumption in Shanghai

25 July 2003  Electrical load  13610MW

Power capacity  9600MW

Electrical load  14500MW

Stop by Gov.  400MW
Restriction  400MW
Peak cut  570MW
Inspection  30MW
Peak delay  280MW

Time

y = 34.503x + 137.22
R² = 0.9885
Shanghai power plants and its network

Grid Power can not catch up the increase of demand
China have “million(many)” reasons to develop the distributed energy resource

<table>
<thead>
<tr>
<th>Necessity or Purpose</th>
<th>USA</th>
<th>EU</th>
<th>JAPAN</th>
<th>CHINA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reliability of power Supply</td>
<td></td>
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<td></td>
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<tr>
<td>Reduction of investment in plant and equipment</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Reduction of erection period</td>
<td></td>
<td></td>
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<tr>
<td>Reduction of energy cost</td>
<td></td>
<td></td>
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<tr>
<td>To keep environmental condition (ex. Reduction of Co2)</td>
<td></td>
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<tr>
<td>To ensure diversity of energy supply</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Power supply to island and/or remote place</td>
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</tbody>
</table>
The 2010 Shanghai World Expo
Planning an Energy Infrastructure with a Low Environmental Load
The Effects of The Shanghai World Expo

The Surge of GDP in China

One thousands Billion RMB

The Surge of GDP in Japan

One thousands Billion Japanese Yen

GDP is predicted to be Four Times compared with today
Project Teams

the Ministry of Economy, Trade and Industry

J-Power
Electric Power Development Co., Ltd

JES
Japan Environment Systems CO., LTD

Waseda University
Toshio Ojima LAB

Tongji University
Research Center of World Expo 2010

Shanghai Construction committee
About 4.5km

Expo site

Shanghai CBD

Huangpu River

Location of the Site and CBD of Shanghai
Outline

Background

- Better City, Better Life
- After the EXPO, re-development as a world trade city

Basic Consideration
As an example of the east Asian big city, energy infrastructure with a lower environmental load should be built

Plan

- Introduce a district heating/cooling system with distributed generation and unused energy (the river water)
- Introduce the underground multi-purpose utility tunnel which aims toward the improvement of city environment
Master plan of 2010 Shanghai World Expo

1.35 km²

3.93 km²
### The Scale of Shanghai Expo (comparison with Osaka and Aichi)

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<tr>
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<tbody>
<tr>
<td><strong>Theme</strong></td>
<td>Progress and Harmony for Mankind</td>
<td>Nature's Wisdom</td>
<td>Better City, Better Life</td>
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<tr>
<td><strong>Area (ha)</strong></td>
<td>350</td>
<td>170</td>
<td>670</td>
</tr>
<tr>
<td><strong>The number of attendance (Million)</strong></td>
<td>64</td>
<td>15</td>
<td>70</td>
</tr>
<tr>
<td><strong>After Expo</strong></td>
<td>EXPO Park</td>
<td>Park, Village (restoration)</td>
<td>The International Trade Center</td>
</tr>
<tr>
<td><strong>Cooling Area (ten thousand m²)</strong></td>
<td>28.5</td>
<td>10</td>
<td>About 120</td>
</tr>
<tr>
<td><strong>Cooling Capacity (kW)</strong></td>
<td>105,000 (30,000RT)</td>
<td>35,000 (10,000RT)</td>
<td>307,900 (88000RT)</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>Forest</td>
<td></td>
<td>Huangpu River Near Nanshi City power plant</td>
</tr>
</tbody>
</table>
### Prediction of maximum cooling load during exposition in 2010

<table>
<thead>
<tr>
<th>Zone</th>
<th>Floor area</th>
<th>Air conditioning area</th>
<th>Cooling load</th>
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<tbody>
<tr>
<td><strong>Government pavilions</strong></td>
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<tr>
<td>Foreign government</td>
<td>800,000m²</td>
<td>703,000m²</td>
<td><strong>307,900 kW</strong></td>
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<tr>
<td>Foreign</td>
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<tr>
<td>Joint pavilions</td>
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<tr>
<td>China pavilion</td>
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<tr>
<td><strong>International Pavilions</strong></td>
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<tr>
<td>Pavilions for Chinese province</td>
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<tr>
<td>Pavilions for enterprises</td>
<td></td>
<td></td>
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<tr>
<td>Urban experimental zones</td>
<td>500,000m²</td>
<td>100,000m²</td>
<td></td>
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<tr>
<td>Auxiliary Facilities</td>
<td>700,000m²</td>
<td>400,000m²</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>2,000,000m²</td>
<td>1,203,000m²</td>
<td><strong>307,900 kW</strong></td>
</tr>
</tbody>
</table>
Distribution of cooling load during Expo
River width 400m, the depth of water 6m-8m, flow 200-300m³/s
Average water temperature in August 29.3 °C.

data
boiler: 220t/h × 4
generator (air bleeding system): 60MW × 2
generator (back air system): 25MW × 1
thermal supply area: 8.1km²
Actual energy savings for DHC systems in Japan
Thermal Environmental Evaluation

The average air temperature in the Case2 is 0.16°C lower than that in Case1, which shows that the DHC system with water cooling has less heat island effect. Especially at the places surrounded by buildings, such as Point 3, the air temperature in Case1 is about 5°C higher than in Case2.
Suggestion for Shanghai EXPO 2010

Underground Life Line (U.L.L.)
Utility tunnels during exposition
Diagram of combined cycle cogeneration system
Thank you for your attention