Innovation, Technology, and Behavioral Insights for Energy Transition to a Low-Carbon Future

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Denryoku Sharing (D-Sharing)

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• Adopt “Nudge” theory in the energy sector, e.g., for mainstreaming Renewable Energy (RE), enhancing Energy Efficiency (EE) and use of Electric Vehicles (EVs)
• Naoki Sakai, CEO & Keiichi Tamaki, Technical Director
• Advise GOJ to develop and execute “Nudge” projects
• Utilize publicly available data in Japan and elsewhere to develop new methodologies/strategies, e.g., Demand and Supply Management with hourly CO₂ emission factors, a.k.a. Carbon Intensity (CI; g-CO₂/kWh)
This Presentation intends to …

• Present some quick observations & anecdotes
• Stimulate brilliant thinkers like ACEF participants to do more analytical works, provoke policy debate, and help formulate reasonable alternative policies
• Disclaimer (Tamaki)
  – I’m neither electric engineer nor economist but urban planner
  – So, forgive me if I cannot answer tough questions!
Japan – Statistical Data Available

- **Organization for Cross-regional Coordination of Transmission Operators (OCCTO)**
  - Demand & Supply (by electricity generation type)
  - Visit any of 10 utilities’ websites (e.g., TEPCO, Kyuden) Some of them started real-time data provision

- **Japan Electric Power Exchange (JEPX)**
  - Market Prices

- **Japan Meteorological Agency**
  - Duration of Sunshine, Wind Speed, Temperature, etc.
Format for Actual Data of Electricity Demands and Supplies (by Power Generation Method)  
OCCTO Data

<table>
<thead>
<tr>
<th>Date_Time</th>
<th>Area Demand</th>
<th>Nuclear</th>
<th>Thermal</th>
<th>Hydro</th>
<th>Geothermal</th>
<th>Biomass</th>
<th>Solar</th>
<th>Wind</th>
<th>Pumping-up Hydro&lt;/br&gt;pump-up (-) / generation (+)</th>
<th>Linked to (-) / from (+) Another Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>2021/4/1 0:00</td>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F</td>
<td>G</td>
<td>H</td>
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<td></td>
<td></td>
<td></td>
<td>J</td>
<td>K</td>
</tr>
<tr>
<td>2022/3/31 23:00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>J</td>
<td>K</td>
</tr>
</tbody>
</table>

*1: A = B + C + D + E + F + G + I + K + L
*2: Thermal is total of oil and LNG (fuel type), and steam-power and combined-cycle (generation method). No breakdown available.
*3: For CO₂ (weighted average) emission modelling, 800g-CO₂/kWh is used for “Thermal” and 0g-CO₂/kWh for all the other power generation methods – just for operation ignoring CO₂ emission for construction.

- Breakdown of “Thermal” (coal, oil, LNG, LNG combined) is not available…
Format for System (Spot Market) Prices of Electricity (by Area)
JEPX Data

<table>
<thead>
<tr>
<th>Date</th>
<th>Time Code</th>
<th>Sell Bids (kWh)</th>
<th>Buy Bids (kWh)</th>
<th>Sold (kWh)</th>
<th>System Price (¥/kWh)</th>
<th>Area Price Hokkaido (¥/kWh)</th>
<th>Area Price Tohoku (¥/kWh)</th>
<th>Area Price Tokyo (¥/kWh)</th>
<th>Area Price Chubu (¥/kWh)</th>
<th>Area Price Hokuriku (¥/kWh)</th>
<th>Area Price Kansai (¥/kWh)</th>
<th>Area Price Chugoku (¥/kWh)</th>
<th>Area Price Shikoku (¥/kWh)</th>
<th>Area Price Kyushu (¥/kWh)</th>
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</thead>
<tbody>
<tr>
<td>2021/04/01</td>
<td>1</td>
<td>18858000</td>
<td>18427950</td>
<td>15407900</td>
<td>5.63</td>
<td>6.29</td>
<td>6.29</td>
<td>6.29</td>
<td>6.29</td>
<td>6.29</td>
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<td>2022/03/31</td>
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<td>17305200</td>
<td>17828000</td>
<td>16118900</td>
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<td>16.78</td>
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</tbody>
</table>
US & UK – **Real-Time** Data Available

- **US** California Independent System Operator (CAISO)
  - Electricity Supply Trend by Generation Type
  - CO₂ Emission Trend by Generation Type
- **US (East Coast)** PJM
  - Electricity Generation by Fuel Type
  - Hourly Total CO₂ Emission by Fuel Type
- **UK** National Grid
  - Historic Generation Mix (incl. Carbon Intensity)
CO₂ Emission

• Decarbonizing transition from fossil-fuel-fired thermal (coal, oil, LNG, LNG combined) to renewable (solar, wind, etc.)
• Analogy with grey, blue, turquoise and green hydrogen
• Clean and dirty electricities get mixed up when fed into grid
• But you can tell weighted average CO₂ emission per kWh, which is known as Carbon Intensity (CI; g-CO₂/kWh)
Kyushu Electric Power Co., Inc. (Kyuden)

Frontier of Japan’s decarbonizing electricity generation transition
Carbon Intensity Kyushu (March 2023)
Carbon Intensity (CI; kg-CO$_2$/kWh)

Hourly Carbon Intensity (CI) of Regional Grid
(CO2 Emission per 1kWh)
Monday, April 3, 2023
*Monday, March 27, 2023 for Kyushu

Local Time

- TEPCO
- Kyushu
- CAISO
- PJM
- UK

PJM

CAISO

UK
CO$_2$ Emission (contd.)

• Balancing demand & supply
  – “Same amount at the same time” Requirement

• Dispatching order of generating units under deregulated market

• Difficulty to recover capital costs of rarely dispatched (relatively more expensive) generating units

• Efficiency Issue (supply-side)
  – Pump-up hydro & storage battery → 30% loss
Demand Management

• Peak cutting to avoid investing in additional power plant/generating unit

• (Rigid) Time-based Pricing/Time-of-Use Tariffs
  – Used to be encouraging customers to use “excess” electricity during nighttime
  – Does it still make sense? → See California’s Net Energy Metering (NEM) Transition

• IoT Smart Meters replacing old “dumb” meters at each customer (not only large industrial/commercial customers but also small household customers) → opportunity for monetary incentives and/or nudging
“Incentivizing/Nudging” Demand Shift

• (Data-driven) Demand Management
  – Peak-time energy saving rewards (bill credits/rebates; manual & automatic by using IoT thermostat) → Use “Nudge” theory to encourage customers to save electricity during peak-time and use “excess cleaner” electricity
  – Kyuden offered discounted rate for “excess cleaner” electricity during daytime for Tokyo Steel, which used to use significant amount of electricity for electric furnace during nighttime

• Efficiency Issue (demand-side)
  – Household storage battery → 30% loss
## California’s Net Energy Metering Transition

NEM 1.0 → NEM 2.0 → NEM 3.0, formally Net Billing Tariff (NBT)

<table>
<thead>
<tr>
<th></th>
<th>NEM 1.0</th>
<th>NEM 2.0</th>
<th>NBT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eligible import rate</td>
<td>Any</td>
<td>TOU rates</td>
<td>Specific “electrification” TOU rates</td>
</tr>
<tr>
<td>schedule</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onsite use of generated</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>energy avoids energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>imports</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Credits for energy exports before true-up basis</td>
<td>Import rates</td>
<td>Import rates</td>
<td>Price of energy that IOUs could buy elsewhere instead</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Credits for net surplus</td>
<td>Wholesale price of energy to IOUs</td>
<td>Wholesale price of energy to IOUs</td>
<td>Wholesale price of energy to IOUs</td>
</tr>
<tr>
<td>energy at true-up basis</td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Non-bypassable charges</td>
<td>Net energy consumed (imports minus exports) in a year</td>
<td>Net energy consumed in a metered interval (1 hour for residential and 15 minutes for nonresidential customers)</td>
<td>All energy imports</td>
</tr>
<tr>
<td>calculation basis</td>
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<tr>
<td>Interconnection fee</td>
<td>None</td>
<td>$75-145</td>
<td>$75-145</td>
</tr>
<tr>
<td>Billing and true-up period</td>
<td>Annual billing, annual true-up (both charges and credits roll over for 12 months)</td>
<td>Annual billing, annual true-up (both charges and credits roll over for 12 months)</td>
<td>Monthly billing (pay monthly); annual true-up (credits roll over for 12 months)</td>
</tr>
<tr>
<td>Installation size limit</td>
<td>Customer’s annual electric load with limited exceptions; capped at 1 MW</td>
<td>Customer’s annual electric load with limited exceptions</td>
<td>Customer’s annual electric load plus up to 50% if customer attests to need</td>
</tr>
</tbody>
</table>
California’s Net Energy Metering Transition
Import & Export Prices under NEM 3.0 formally Net Billing Tariff (NBT)
Thermostat Old & New
**Peak-time Energy Saving Rewards**

(“Pay-for-not-using-electricity” example in USA)

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**The hands-on way**

Simply use less electricity between 1 pm – 7 pm on Energy Savings Days. Earn $1.25 for every kilowatt-hour saved by:

- reducing air conditioning use
- delaying the use of large appliances
- turning off lights

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**The automatic way**

Receive $50–200 in bill credits, which includes a first year participation bonus. Your air conditioner will be cycled up to 50% from 1 pm – 7 pm on Energy Savings Days.

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**No sign up necessary!**

Enroll at BGESavings.com

Participate in both and you are guaranteed to receive whichever credit is greater on your summer bills.

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For more energy saving tips, visit BGE.COM/EnergySavingsDayTips

To learn more about your typical energy usage and receive customized saving tips for your home, log into BGE.COM/MyAccount and select the My Energy Use tab.

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**Why is BGE offering these programs?**

BGE is offering these programs to encourage customers to use less energy during summer peak hours. Managing summer peak demand helps to reduce the need for additional power plants, helps to keep down the overall cost of electricity and eases the burden on Maryland’s electricity delivery system as our state’s population continues to grow.

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La versión en español de esta guía está disponible en línea en BGE.COM/EnergySavingsDay/Spanish

These programs support the EmPowerMaryland Energy Efficiency Act.
Peak-time Energy Saving Rewards
(“Pay-for-not-using-electricity” example in USA)
Thank you

For more info contact: sakai@d-sharing.jp
keiichi.tamaki@mac.com
Carbon Intensity Kyushu (March 2023; Non-Working Days)
Area Price Kyushu (March 2023; Working Days)
Area Price Kyushu (March 2023; Non-Working Days)