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 CO_2 emission factors, a.k.a. Carbon Intensity (CI; g-CO_2/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

〔MWh for one-hour interval〕

Date_Time	Area Demand	Nuclear	Thermal	Hydro	Geo-thermal	Biomass	Solar		Wind		Pumping-up Hydro pump-up (-) / generation (+)	Linked to (-) / from (+) Another Utility
							Utilized	Suppressed	Utilized	Suppressed		
2021/4/1 0:00	A	B	C	D	E	F	G	H	I	J	K	L
~												
2022/3/31 23:00												

*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 CO_2 (weighted average) emission modelling, 800g-CO_2/kWh is used for “Thermal” and 0g-CO_2/kWh for all the other power generation methods – just for operation ignoring CO_2 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

Date	Time Code	Sell Bids (kWh)	Buy Bids (kWh)	Sold (kWh)	System Price (¥/kWh)	Area Price Hokkaido (¥/kWh)	Area Price Tohoku (¥/kWh)	Area Price Tokyo (¥/kWh)	Area Price Chubu (¥/kWh)	Area Price Hokuriku (¥/kWh)	Area Price Kansai (¥/kWh)	Area Price Chugoku (¥/kWh)	Area Price Shikoku (¥/kWh)	Area Price Kyushu (¥/kWh)
2021/04/01	1	18858000	18427950	15407900	5.63	6.29	6.29	6.29	6.29	6.29	6.29	6.29	6.29	5.63
~	~													
2022/03/31	48	17305200	17826000	16118900	17.00	16.78	16.78	16.78	16.78	16.78	16.78	16.78	16.78	16.78

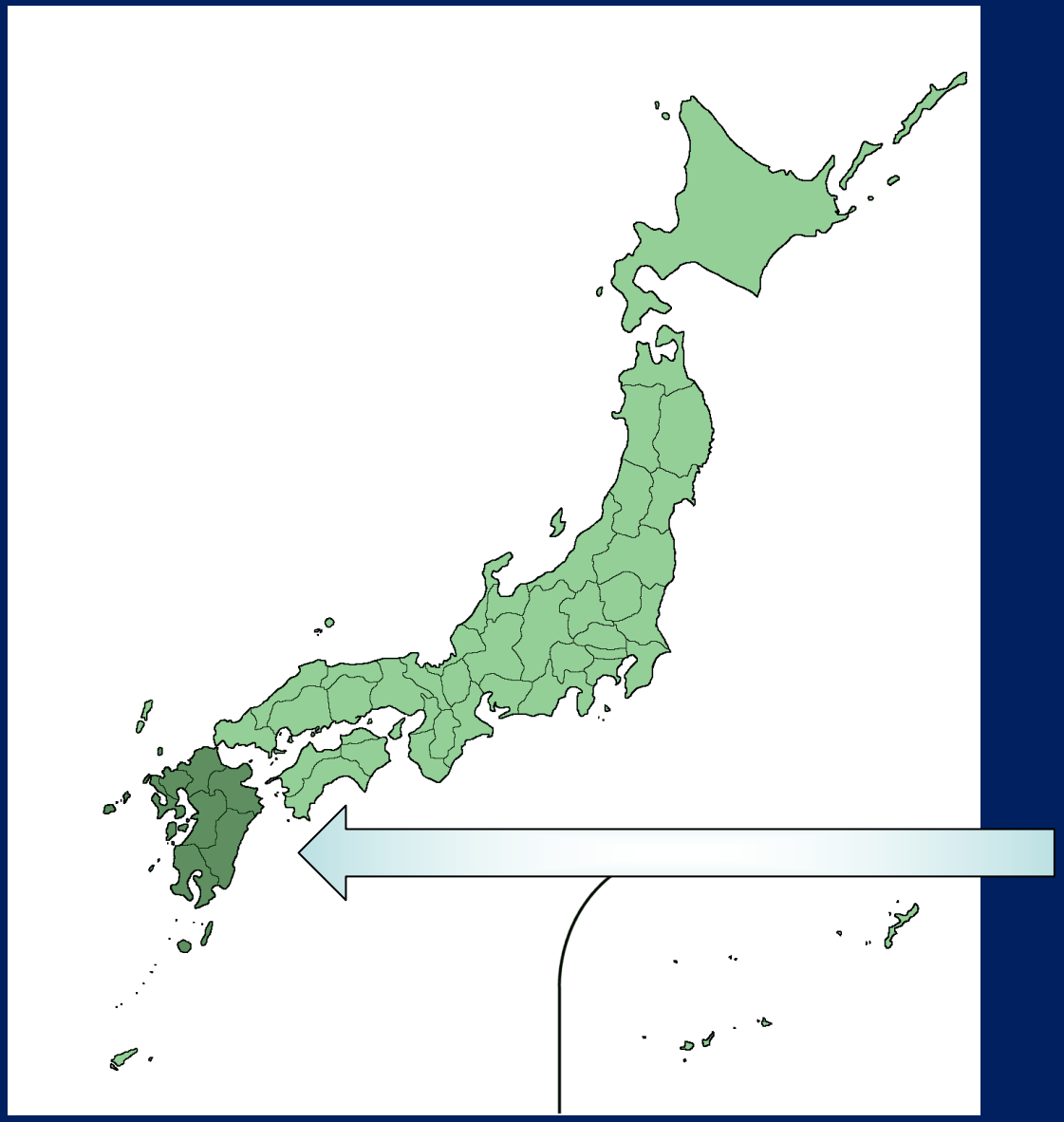
US & UK – Real-Time Data Available

- US California Independent System Operator (CAISO)
  - Electricity Supply Trend by Generation Type
  - CO_2 Emission Trend by Generation Type
- US (East Coast) PJM
  - Electricity Generation by Fuel Type
  - Hourly Total CO_2 Emission by Fuel Type
- UK National Grid
  - Historic Generation Mix (incl. Carbon Intensity)

CO_2 Emission

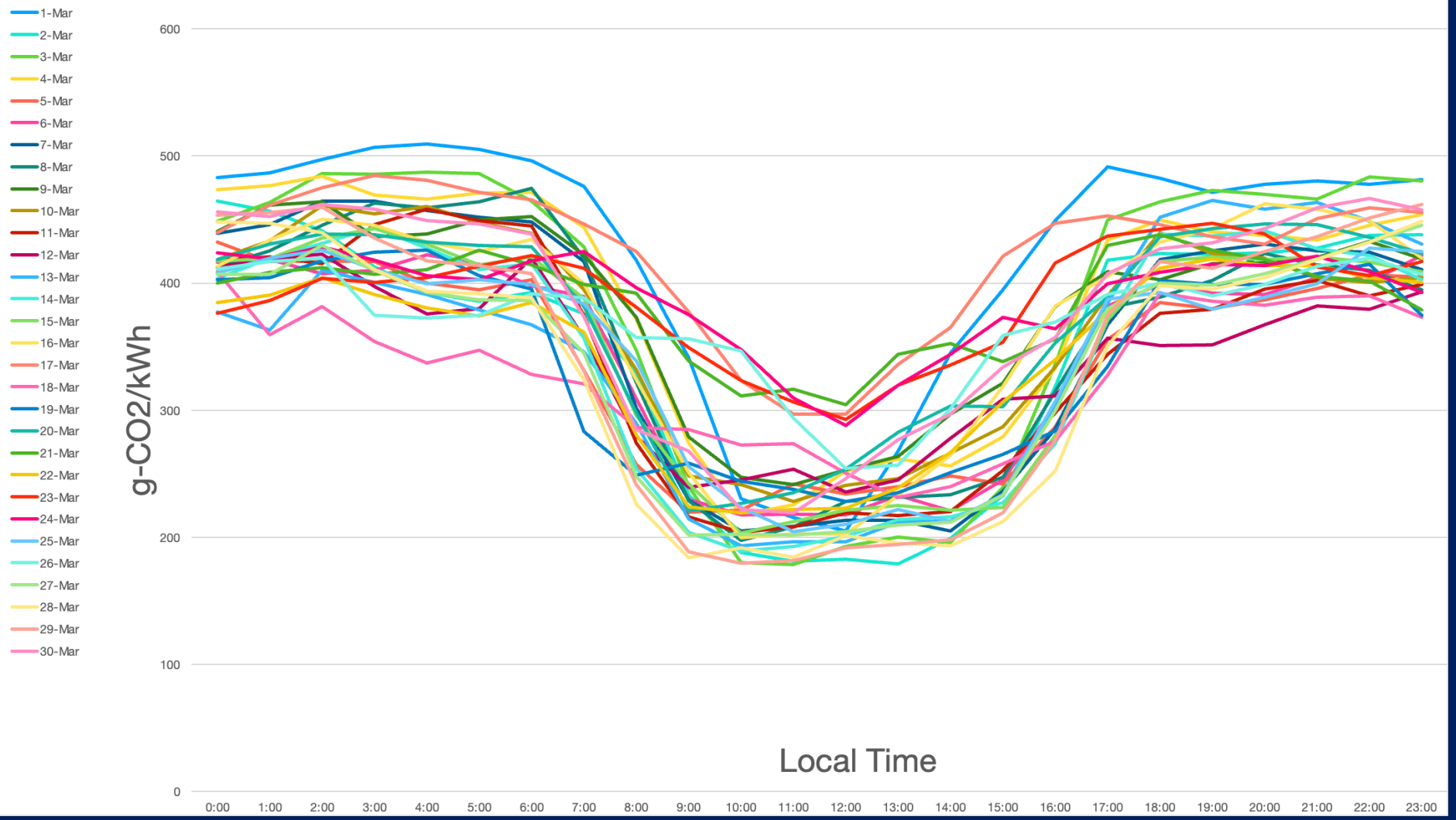
- Decarbonizing transition from fossil-fuel-fired thermal (coal, oil, LNG, LNG combined) to renewable (solar, wind, etc.)
- Analogy with grey, blue, turquoise and green hydrogen
- Clean and dirty electricities get mixed up when fed into grid
- But you can tell weighted average CO_2 emission per kWh, which is known as Carbon Intensity (CI; g-CO_2/kWh)

Kyushu Electric Power Co., Inc. (Kyuden)

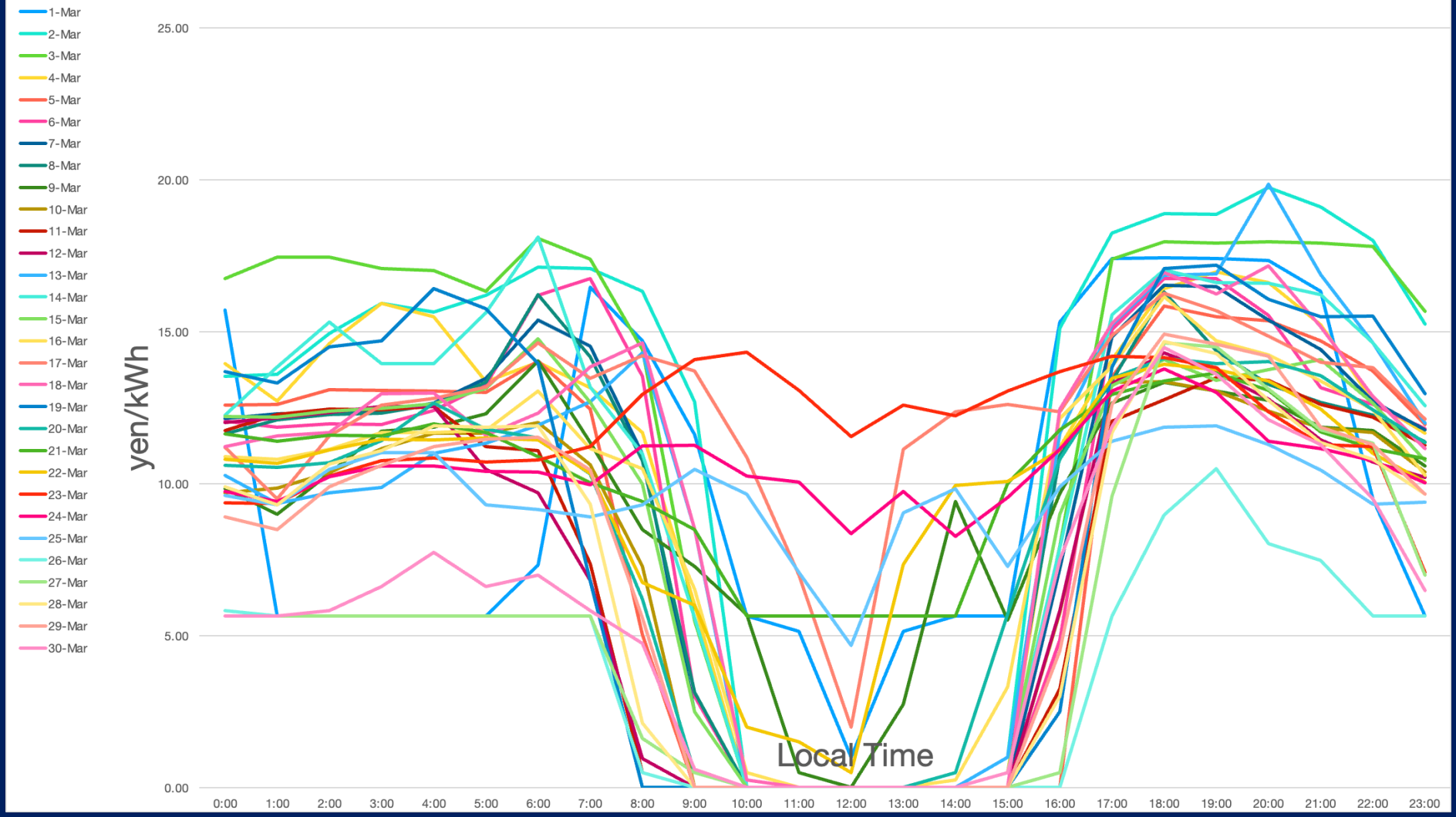


Frontier of Japan's decarbonizing electricity generation transition

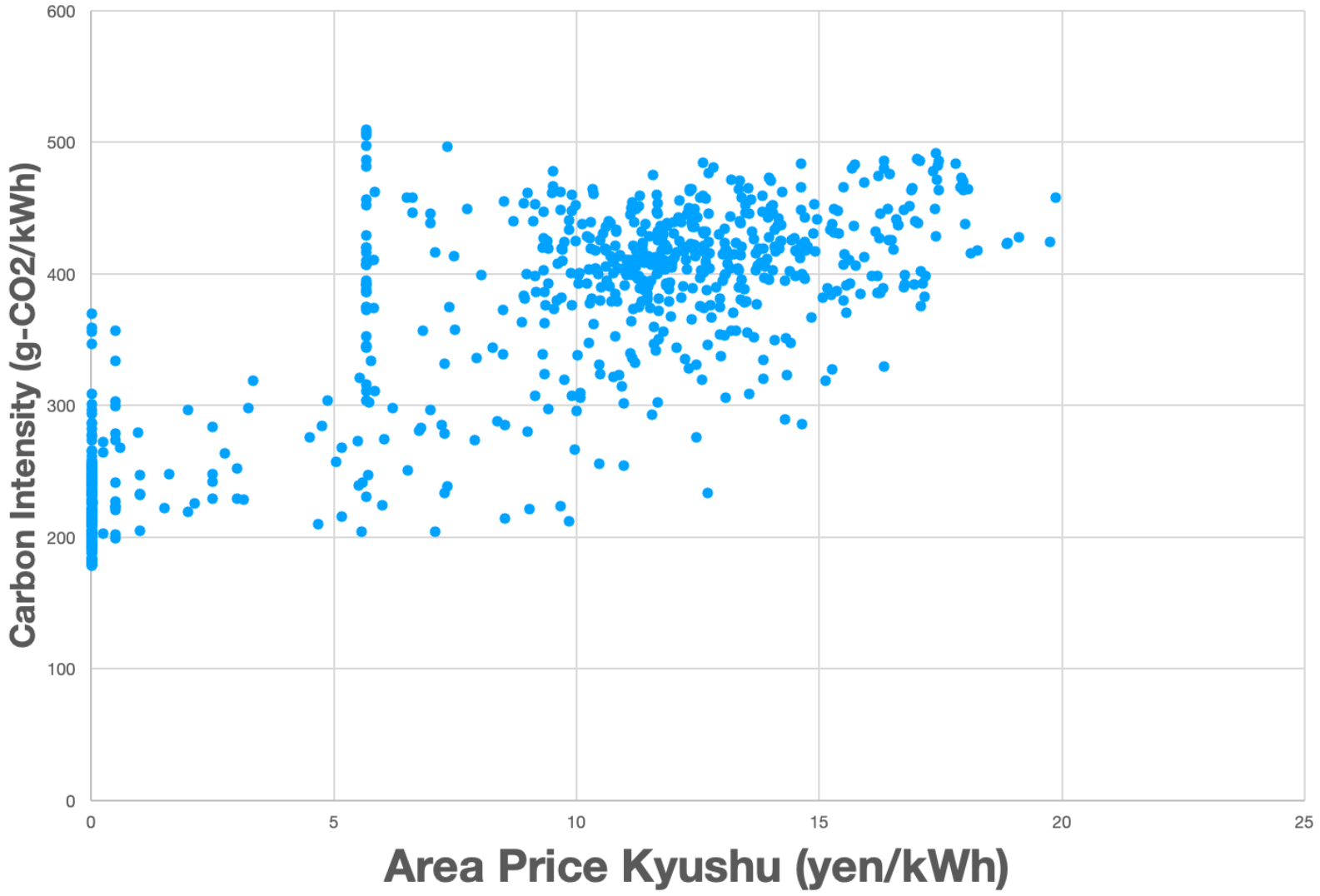
Carbon Intensity Kyushu (March 2023)



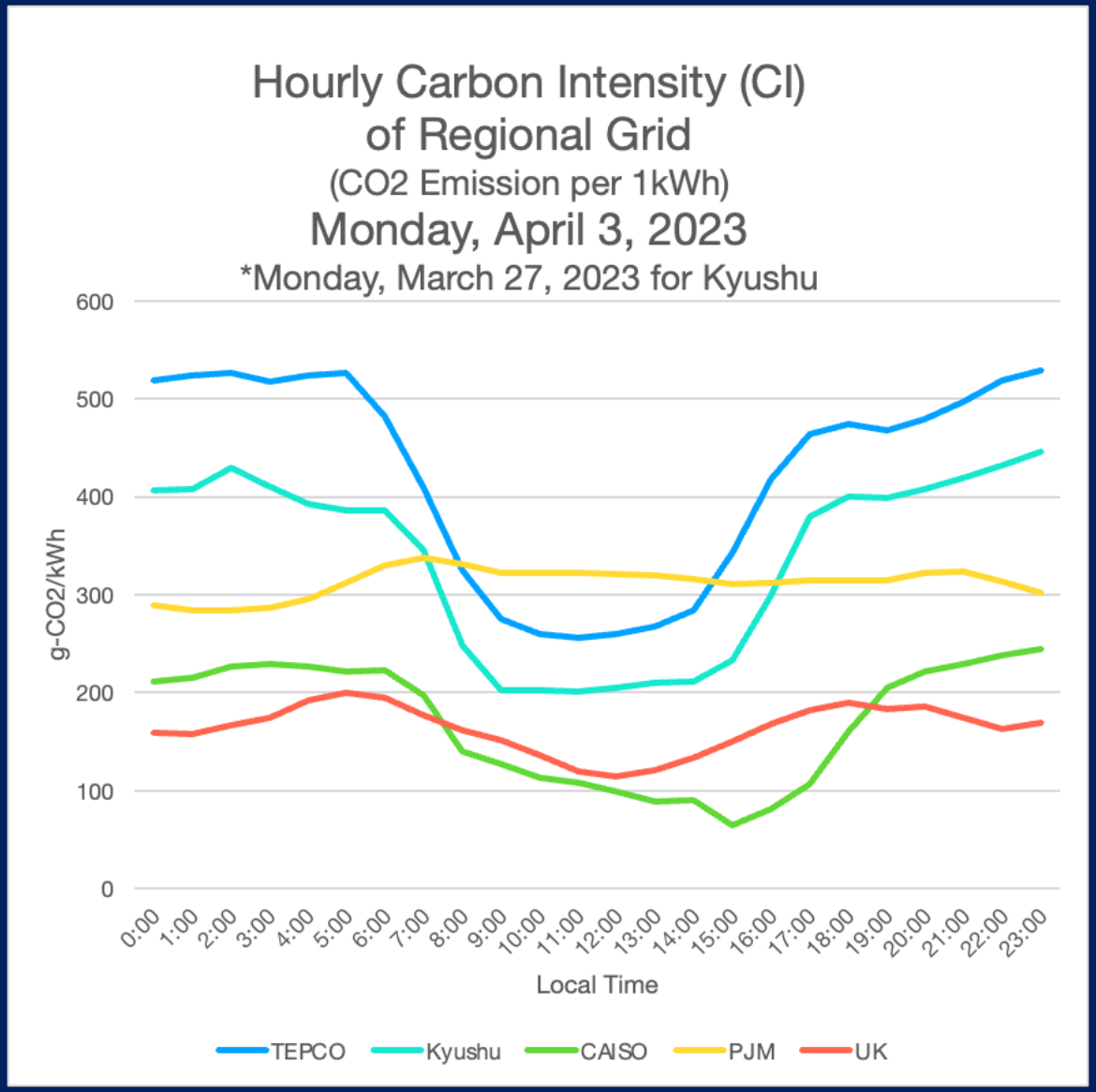
Area Price Kyushu (March 2023)



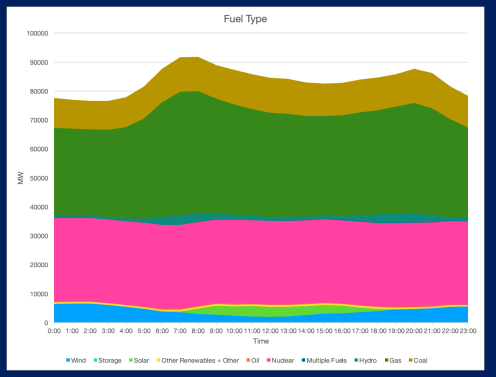
Carbon Intensity vs Area Price Kyushu (March 2023)

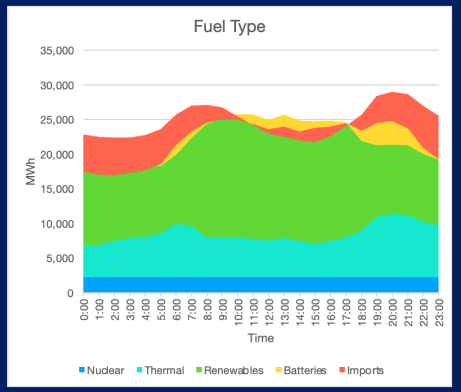


Carbon Intensity (CI; kg-CO_2/kWh)



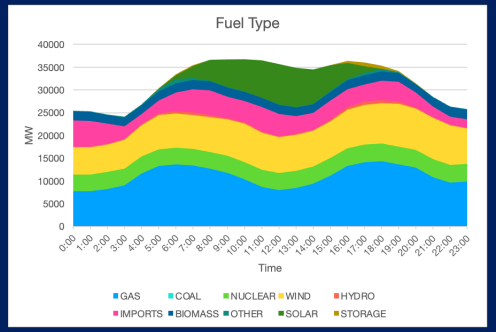
PJM





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

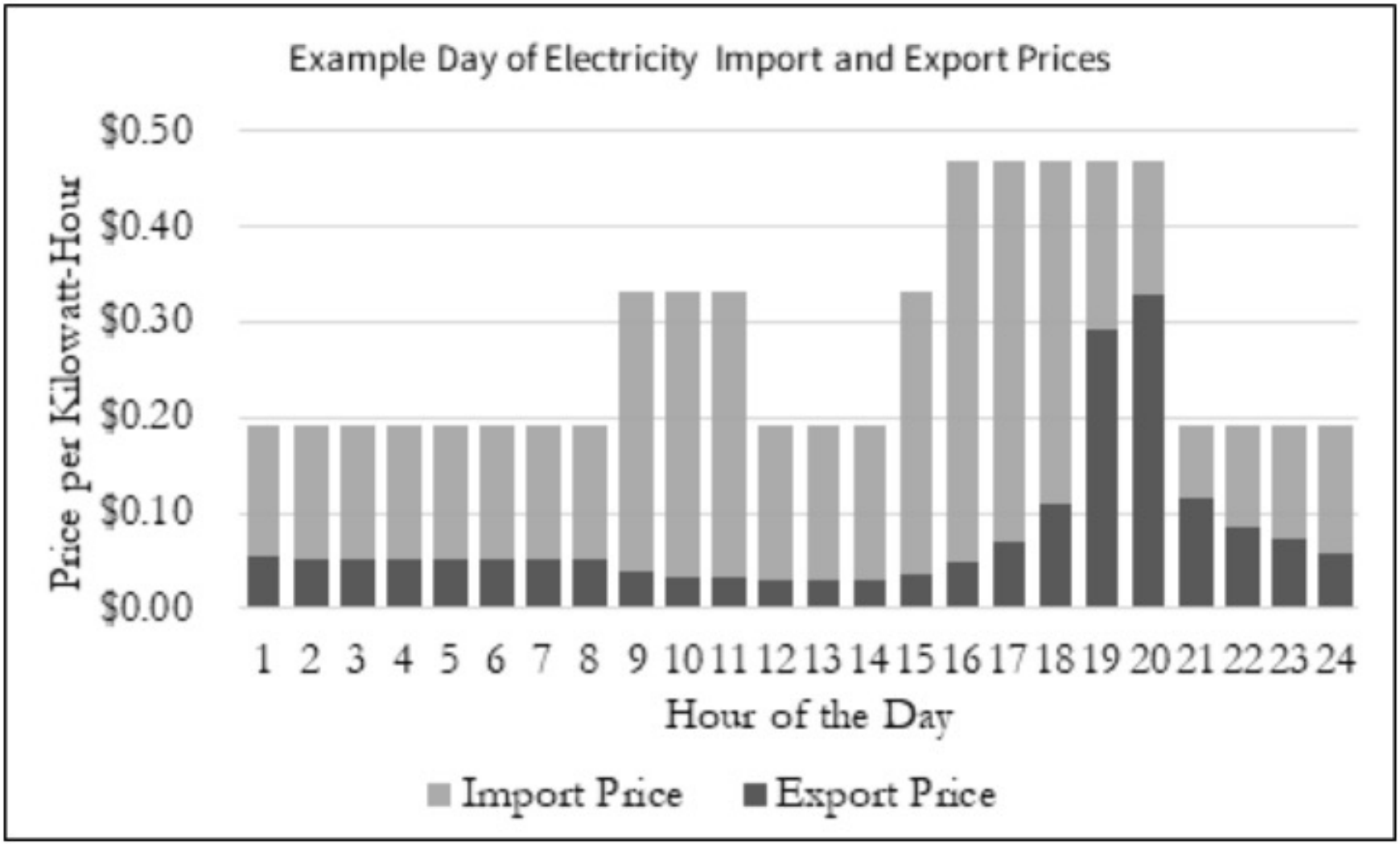
“Incentivizing/Nudging” Demand Shift

- (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

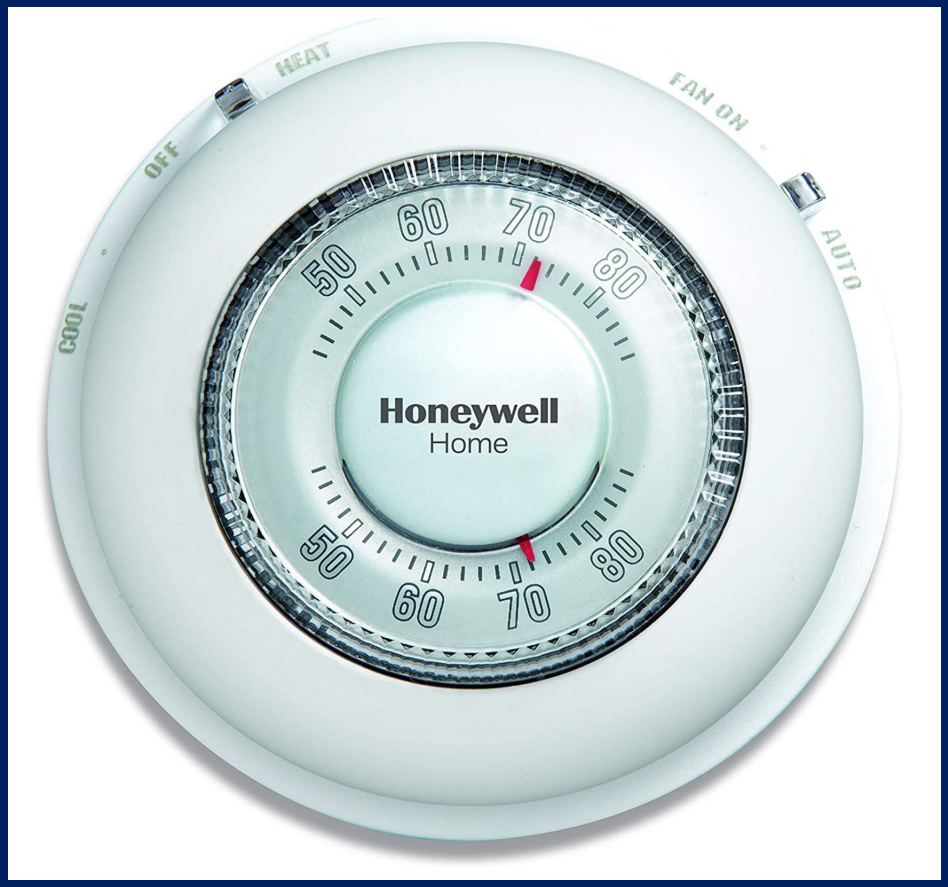
California's Net Energy Metering Transition
NEM 1.0 → NEM 2.0 → NEM 3.0, formally Net Billing Tariff (NBT)

	NEM 1.0	**NEM 2.0**	**NBT**
Eligible import rate schedule	Any	TOU rates	Specific "electrification" TOU rates
Onsite use of generated energy avoids energy imports	Yes	Yes	Yes
Credits for energy exports before true-up basis	Import rates	Import rates	Price of energy that IOUs could buy elsewhere instead
Credits for net surplus energy at true-up basis	Wholesale price of energy to IOUs	Wholesale price of energy to IOUs	Wholesale price of energy to IOUs
Non-bypassable charges calculation basis	Net energy consumed (imports minus exports) in a year	Net energy consumed in a metered interval (1 hour for residential and 15 minutes for nonresidential customers)	All energy imports
Interconnection fee	None	$75-145	$75-145
Billing and true-up period	Annual billing, annual true-up (both charges and credits roll over for 12 months)	Annual billing, annual true-up (both charges and credits roll over for 12 months)	Monthly billing (pay monthly); annual true-up (credits roll over for 12 months)
Installation size limit	Customer's annual electric load with limited exceptions; capped at 1 MW	Customer's annual electric load with limited exceptions	Customer's annual electric load plus up to 50% if customer attests to need

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)

Peak-time Energy Saving Rewards ("Pay-for-not-using-electricity" example in USA)

the **hands-on** way

BGE SMARTENERGY rewards

Put your new smart meter to work for you.

Smart meters provide you access to timely and detailed information about your energy use and make it possible for you to save energy and earn summer bill credits on Energy Savings Days. You are automatically enrolled, so there is no need to sign up and you can participate regardless of your choice of energy supplier.

What are Energy Savings Days?

Energy Savings Days are typically very hot summer weekdays when the demand for electricity is expected to be particularly high. BGE generally schedules Energy Savings Days when homes and businesses are both using higher amounts of electricity, especially through air conditioning. BGE anticipates that there could be up to ten Energy Savings Days each summer.

HERE'S HOW IT WORKS:

we'll notify you
BGE will notify you by phone, email or text between 2 pm – 8 pm the day before an Energy Savings Day. To ensure you receive these notifications, log into **BGE.COM/MyAccount**, verify your email address and phone number shown in the My Profile section and select your notification preferences for *Smart Energy Rewards: Energy Savings Day.*

reduce your use
Between 1 pm – 7 pm on an Energy Savings Day, simply use less electricity by doing things like reducing air conditioning use, delaying the use of large appliances or turning off lights. For more energy savings tips, visit **BGE.COM/EnergySavingsDayTips**.

earn rewards
Within a few days, we'll notify you by phone, email or text to let you know how much you saved. You'll earn bill credits of $1.25 for every kilowatt-hour saved compared to your typical usage on days with similar weather. Your credits will appear on your next bill.

How much can I save?

BGE will calculate your savings by comparing your electricity usage during an Energy Savings Day with your usage on days with similar weather leading up to it. You earn $1.25 for every kilowatt-hour of electricity you reduce on an Energy Savings Day, compared with what you normally use. Based on results from summers 2014-2015, participating customers saved an average of $5-$8* per Energy Savings Day.

*Your actual savings will vary. Customers should exercise discretion and consider health impacts when reducing electricity usage.

Sign up for alerts and stay informed!

BGE will notify you by phone, email or text* the day before an Energy Savings Day. To ensure you receive these notifications, make sure your contact information is up to date through your BGE online account.

Sign up to receive text alerts directly to your mobile phone. Text messages are a great way to receive immediate notification in advance of an Energy Savings Day. To sign up for text alerts:

1. Log into **BGE.COM/MyAccount**
2. Provide your cell phone number under the *My Profile* tab and
3. Select text alerts for *Smart Energy Rewards: Energy Savings Day*

You can cancel your alert subscriptions at any time.

*Data and message rates may apply.

To learn more about Energy Savings Days, visit **BGE.COM/SmartEnergyRewards**.

the **automatic** way

peak rewards

PeakRewards® Air Conditioning (A/C) Program

The PeakRewards A/C program is designed to help ease the peak demand for electricity in the Mid-Atlantic region. By enrolling in the program, you allow BGE to cycle your air conditioner on and off during periods of summer peak demand in exchange for bill credits. As a reward for participation, you'll receive bill credits of $50 – $200* June through September. If there is a significant increase in summer peak energy demand, your PeakRewards device (either a professionally-installed thermostat or outdoor switch) will receive a signal to cycle your air conditioner.

Choose a cycling level that's right for you.

Choose a cycling level that best fits your lifestyle—50%, 75% or 100%.

At **50%**, you receive $50 in summer bill credits ($12.50 per month June-September). During emergency cycling events, your A/C will produce cool air for only half of the time it would normally run.

At **75%**, you receive $75 in summer bill credits ($18.75 per month June-September). During emergency cycling events, your A/C will produce cool air for only 25% of the time it would normally run.

At **100%**, you receive $100 in summer bill credits ($25 per month June-September). During emergency cycling events, your A/C will be off and will not produce cool air for the duration of the event, even if it lasts multiple hours.

To sign up, visit **BGESavings.com**.

*This includes first-year bonus credits. A customer moving into a home with an existing PeakRewards device is not eligible to receive the first-year bonus credits since the bonus is intended for the initial enrollment and installation of a device at a customer's home.

Energy Savings Days and PeakRewards

During Energy Savings Days, your PeakRewards device will only be cycled up to 50%, regardless of your chosen cycling level. You have unlimited cycling overrides on Energy Savings Days. However, as in the past, during emergency cycling events, you will be cycled up to your chosen participation level (50%, 75% or 100%) and overrides are not permitted.

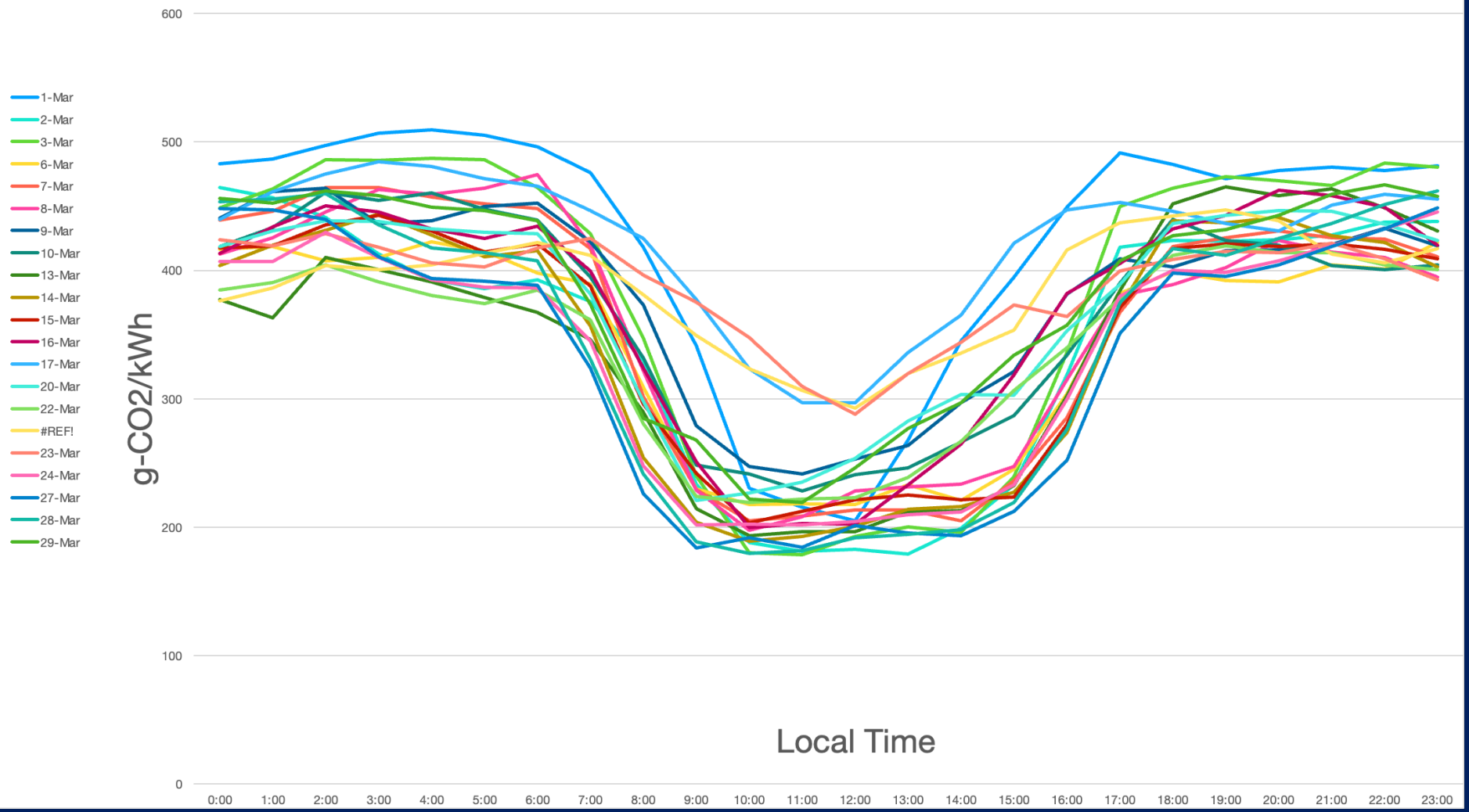
On Energy Savings Days, you can choose ways to voluntarily reduce your energy use, in addition to cycling, and potentially earn more credits. You are guaranteed to receive your monthly PeakRewards credit. If you choose to participate on Energy Savings Days and reduce your electricity usage, you can earn a bill credit of $1.25 for every kilowatt-hour saved compared to your typical usage. You will receive whichever credit is greater; either your PeakRewards credit or your Energy Savings Day credit on your June through September bills.

For more information on how PeakRewards works during Energy Savings Days, visit **BGE.COM/TwoWaysToSave**.

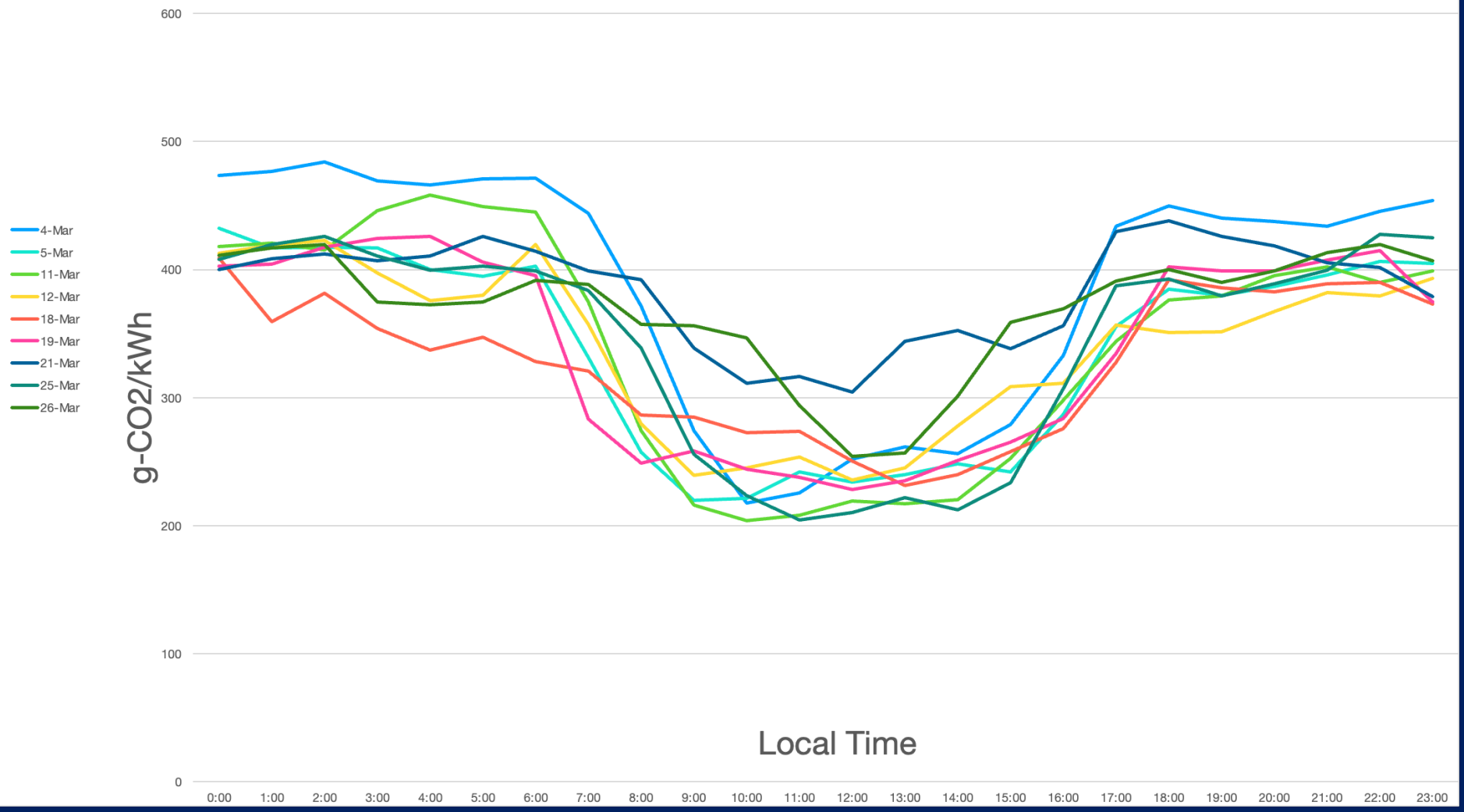
Thank you

For more info contact: sakai@d-sharing.jp
keiichi.tamaki@mac.com

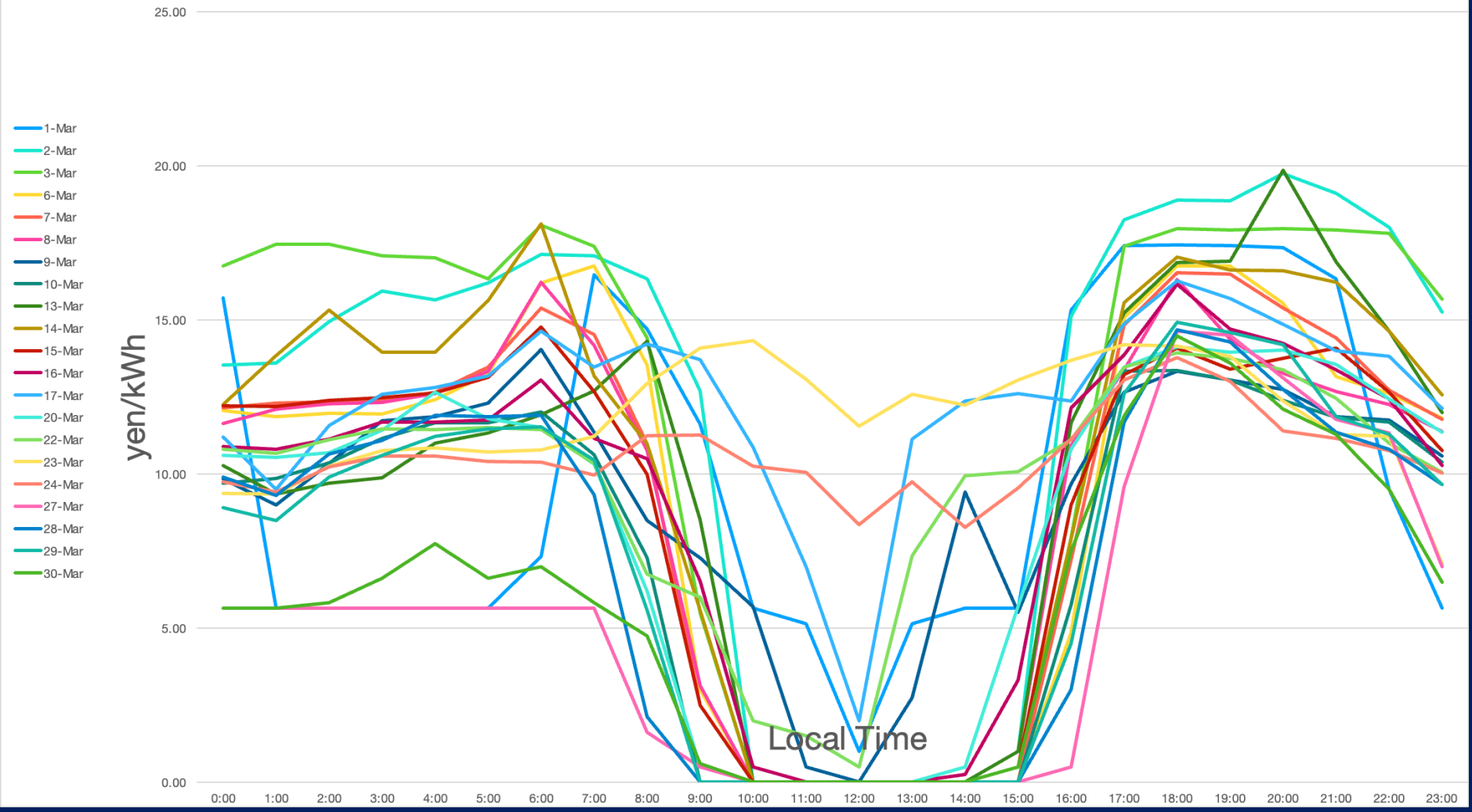
Carbon Intensity Kyushu (March 2023; Working Days)



Carbon Intensity Kyushu (March 2023; Non-Working Days)



Area Price Kyushu (March 2023; Working Days)



Area Price Kyushu (March 2023; Non-Working Days)