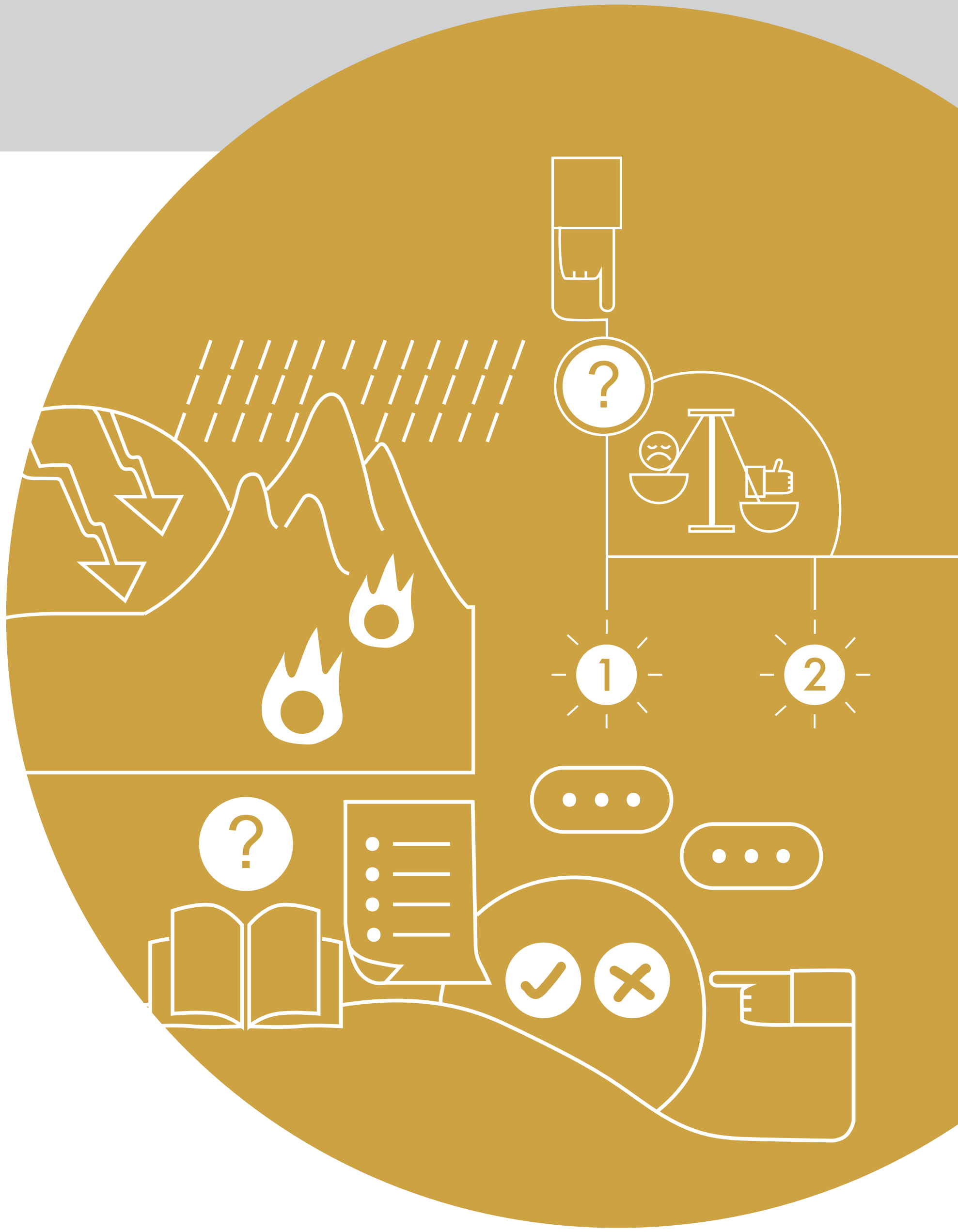


The Online Deliberative Poll on Solar Future in Tokyo

Expressing the Local Voice for 2030

Participant Guide

Tokyo, Japan
4th April 2020

Authors: Daphne Ngar-yin MAH
Darren Man-wai CHEUNG
Glenn Hin-fan LEE
Benjamin-craig MCLELLAN

Hosting Organisations: Kyoto University (Japan)
Hong Kong Baptist University (Hong Kong)
College of the Mainland (US)

in consultation with Center for Deliberative Democracy at Stanford University (US)

CONTENTS

List of Abbreviations

BAU	Business as usual
DR	Demand response
EV	Electric vehicle
FiT	Feed-in Tariff
GW	Gigawatts
GWh	Gigawatt hours
HEMS	Home energy management system
KEPCO	Kansai Electric Power Company
kW	Kilowatts
kWh	Kilowatt hours
Kyuden	Kyushu Electric Power Company
MW	Megawatts
NGO	Non-governmental organisation
PV	Photovoltaic(s)
RE	Renewable energy
TEPCO	Tokyo Electric Power Company
VPP	Virtual Power Plant
W	Watt
ZEV	Zero-emission vehicle

Chapter 1
INTRODUCTION

1.1 Purpose of *the Online Deliberative Poll on Solar Future in Tokyo*

The Online Deliberative Poll on Solar Future in Tokyo creates a platform for gathering citizens from Tokyo for envisioning Tokyo's solar future in 2030. The concept of "Deliberative Polling" was first introduced by Prof. James Fishkin at Stanford University's Center for Deliberative Democracy in 1988. The purpose of "Deliberative Poll" is to engage participants in discussing with others, weighing the pros and cons of issues and policy proposals. The purpose of this online deliberative poll is neither to discuss technical problems nor to study energy predictions in details. Rather, this online deliberative poll allows participants to gain a more considered view on the challenges, trade-offs and opportunities citizens may face if solar is adopted as a main electricity source in Tokyo.

It is also an opportunity for the Tokyo Metropolitan Government to learn people's preferences on their ideal future. The government can also use the result of the discussions to consider how to better support the energy policies in the city.

1.2 Who are the participants in *the Online Deliberative Poll on Solar Future in Tokyo?*

The key participants at the Online Deliberative Poll on Solar Future in Tokyo are Tokyo citizens. A random, representative sample of 180 citizens is recruited as participants of this online deliberative poll based on sex and age groups of the population structure of Tokyo. Experts who hold expertise in solar energy and energy policy development in Japan are invited to sit in this online deliberative poll and answer questions. A technical team will monitor the online platform throughout the online deliberative poll and take enquiries from participants who need technical assistance to the online platform.

1.3 What Platform is this Project Using?

This online deliberative poll utilises the Stanford Online Deliberative Platform for online discussions among our participants. Designed by the Center for Deliberative Democracy and the Crowdsourced Democracy Team at Stanford University, the Stanford Online Deliberative Platform is a web-based platform that facilitates thoughtful, respectful, and informative discussions on issues with the use of an automated moderator. The main functions of the automated moderator include:

1. stimulating participants to consider arguments from both sides of all proposals;
2. maintaining civility in the discussion;
3. encouraging equitable participation by all participants; and
4. providing a structured collaboration phase for participants to come up with a small set of questions or action items.

To ensure these functions, the platform has features such as a speaking queue for participants to speak, prompts to encourage participants to join the discussion, and time limit for participants' speech in order to facilitate participants to discuss the pros and cons of the solar future.

Even though the platform is automated; rest assured, the platform's technical team will stand by and monitor the platform during the online deliberative poll and resolve any issues that may arise.

Chapter 1 Introduction

1.4 Who Supports this Effort?

This online deliberative poll is organised by the Executive Committee of the Online Deliberative Poll on the Solar Future in Tokyo, a research consortium formed by academies from Kyoto University (Japan), Hong Kong Baptist University (Hong Kong) and College of the Mainland (US) in consultation with the Center for Deliberative Democracy at Stanford University (US). The Executive Committee is also responsible for editing this participant guideline to ensure balanced and accurate information of the energy issues and solar future options for deliberation at the Online Deliberative Poll on Solar Future in Tokyo.

This document was reviewed by a Steering Committee, which includes experts from academia and utilities sector. They are responsible for providing advices and feedback for this participant guide and the questionnaires from a standpoint of experts. The Steering Committee will also act as expert panels during the Online Deliberative Poll on Solar Future in Tokyo. They will answer questions on future solar development raised from participants during the plenary sessions.

The members of the Steering Committee include (in alphabetical order):

AOKI Kazumasu (青木　一益)

Professor, Academic Assembly,
Faculty of Social Sciences,
University of Toyama
(富山大学 学術研究部社会科学系
(経済学部) 教授)

MCLELLAN Benjamin-craig (マクレラン　ベンジャミンクレイグ)

Associate Professor,
Graduate School of Energy Science,
Kyoto University
(京都大学 エネルギー科学研究科 准教授)

SHIHARA Keiichi (石原　慶一)

Professor,
Graduate School of Energy Science,
Kyoto University
(京都大学 エネルギー科学研究科 教授)

NISHIMURA Kiyoshi (西村　陽)

Deputy Director, Customer Relations and Services Division, Kansai Electric Power;
Specially Appointed Professor, Business Engineering, Digital & DER Innovation,
Osaka University
(関西電力お客さま本部 担当部長；
大阪大学大学院工学研究科 ビジネスエンジニアリング専攻 特任教授)

KISHITA Yusuke (木下　裕介)

Lecturer,
Graduate School of Engineering,
University of Tokyo
(東京大学 大学院工学系研究科 講師)

OBANE Hideaki (尾羽　秀晃)

Visiting Researcher,
Central Research Institute of Electric
Power Policy (CRIEPI)
(電力中央研究所 特別契約研究員)

The Executive Committee would like to sincerely thank Center for Deliberative Democracy and the Crowdsourced Democracy Team at Stanford University for providing consultation and technical support for the online deliberative poll. This session would also not have been possible without the generous funding support from General Research Fund of the University Grants Committee in Hong Kong (Project No: 12602717) and the Research Committee of Hong Kong Baptist University.

1.5 Agenda for the Day

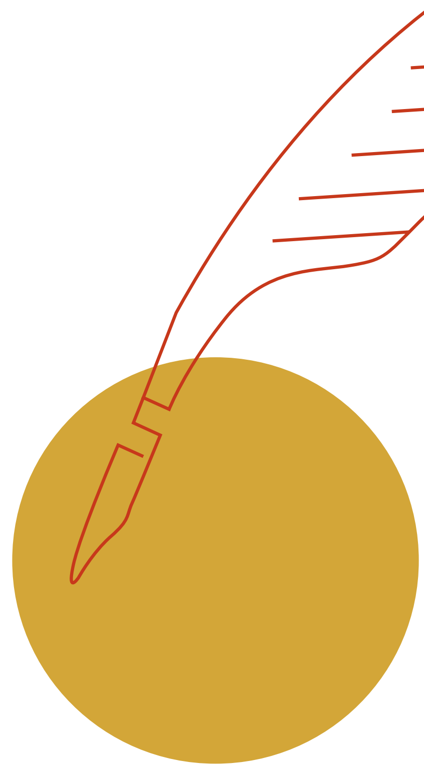
4th April 2020 (Saturday)

1:00 – 1:20 p.m.	**Pre-DP questionnaire & software trail period**
1:20 – 1:30 p.m.	Break
1:30 – 2:30 p.m.	**Small group discussion 1**
2:30 – 2:40 p.m.	Break
2:40 – 3:40 p.m.	**Plenary session 1**
3:40 – 3:50 p.m.	Break
3:50 – 4:50 p.m.	**Small group discussion 2**
4:50 – 5:00 p.m.	Break
5:00 – 6:00 p.m.	**Plenary session 2**
6:00 – 6:45 p.m.	**Small group discussion 3 (summary) & Post-DP questionnaire**

Chapter 1 Introduction

1.6 Instructions

1. *The Online Deliberative Poll on the Solar Future in Tokyo* process begins with a questionnaire on a representative sample of the public.
2. A random, representative sample of 180 Tokyo citizens is recruited to participate in this online deliberative poll.
3. Prior to the event, participants fill out a pre-event questionnaire (T1).
4. A trial testing for the web platform is provided about 1 week before the online deliberative poll.
5. Participants receive balanced briefing materials (this Participant Guide) on the solar future options in Tokyo.
6. Participants fill out a pre-deliberation questionnaire (T2) right before the event.
7. At the event, participants are randomly assigned to small groups with automated moderators.
8. Participants pose questions to experts in the plenary sessions.
9. Participants summarise their considered opinions in the third small group discussion.
10. Participants fill out a post-deliberation questionnaire (T3) right after the event.
11. Results are analysed and released.



Chapter 2
THE ISSUE

2.1 Statement of the Problem

Fossil fuels have been one of the major part of the electricity mix in Japan. According to Figure 1, since the Great Eastern Japan Earthquake in 2011, there has been a marked reduction on nuclear energy in the electricity mix, from 31% in 2010 before the Fukushima Nuclear Accident to 2% in 2012 after the Accident, and gradually increased to 7% as of 2018. Fossil fuels has significantly increased from 60% of the electricity mix in 2010 before the Fukushima Nuclear Accident to 89% in 2012 after the Accident, and reduced to 79% in 2018. Meanwhile, solar only accounted for around 1% in the electricity mix as of 2018.

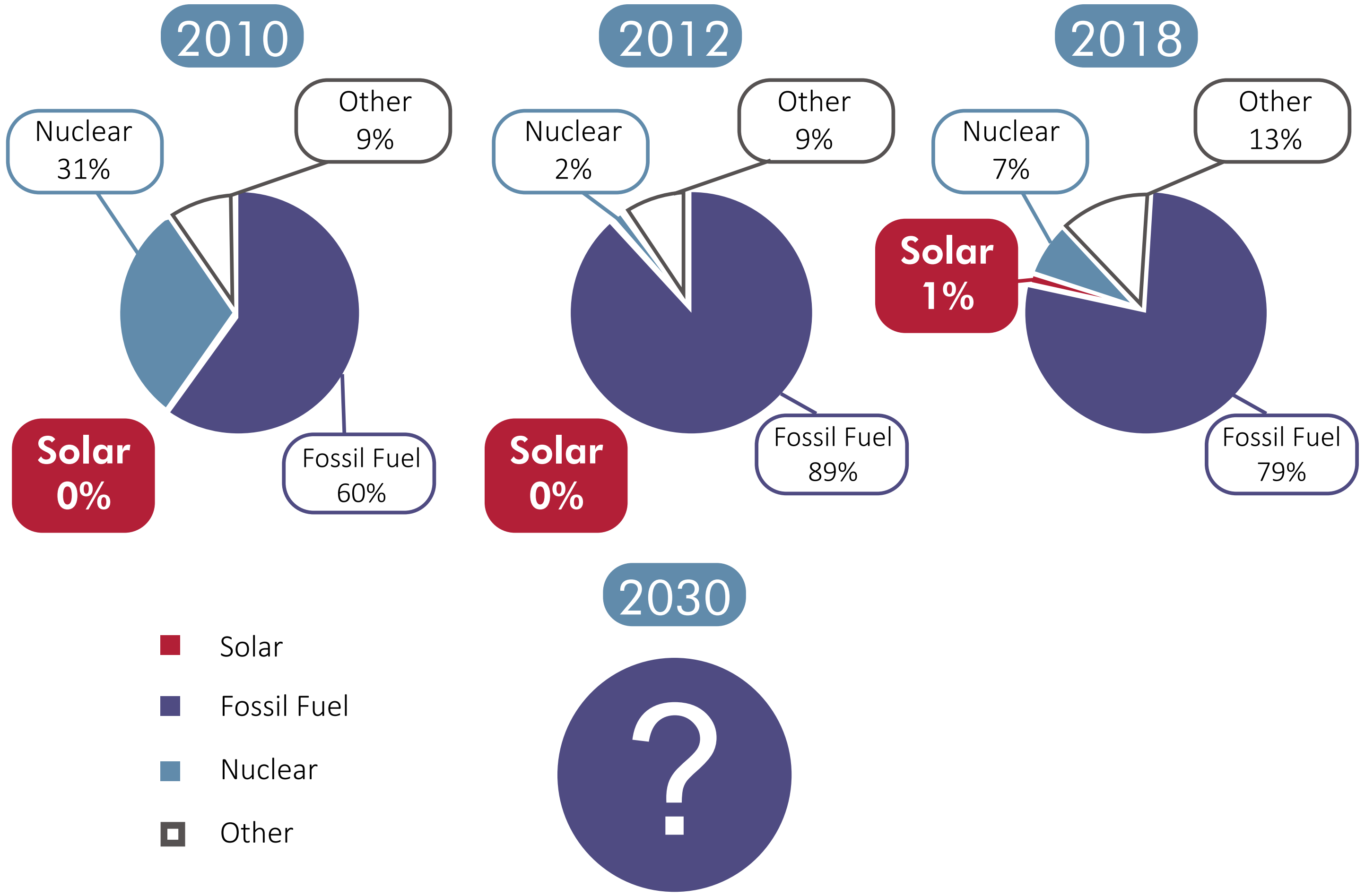


Figure 1. Japan's electricity mix in 2010, 2012 and 2018
(Source: Compiled from data published by Agency of Natural Resources and Energy in 2018)

For years, Japan relies on fossil fuels to generate electricity, and the effect of climate change has started to affect Japan and the globe. For examples:

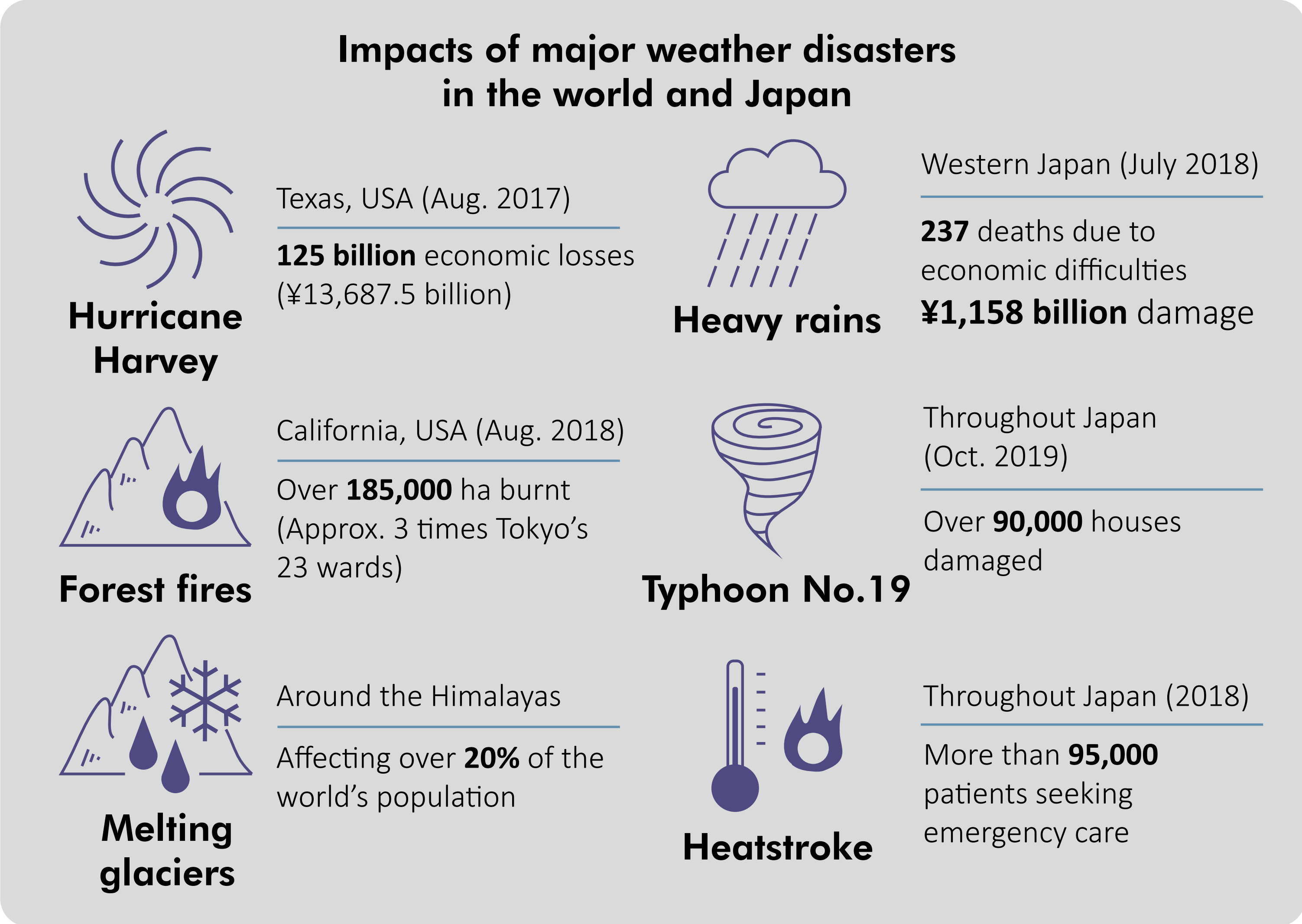


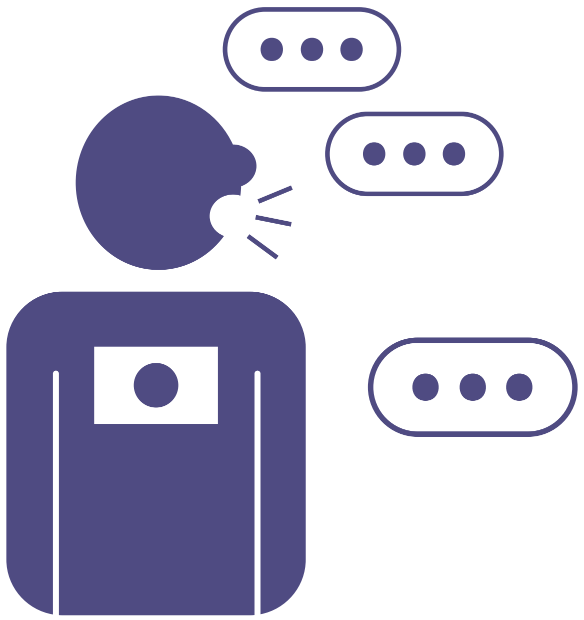
Figure 2. Impacts of major weather disaster in the world and Japan
(Source: Tokyo Metropolitan Government, 2019, Zero Emission Tokyo Strategy (ゼロエミッション東京戦略))

It is expected that the effect of climate change will be more obvious. The use of more solar in the future can provide a way to at least lower the greenhouse gases emission and slow down climate change. Since the effect of climate change is close to Japan and Tokyo, it becomes more important for Tokyo citizens to discuss about the future energy development of Tokyo seriously. According to the Tokyo Environmental Basic Plan in 2016 (東京都環境基本計画), Tokyo will use more renewable energy, especially solar, in the next ten years to reduce carbon dioxide emission to mitigate climate change. It is thus important for Tokyo citizens to consider the challenges, trade-offs and opportunities after weighing the pros and cons of using solar as one of the main electricity sources in the future.

2.2 Why are Tokyo Citizens' Voices Important?

Tokyo citizens' voices are important in the solar future in Tokyo as the role of citizens in the electricity market will be transformed from electricity consumers to prosumers (生産消費者). Unlike fossil fuels and other conventional electricity sources which require centralised electricity system and power plants to generate electricity, renewable energy (RE), including solar, require a more decentralised electricity system and even individuals can produce own electricity. For instance, Tokyo citizens can install solar panels on their rooftops with supporting equipments such as storage batteries. Both the Government of Japan and Tokyo Metropolitan Government have been proactive in promoting solar panel adoption at individual level.

One of the major renewable energy policies is the residential Feed-in Tariff (FiT) provided by the Government of Japan. The FiT provides a premium payment per unit of solar electricity guaranteed for a long period of time. It allows local residents to use the RE produced first for self-consumption before selling the surplus renewable electricity to electric utilities. The residential sector has higher FiT rates and a shorter contract length (10 years) than the non-residential sector (See Appendix 3).

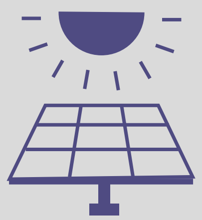


As a policy beneficiary, the Tokyo citizens' voice is essential to the RE development. The result of the discussion in this online Deliberative Poll will be heard by policy makers, academes and electricity companies. Participants' opinions may affect Tokyo's energy policies in the future.

Chapter 2 The Issue

2.3 Main Issues, Key Terminologies and Brief Explanation

Table 1. Main issues and key terminologies



Security of Supply

It refers to whether citizens can reduce reliance on electricity grids to become less susceptible to future energy price increase. It also refers to the independence on electricity generation, on whether people can be protected from power outage caused by natural disasters (e.g. earthquakes). Installing solar panels on the rooftops can be one potential option to enhance the security of supply as solar panels can provide electricity to the owner independently.

Energy Autonomy

It refers to the degree to which local generation for local consumption can replace grid power or external support in the form of energy import. Citizens can enhance energy autonomy through installing storage batteries with solar panels, allowing them to store surplus electricity produced and use them during nighttime.

Cost

The cost for electricity is subject to change. a.) For the upfront cost for installing solar panels, it will depends on the solar PV system costs in the future. b.) For citizens who have installed solar panels, their electricity charges depend on the amount of FiT recevied from electricity generation, the amount of electricity consumption from the grid and amount of renewable energy surcharges. Time-of-use tariff can be applied in full scale in the future which people need to pay a higher rate during peak hour and lower rate at off-peak hour.

Grid Interconnection

It refers to connecting distributed power facilities to a grid. On a local level, it refers to connecting solar panels on citizens' rooftops to the grid. It is a critical process to receive FiT from utilities and sell electricity to the retailers. On a national level, it refers to connecting utilities' grids and form a regional and even national grid which covers most of Japan.

Convenience

Convenience. Convenience can refer to the degree for citizens to save time and efforts on managing family daily routines. In addition, for adopting renewable energy, convenience can refer to the degree of modifications need to be made by citizens for accommodating the new electricity generation system (e.g. space area required, modification to the rooftops etc.)

Demand Response

DR is all intentional electricity consumption pattern modifications by end-use customers that are intended to alter the instantaneous electricity demand, or total electricity consumption. DR works in two ways. The first way is to shift the demand from peak period to off-peak period through introducing dynamic pricing. The second way is to reduce consumption through encouraging consumers to adopt energy saving practices.

Electricity Market Reform

The Government of Japan has introduced an electricity market reform since 1995 to fully liberalise the electricity market, and the reform is expected to complete by 2020. It has attracted new companies to join the electricity retail market. Citizens can then choose electricity suppliers in the market without being tied by utilities. It can also become possible to use 100% solar electricity by choosing suppliers which generate electricity solely from solar panels.

Types of Electricity Markets

The Japanese electricity market reform can allow different types of electricity market to co-exist in Japan. This reform allows Japan to introduce a national markets by increasing the transmission capacity between grids. In addition, a liberalised market enables companies to collect solar electricity from Tokyo citizens and sell them to other local consumers, which forms a local electricity market.

Solar Investment

Tokyo citizens without solar panels can still support solar by investing in community-owned/ citizen-owned solar projects. Most of these projects are operated by NGOs and community organisations.

Chapter 2 The Issue

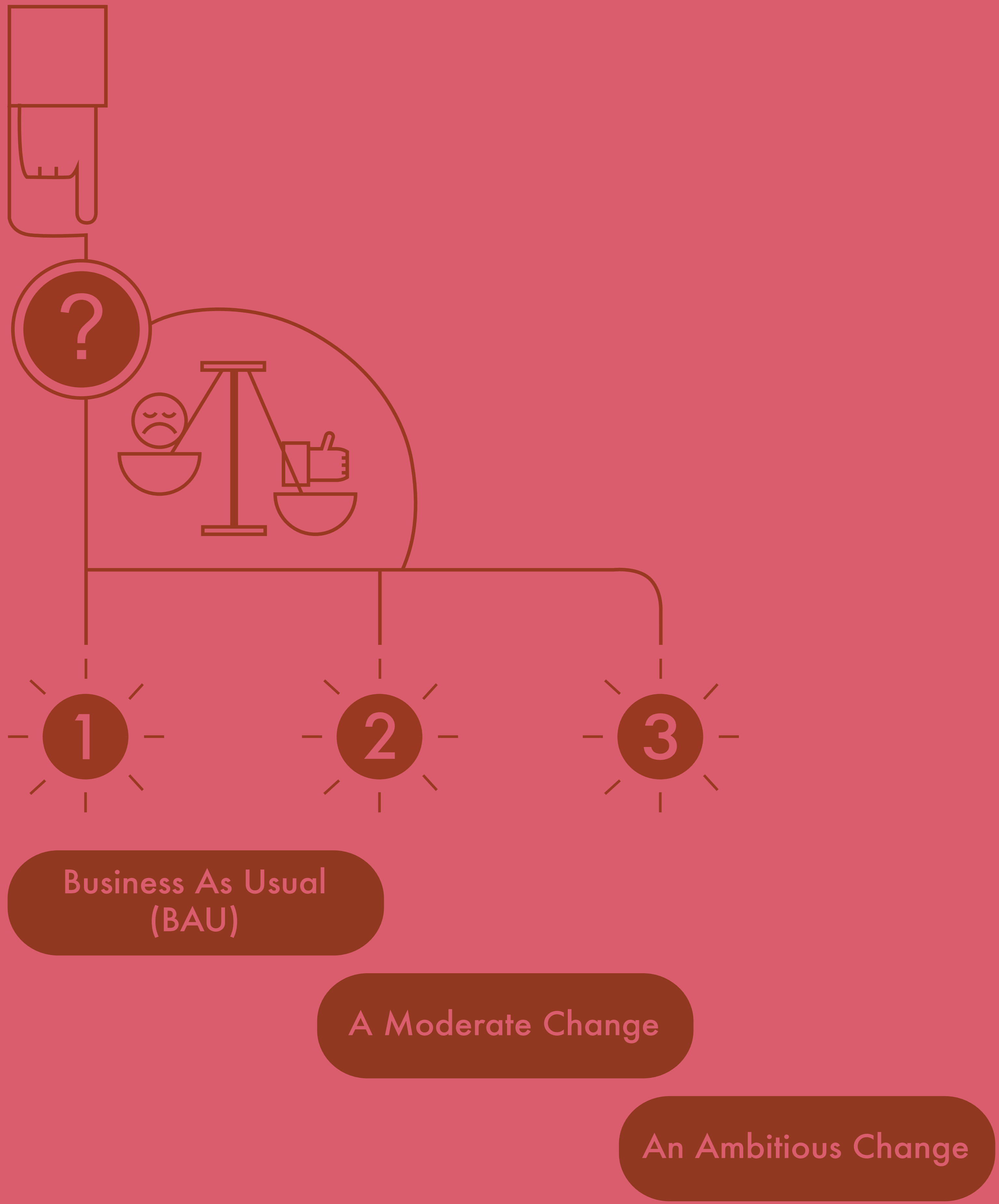
Electricity Vehicles

EVs can also serve as a mobile battery for Tokyo's citizens. EVs' battery can serve as a storage battery for solar panels and provide electricity to houses while in need. At present, an EV's battery can provide electricity for two to four days for a family's consumption in Tokyo.

Virtual Power Plant (VPP)

VPP as a cloud-based (virtual) power system which collects and integrates the capacities of different distributed energy resources (which include solar electricity) and energy storage systems (which include EVs) for the purposes of optimising electricity generation, as well as trading or selling electricity in electricity markets. VPP can result in cost and loss minimisation.

Please refer to Appendix 4 for detailed explanation.



Chapter 3
THREE OPTIONS OF SOLAR FUTURE IN TOKYO

Chapter 3 Three Options of Solar Future in Tokyo

3.1 Summary of the Three Alternative Solar Future

1 Option 1: Business As Usual (BAU)

The first option of Tokyo's Solar Future is to increase the ratio of solar electricity generated within Tokyo to 2% of the Tokyo's electricity consumption mix, with another 28% comes from renewable energy (RE) mainly imported from outside Tokyo, by which the RE targets set by the Tokyo Metropolitan Government can be achieved[1]. Tokyo citizens pay electricity charges based on either a tier-based tariff or nighttime tariff plans, with a RE surcharge for financing Feed-in Tariff (FiT) and grid connection of solar PV systems. A few homes have installed storage batteries which can be used for storing solar electricity or emergency. In addition, Tokyo citizens can support RE through purchasing RE certificates. The grid interconnection capacities have also increased, allowing regional electricity trading in Kanto region.

2 Option 2: A Moderate Change

The second option of Tokyo's Solar Future is to increase the ratio of solar electricity generated within Tokyo to 7% of the Tokyo's electricity consumption mix, with another 24% comes from RE mainly imported from outside Tokyo, by which the Government of Japan's Paris Agreement commitment of 26% reduction in carbon emissions can be achieved. Tokyo citizens pay electricity charges based on a time-of-use tariff with mild allowances for off-peak use, with a RE surcharge for financing FiT and grid connection of solar PV systems. Some homes have installed storage batteries which can maintain emergent use temporarily. In addition, there are some small and medium-sized electricity retails selling 100% RE for citizens to choose. The grid interconnection capacities have also increased, allowing regional electricity trading in north-eastern and central Japan.

3 Option 3: An Ambitious Change

The third option of Tokyo's Solar Future is to increase the ratio of solar electricity generated within Tokyo to 30% of the Tokyo's electricity consumption mix, by which the RE targets set by the Tokyo Metropolitan Government can be achieved solely by solar electricity generated within Tokyo. Tokyo citizens pay electricity charges based on a time-of-use tariff with higher rates for peak-hour use, with a RE surcharge for financing grid improvement. Most homes have installed storage batteries which can maintain normal electricity consumption for about a week. In addition, there are many choices for citizens to choose whether and which RE sources to purchase from various electricity retailers. The grid interconnection capacities have also increased, allowing regional electricity trading in the main islands.

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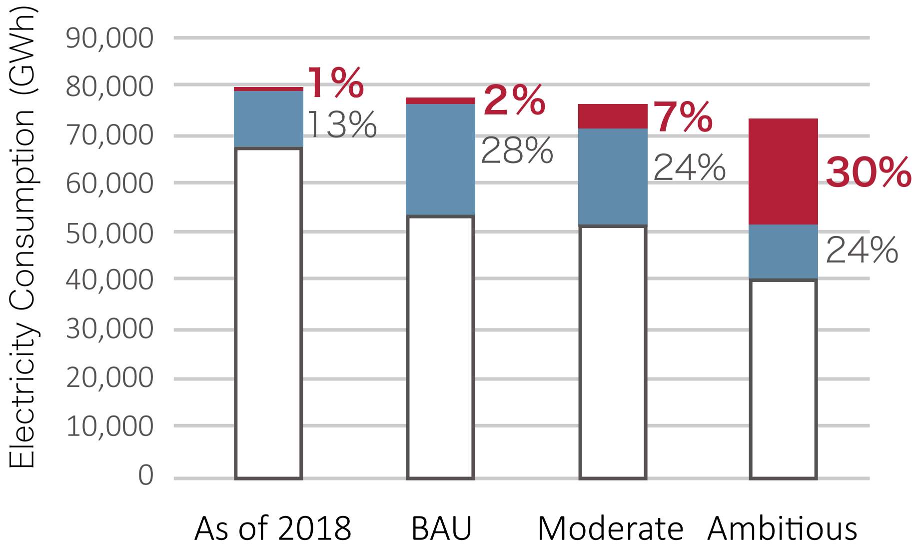
1 The Tokyo Metropolitan Government has announced the renewable energy target for 2030 in the "Tokyo Environmental Basic Plan" published in 2016, which includes a 1.3 GW solar installed capacity target in 2030.

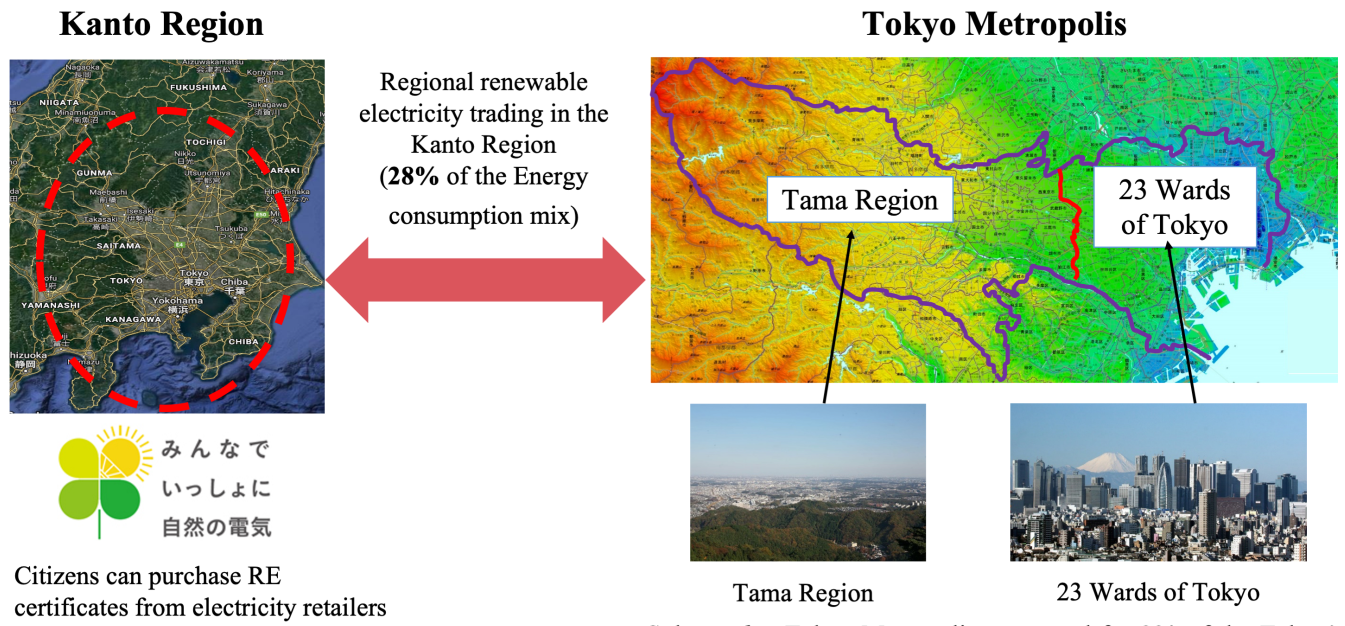


Options	Solar electricity generation within Tokyo
As of 2018	530 GWh
BAU	1,300 GWh
Moderate	5,200 GWh
Ambitious	22,151 GWh

- Solar electricity generation whithin Tokyo
- RE imported from outside Tokyo
- Other electricity (inc. coal, natural gas and nuclear energy)

Figure 3. Solar electricity and RE generation in the electricity consumption mix in Tokyo at present and under the 3 Solar Future Options

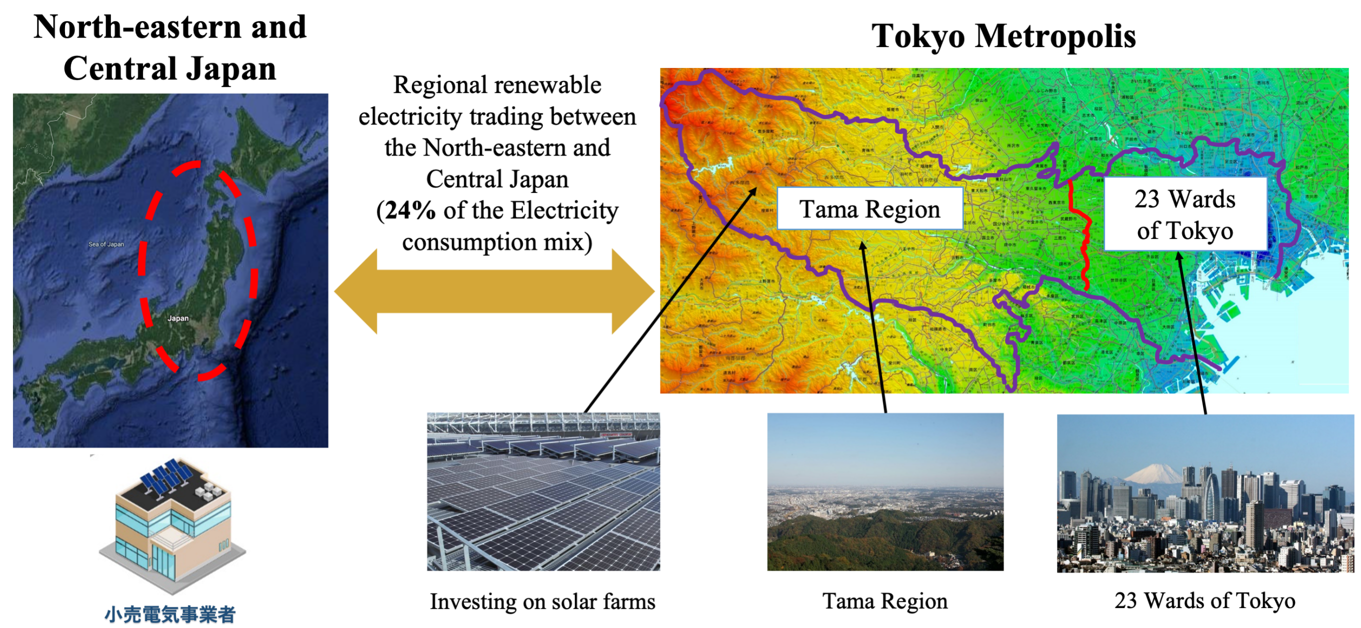
Figure 4a. Option 1: Business As Usual (BAU)
(2% of Tokyo's electricity consumption mix will come from solar generated within Tokyo Metropolis)



Citizens can purchase RE certificates from electricity retailers to support renewable energy.

Solar *within* Tokyo Metropolis accounted for **2%** of the Tokyo's electricity consumption mix (**1,300 GWh**). Most of the solar electricity generated from **20%** of detached houses which have installed rooftop solar PV system.

Figure 4b. Option 2: A Moderate Change
(7% of Tokyo's electricity consumption mix will come from solar generated within Tokyo Metropolis)

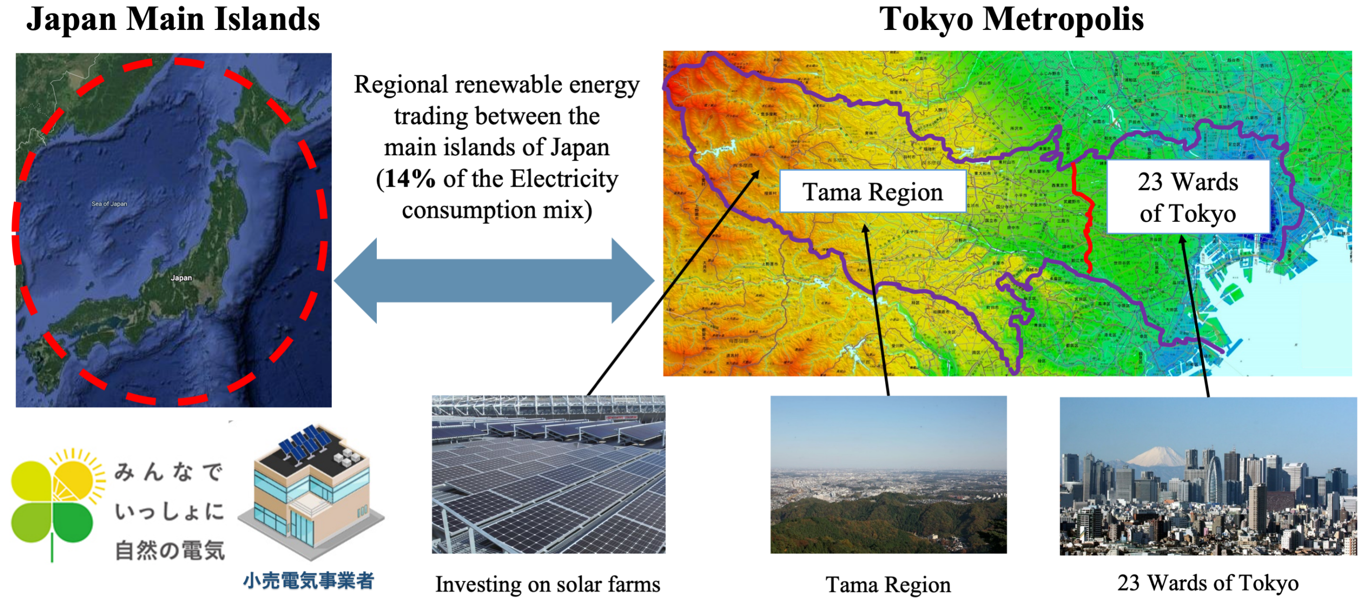


Some small and medium-sized electricity retails selling 100% RE are now available for residential customers.

A few choices for citizens to invest on local solar projects managed by NGOs or community organisations.

Solar *within* Tokyo Metropolis accounted for **7%** of the Tokyo's electricity consumption mix (**5,200 GWh**). Most of the solar electricity generated from **80%** of detached houses which have installed rooftop solar PV system.

Figure 4c. Option 3: An Ambitious Change
(30% of Tokyo's electricity consumption mix will come from solar generated within Tokyo Metropolis)



Citizens can support through either purchasing RE certificates or purchasing RE from small and medium-size electricity retails

Many choices for citizens to invest on local solar projects managed by NGOs or community organisations

Solar *within* Tokyo Metropolis accounted for **30%** of Tokyo's electricity consumption mix (**22,151 GWh**). About 75% of solar *within* Tokyo (**16,500 GWh**) are from rooftop PV system in 23 Wards of Tokyo, **5%** (**1,100 GWh**) from rooftop PV system in Tama Region, **20%** (**4,400 GWh**) from solar farms in Tama Region.

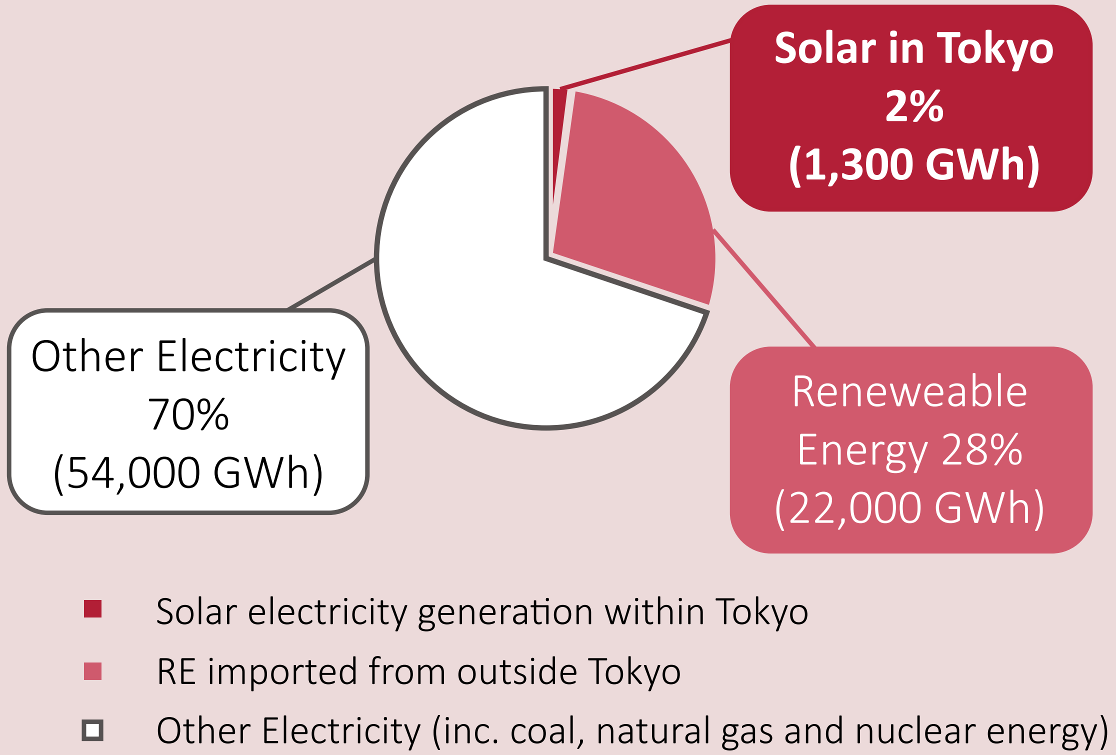
(Sources: Geographical Information Authority of Japan (国土地理院), 2011, 東京都【技術資料D1-No.777】デジタル標高地形図 東京都, https://www.gsi.go.jp/common/000184230.jpg; Kurofune (くろふね), 2018, Scenery form Mt. Takao (高尾山からの風景), https://commons.wikimedia.org/w/index.php?curid=51076331; Morio, 2009, Shinjuku skyscrapers and Mt. Fuji (新宿の超高層ビル群と富士山), https://commons.wikimedia.org/w/index.php?curid=5794297; Tokyo Metropolitan Government, 2019, Zero Emission Tokyo Strategy (ゼロエミッション東京戦略); Tokyo Metropolitan Government, 2019, Group purchasing renewable electricity (みんなでいっしょに自然の電気), https://www.metro.tokyo.lg.jp/tosei/hodohappyo/press/2019/11/22/08.html)a

Option 1

Business As Usual (BAU)

Key Elements of Option 1

2030 Tokyo's Electricity Consumption Mix under BAU Option



Cost

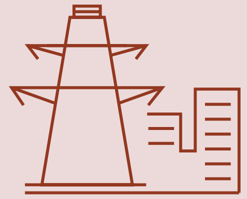
- A 4 kW solar PV system costs about JPY 990,000
- A 13 kWh (for 1 day consumption) storage battery system costs about JPY 280,000

Tariff

- A tier-based electricity tariff system continues to be in use; nighttime (time-of-use) tariff plans are available
- RE surcharges at JPY 3/kWh for financing FiT and grid connection of solar PV systems
- FiT continues to be in use

Energy Situation

- 1,300 GWh solar electricity generated from
- 1.3 GW solar installed capacity within Tokyo, contributing to 2% of Tokyo's electricity consumption mix
- Most solar electricity from Tokyo citizens within Tokyo and Tama Region
- 20% of detached houses in Tokyo have rooftop solar PV systems
- RE contributes to 28% of Tokyo's electricity consumption mix (mainly imported from other prefectures)
- 1.8% of electricity consumption reduction (compared to 2018's level)
- Mild electricity cost savings from peak load shifting



Technical and infrastructural Support

- Grid interconnection capacities increase for regional electricity trading in Kanto region
- A few homes install storage batteries for self-sustained operation in the event of power outage or emergency
- A few homes install HEMS for managing real-time electricity generation and consumption
- 50% of new passenger car sales comes from ZEVs (including EVs)

Market

- TEPCO remains as the major electricity supplier in Tokyo; a few other companies sell electricity through bundled services (e.g., bundling of telecommunications and electricity services, bundling of gas and electricity, etc.)
- Tokyo citizens support RE mainly through purchasing RE certificates
- TEPCO as the major pilot VPP service provider
- Tokyo citizens mainly invest in solar by installing solar PV systems.
- Citizens sell solar electricity generation for FiT at fixed rate

Option 1

Business As Usual (BAU)

Pros

- Tokyo citizens enjoy relatively low electricity expenses under the tier-based tariff system and low RE surcharges. They have the option to choose nighttime plans based on their lifestyle.
- Tokyo citizens can receive stable FiT income through selling surplus solar electricity to incumbent utilities.
- Centralised electricity system with small proportion of solar PV systems reduce citizens' financial burdens in maintaining self-sustained solar PV systems and home batteries.
- Tokyo citizens have one major reliable electricity retailer (TEPCO) for stable electricity supply. The TEPCO's electricity plans are easy to understand. They also have the option to choose bundled services (e.g., bundling of telecommunications and electricity, bundling of gas and electricity, etc.) from a few other companies to reduce electricity expenses.
- Tokyo citizens can evaluate the payback period of solar PV system, solar potentials and risks to decide whether to install solar PV systems.
- Tokyo citizens can experience VPP by joining the pilot programme offered by TEPCO and help improving VPP for the future electricity market.

Cons

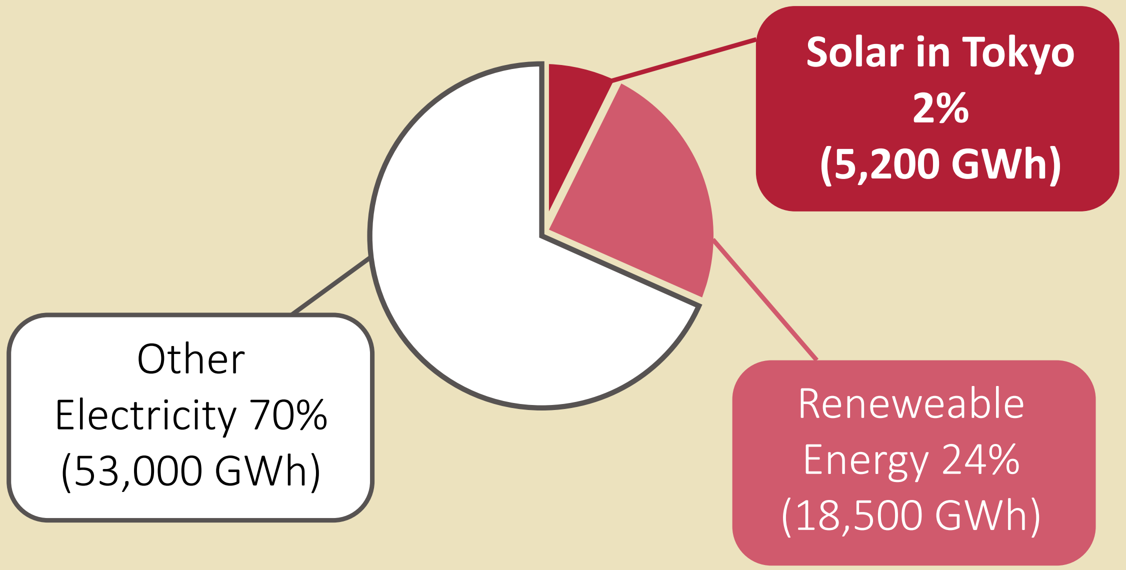
- There are limited options and flexibilities to save electricity expenses from adjusting electricity use hours except using less.
- Only Tokyo citizens who own rooftop have the potential to install solar PV systems to earn FiT income; citizens who have no rooftop still have to bear RE surcharges.
- In the event of power outages and disasters such as earthquakes or typhoons, only the Tokyo citizens who own solar PV systems and home batteries might maintain normal electricity consumption. The majority have to suffer power outage during emergency.
- Tokyo citizens have little choice but only one major electricity retailer to choose from. The only a few small retailers providing bundled services may not be reliable.
- Tokyo citizens have to bear risks and invest a lot of money and time to understand the payback period of solar PV system, potentials and risks of solar PV system installation, as well as identifying suitable solar installers.
- Most of the Tokyo citizens do not agree that VPP can bring perceived benefits to them. Tokyo citizens do not notice and concern about the VPP pilot programmes.

Option 2

A Moderate Change

Key Elements of Option 2

2030 Tokyo's Electricity Consumption Mix under Moderate Option



- ■ Solar electricity generation within Tokyo
- ■ RE imported from outside Tokyo
- □ Other Electricity (inc. coal, natural gas and nuclear energy)

Cost

- A 4 kW solar PV system costs about JPY 760,000
- A 40 kWh (for 3 days consumption) storage battery system costs about JPY 850,000

Tariff

- A time-of-use tariff system with mild allowances for different off-peak hours
- RE surcharges at JPY 3/kWh for FiT and grid connection of solar PV systems
- FiT continues to be in use with low rate

Chapter 3 Three Options of Solar Future in Tokyo

Energy Situation

- 5,200 GWh solar electricity generated from
- 5.2 GW solar installed capacity within Tokyo, contributing to 7% of Tokyo's electricity consumption mix
- Most solar electricity from Tokyo citizens within Tokyo and Tama Region
- 80% of detached houses in Tokyo have rooftop solar PV systems
- RE contributes to 24% of Tokyo's electricity consumption mix (mainly imported from other prefectures)
- 3.1% of electricity consumption reduction (compared to 2018's level)
- 2% electricity cost savings through peak load shifting

Technical and infrastructural Support

- Grid interconnection capacities increase for regional electricity trading in north-eastern and central Japan
- Some homes install storage batteries for self-sustained operation in the event of power outage or emergency
- Some homes install HEMS for managing real-time electricity generation and consumption
- 70% of new passenger car sales from ZEVs (including EVs)

Market

- Choices of electricity retailers for consumers: A few dominating traditional utilities from north-eastern and central Japan (TEPCO, Chuden, Tohokuden, etc.), some small and medium-sized electricity retailers (小売電気事業者), and some service companies providing bundled services (e.g., package of telecommunications and electricity, package of gas and electricity, etc.) co-exist at Tokyo's electricity market
- Some small and medium-sized electricity retails selling 100% RE are now available for residential customers
- A few traditional utilities and energy service companies as VPP service providers
- A few choices for investing in local community/ citizen-owned solar projects managed by NGOs or community organisations
- Citizens have options to sell solar electricity for FiT, sell at market price, or use for charging their EVs

Chapter 3 Three Options of Solar Future in Tokyo

Option 2

A Moderate Change

Pros

- Tokyo citizens can save electricity expenses by shifting their consumption to off-peak hours and earn allowances.
- Tokyo citizens can decide whether to sell surplus electricity from solar PV systems for FiT (at stable but low rate), at market price (fluctuating), or use it for own consumption (such as charging EVs).
- In the event of power outages and disasters such as earthquakes or typhoons, Tokyo citizens can switch the solar PV systems to self-sustained operation mode for some emergent use temporarily.
- Tokyo citizens have a few large and reliable electricity retailers (TEPCO, Chuden, Tohokuden, etc.) for stable electricity supply to choose from. The electricity plans are easy to understand, and they can switch to another electricity retailer if they don't trust their current retailer. They also have the options to choose small and medium-sized retailers or bundled services (e.g., package of telecommunications and electricity, package of gas and electricity, etc.) from a few other companies.
- Tokyo citizens can go solar by investing in community or citizen-owned solar projects managed by NGOs or community organisations in their communities which can be effectively monitored. These projects can be located in Tokyo or Kanto Region outside Tokyo.
- Tokyo citizens have a few options to subscribe to VPP programmes offered by a few major electricity retailers and a few small energy service companies. The service quality of the companies can be effectively monitored by the authority.

Cons

- The mild allowances for shifting electricity use to off-peak hours may not be attractive to encourage electricity use in off-peak hours.
- Tokyo citizens have to bother their minds and be highly strategic to compare the benefits between selling surplus electricity at FiT rate or at market prices.
- In the event of power outages and disasters such as earthquakes or typhoons, there may be only very limited or minimal electricity use as some solar PV systems and home batteries can be damaged during disasters.
- Although Tokyo citizens have some choices for electricity retailers, the major electricity retailers offer more or less the same electricity plans and their trustworthiness are equally low. The small and medium-sized retailers or bundled service providers are uncertain in the reliability of their performance.
- There are only a few solar projects to choose in the communities and their rates of return and potentials are usually low.
- The VPP programmes offered by major companies are more or less the same and their trustworthiness are equally low. The small energy service companies may not have a large number of customers for providing effective energy management.

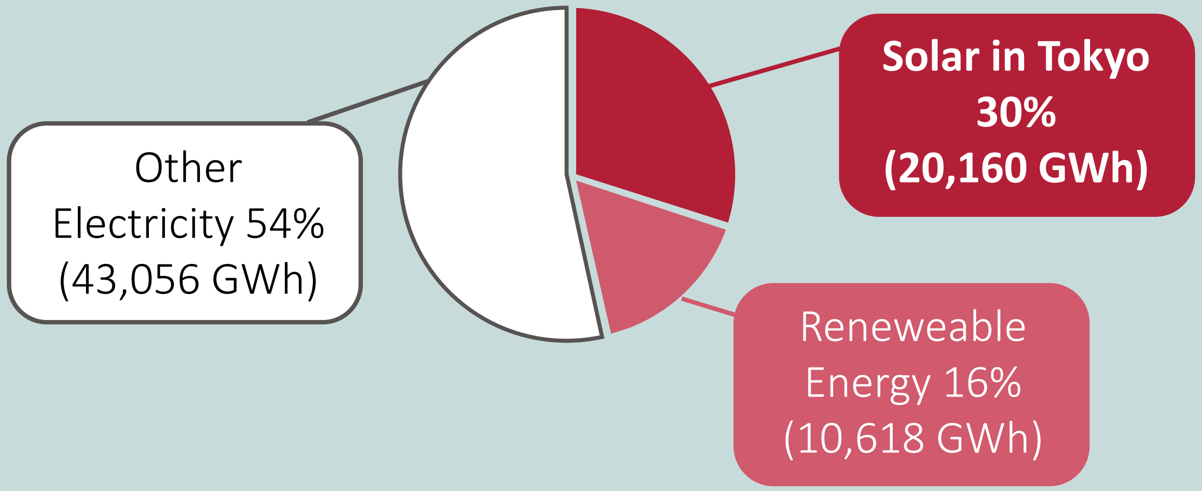
Chapter 3 Three Options of Solar Future in Tokyo

Option 3

An Ambitious Change

Key Elements of Option 3

2030 Tokyo's Electricity Consumption Mix under Ambitious Option



- Solar electricity generation within Tokyo
- RE imported from outside Tokyo
- Other Electricity (inc. coal, natural gas and nuclear energy)

Cost

- A 4 kW solar PV system costs about JPY 750,000
- A 80 kWh (for 6 days consumption) storage battery system costs about JPY 1,720,000

Tariff

- A time-of-use tariff system with higher rates for peak-hour use
- RE surcharges at JPY 3/kWh for financing grid expansion and grid enhancement to accommodate large-scale solar
- FiT phased out

Energy Situation

- 22,151 GWh solar electricity generated from 22.2 GW solar installed capacity within Tokyo (mostly in the 23 wards, but also include the Tama area), contributing to 30% of Tokyo's electricity consumption mix
- 80% of solar electricity from Tokyo's rooftop; the other 20% from solar farms in Tama area achieved by cutting 11% of the forest to install PV
- Most detached houses and apartments in Tokyo have rooftop solar PV systems, with about 10 GW installed capacity
- RE contributes to 14% of Tokyo's electricity consumption mix (mainly imported from other prefectures)
- 6.6% of electricity consumption reduction (compared to 2018's level)
- 10% electricity cost savings through peak load

Technical and infrastructural Support

- Grid interconnection capacities increase for regional electricity trading in the main islands
- Most homes install storage batteries for self-sustained operation in the event of power outage or emergency
- Most homes install HEMS for managing real-time electricity generation and consumption
- 100% of new passenger car sales from ZEVs (including EVs)

Market

- Choices of electricity retailers for consumers: many traditional utilities (TEPCO, KEPCO, Chuden, Tohokuden, etc.), many dominating small and medium-sized electricity retailers (小売電気事業者), and many service companies providing bundled services (e.g., package of telecommunications and electricity, package of gas and electricity, etc.) co-exist at Tokyao's electricity market
- Many choices for citizens to choose whether and which RE sources to purchase (e.g. through RE certificates) from electricity retailers
- Many choices for subscribing to VPP service providers for electricity management
- Many choices for investing in community/ citizen-owned solar projects managed by NGOs or community organisations
- Citizens' solar electricity generation sold at market prices or for charging their EVs

Chapter 3 Three Options of Solar Future in Tokyo

Option 3

An Ambitious Change

Pros

- Tokyo citizens can save electricity expenses by shifting their consumption to off-peak hours to avoid expensive peak-hour rates.
- Tokyo citizens can sell surplus electricity from solar PV systems (stored in batteries and EVs) in the electricity market when the price is high (such as during peak-hours) and use solar electricity produced for charging EVs when the price is low.
- In the event of power outages and disasters such as earthquakes or typhoons, Tokyo citizens can switch the solar PV systems to self-sustained operation mode and use home batteries to maintain normal electricity consumption for about a week.
- Tokyo citizens can have a wide range of choices for: 1) which electricity retailers to sign contracts with; and 2) whether to subscribe to VPP providers for energy management.
- Tokyo citizens have many choices to go solar and make modest revenue, including investing in community or citizen-owned solar projects managed by NGOs or community organisations in different region in Japan.
- Real-time electricity information managed by VPP helps Tokyo citizens better manage their electricity use and the selling of surplus solar electricity.

Cons

- Some Tokyo citizens have to pay higher electricity prices for a) unavoidable peak-hour uses (e.g. rice cooking; kotatsu 炬燵) and b) RE surcharges.
- The income from solar electricity selling for Tokyo citizens is unstable as the market price is subject to fluctuation. There is also a high cost in maintaining or replacing EVs for constant charging and transferring electricity.
- As most people have bought home batteries in their homes, the home batteries may cause more extensive and severe damages during disasters. The solar PV systems and batteries also take more time and costs to maintain in order to ensure its normal operation in the event of power outages caused by disasters such as earthquakes or typhoons.
- Tariff plans are much more complicated and confusing and the quality of electricity retailers are difficult for citizens to compare as there are many different electricity retailers in the market offering different kinds of electricity-related services.
- The investment in remote community or citizen-owned solar projects managed by NGOs or community organisations may be risky (e.g. as the projects are vulnerable to extreme weather conditions, etc.) and some projects recorded financial losses.
- Tokyo citizens have little time to monitor electricity generation and consumption even when real-time information is provided by VPP. The VPP companies managing the electricity data may be suspicious in using the data in unethical way (e.g. selling the data for profits).

APPENDICES

Appendix 1:
A Turning Point in Japanese Energy Policy:
The Fukushima Nuclear Accident in 2011

The 311 Eastern Japan Earthquakes (311 Earthqukaes) and the Fukushima Nuclear Accident in 2011 has changed the Japanese energy policy. In the 3rd Strategic Energy Plan published in 2010, nuclear energy was identified as a key energy sources in the future[2]. However, after the earthquakes, there was a sharp reduction on nuclear energy and an increase on fossil fuels in the electricity mix between 2010 and 2012[3].

For the social aspect, the Fukushima Nuclear Accident has led to a series of anti-nuclear movement across Japan. The human errors and the lack of an effective management system in the incident led to the distrust in government, regulations and TEPCO[4]. For the economic aspect, the shutdown of the nuclear power plants has increased Japan's trade deficit and greenhouse gases emissions from using fossil fuels[5,6].

After the 311 Eastern Japan Earthquake in 2011, Kan's and Noda's Administrations (DPJ) introduced a nuclear phase-out policy, which aimed to phase-out nuclear policy in the 2030s. However, the nuclear policy has switched to a nuclear resumption following the change of political leadship from anti-nuclear Democratic Party of Japan (DPJ) to Liberal Democratic Party (LDP). The Abe Administration (LDP) stated that nuclear power source that supports the stability of the energy supply and demand structure but suggested that Japan should reduce the degree of dependence on nuclear in the 4th Strategic Energy Plan in 2014[7]. As of December 2019, nine reactors have resumed operation[8]. According to the governmental nuclear target, nuclear energy will be accounted for 20% – 22% in the electricity mix in 2030[9].

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2 Institute of Energy Economics, 2010, *Japan Energy Brief*
3 Compiled from data published by Agency of Natural Resources and Energy in 2018
4 The National Diet of Japan, 2012, *The Official Report of The Fukushima Nuclear Accident Independent Investigation Commission: Executive Summary*
5 Ministry of Economy, Trade and Industry, 2013, *FY 2012 Annual Report on Energy (Energy White Paper 2013) Outline*
6 Ministry of Economy, Trade and Industry, 2014, *Outline of the Annual Report on Energy for FY 2013 (Energy White Paper on 2014) Outline*
7 Yuchiro Tsuji, 2019, Nuclear power plant reactivation in Japan: An analysis of administrative disrection
8 World Nuclear Association, 2020, Nuclear power in Japan
9 The Ministry of Economy, Trade and Industry, 2018, *Strategic Energy Plan*

Appendix 2:
Japan's Major Energy Targets

Following the Fukushima Nuclear Accident in 2011, the Government of Japan has published two Strategic Energy Plans. These plans outlined the direction of the national energy development. In the national context, the Tokyo Metropolitan Government has set energy targets at the city level. Table 2 outlined the major targets set by the national and Tokyo governments. These include targets of greenhouse gases reduction, renewable energies (RE), and energy consumption reduction.

Table 2.Major energy targets set by the Government of Japan and Tokyo Metropolitan Government.

Documents (Date)	**Targets**
The Government of Japan	
4th Strategic Energy Plan 第４次エネルギー基本計画 (Apr 2014)	RE in Electricity Mix: • About 13.5% in 2020; About 20% in 2030 Others: • "3E+S" basic policies ("3E" refers to "Energy Security", "Economic Efficiency" and "Environmental Protection", and "S" refers to "Safety")
5th Strategic Energy Plan 第５次エネルギー基本計画 (Jul 2018)	Greenhouse Gases Emission: • 26% reduction by 2030 compared to 2013's level RE in Electricity Mix: • 22% – 24% in 2030 • Renewable energy as a major power source Others: • Nuclear at 20% – 22% in 2030 • All households and businesses installed smart meter by 2020
Tokyo Metropolitan Government	
The Long-Term Vision for Tokyo 東京都長期ビジョン (Dec 2014)	Solar Installed Capacity: • 1 GW in 2024 RE in Electricity Mix: • 20% in 2024 Energy Consumption: • 30% reduction in 2030 compared to 2000's level
Tokyo Environmental Basic Plan 東京都環境基本計画 (Mar 2016)	Greenhouse Gases Emission: • 30% reduction by 2030 compared to 2000's level Solar Installed Capacity: • 1 GW in 2024; 1.3 GW by 2030 RE in Electricity Mix: • 20% in 2024; 30% in 2030 Energy Consumption: • 38% reduction in 2030 compared to 2000's level
The White Paper on Tokyo Environment 2019 東京都環境白書 2019 (published annually; latest in Oct 2019)	• Adopted energy targets from 東京都環境基本計画 published in 2016 Others: • 50% of total vehicle sales form Zero-emission vehicles (ZEV) (inc. Electric Vehicles (EVs))
ゼロエミッション東京戦略 （2019年12月）	Renewable Energy: • All energy used to be decarbonised by 2050 Others: • All cars driven in Tokyo to be ZEVs by 2050

Appendix 3: Major Renewable Energy Policies in Japan

1.Renewable energy (RE) policies introduced by the Government of Japan

Feed-in Tariff

Feed-in Tariff (FiT) is one of the major policies on promoting the use of renewable energy (RE) in Japan. FiT provides a premium payment per unit of electricity guaranteed for a long period of time. There are two streams for FiT in Japan, residential FiT (systems smaller than 10 kW) and non-residential FiT (system between 10 kW and 2 MW). Residential FiT has started since November 2009 with a 10-year contract length. It allows citizens to sell surplus solar electricity to receive FiT. The non-residential FiT has started in July 2012, with a 20-year contract length[10]. The utilities purchase all the solar electricity generated in the non-residential sector, but curtailment may be applied to non- residential solar generators when there is an overgeneration of electricity[11]. The tariff rate for residential sector (24 yen/ kWh in 2019) is higher than the non-residential sector (14 yen/ kWh)[12]. The rate is adjusted annually base on the installation cost. The tariff rate is fixed once the FiT contract is signed, citizens can get a higher FiT rates if they sign up earlier [13].

Renewable energy surcharge

The Government of Japan has introduced a RE surcharge to all electricity end-users to finance FiT since 2012. The RE surcharge is calculated based on the purchasing cost for FiT minus the administrative costs. The costs will then be distributed to all the electricity consumers in Japan as a RE surcharge[14]. It is charged based on the citizen's electricity consumption level. From May 2019 to April 2020, the RE surcharge rate is set at 2.95 yen per kWh[15].

10 Ministry of Economy, Trade and Industry, 2012, Feed-in Tariff Scheme in Japan
11 Jiji Kyodo, 2018, Fearing blackouts, Kyushu Electric asks solar power generators to suspend generation, The Japan Times
12 Marian Willuhn, 2012, Japan's METI cuts C&I FIT by 22%, PV Magazine
13 Ichigo Green Infrastructure Investment Corporation, 2019, About Japan's Feed-in Tariff (FIT)
14 Ministry of Economy, Trade and Industry, 2016, Settlement of FY 2016 Purchase Prices and FY 2016 Surcharge Rates under the Feed-in Tariff Scheme for Renewable Energy
15 TEPCO, 2019, The unit price of the renewable energy power promotion surcharge

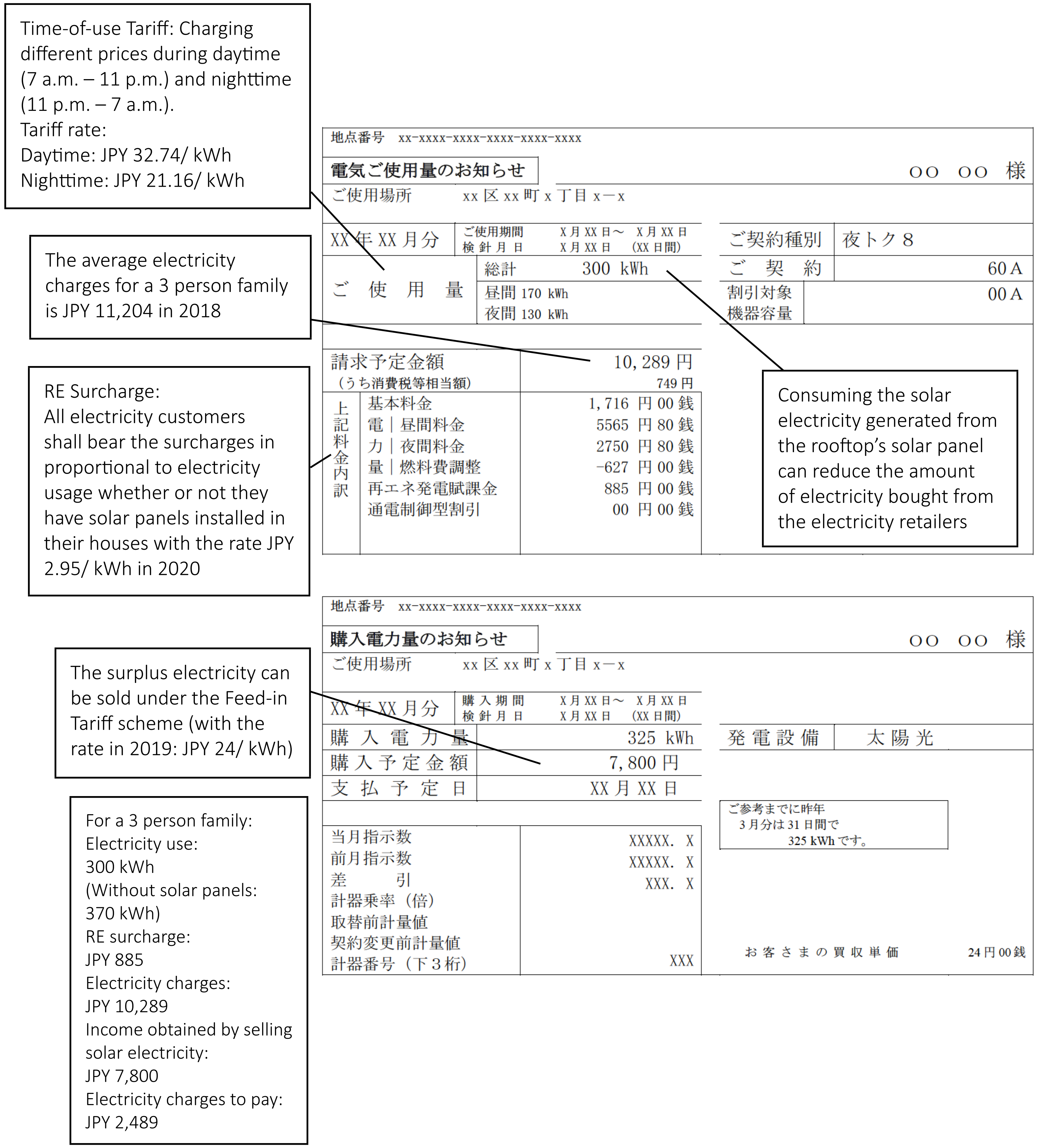


Figure 5. Example of lowering energy bill through FiT
(Source: Agency for Natural Resources and Energy, 2011, Feed-in Tariff Scheme for Renewable Energy)

Renewable Energy (RE) Certificate System

A RE certificate system allows buyers to entrust providers to generate electricity from renewable sources and pay for the cost of generation. A buyer of a certificate is regarded as using green power. There are more than one schemes available in Japan, including J-credit, Non-Fossil Fuel Energy Certificates, etc[16]. Electricity retailers or enterprises can then purchase these certificates to fulfill their corporate social responsibility[17]. However, citizens are not allowed to buy these certificates on an individual basis currently, while the Tokyo Metropolitan Government is developing business models to offer different renewable energy plans for citizens to purchase RE certificate in the future[18,19].

Box 1. Case study of the first renewable energy certificate scheme in Japan

The First renewable energy certificate scheme in Japan: Green Power Certificate

The first renewable energy certificate scheme is the Green Power Certificate, which was established in 2001 by Sony. They cooperated with TEPCO and developed the Green Power Certificate to secure renewable energy supply. The Green Energy Certificate covers multiple renewable sources such as, solar, wind, geothermal and even ice energy. The certificate scheme has also expanded to include heat generation through green thermal energy and start selling Green Heat Certificate.

From 2008 to 2017, the Green Power Certificate has issued certificates which worth more than 2,700 GWh and traded more than 2,600 GWh of certificates. Sony is also one of the major buyers of this scheme. They have committed to purchase 37 GWh of green heat certificates per year since 2012, making them the largest purchaser of Green Heat Certificate in Japan at that time.

(Sources: WWF Climate Savers, 2014, Sony leads the charge of renewable energy in Japan; Jules Chuang, Hsing-Lung Lien, Akemi Kokubo Roche, Pei-Hsuan Liao and Walter Den, 2019, Consolidated climate markets mechanism analysis—Case studies of China, Japan, and Taiwan)

16 Wataru Yamazaki, 2019, Japanese Renewable Energy Market, EKOEnergy
17 J-Credit Scheme, 2020, *J-Credit Scheme*
18 Misato Noto, 2019, Tokyo is promoting collective renewable energy scheme for households, Zenbird
19 Tokyo Metropolitan Government, 2019, Zero Emission Tokyo Strategy (ゼロエミッション東京戦略)

Appendices

2. Renewable policies introduced by the Tokyo Metropolitan Government

Solar Map

The Tokyo Metropolitan Government launched The Tokyo Solar Potential Map (東京ソーラー屋根台帳) since 2014. This map helps citizens to predict the annual solar radiation received for each building (Figure 6). The map also helps citizens to estimate the maximum size of solar installed capacity, and provides advice on the building suitability of solar panel installation. Citizens can use this map as a guideline if they are interested to install a solar panel on their rooftop[20].

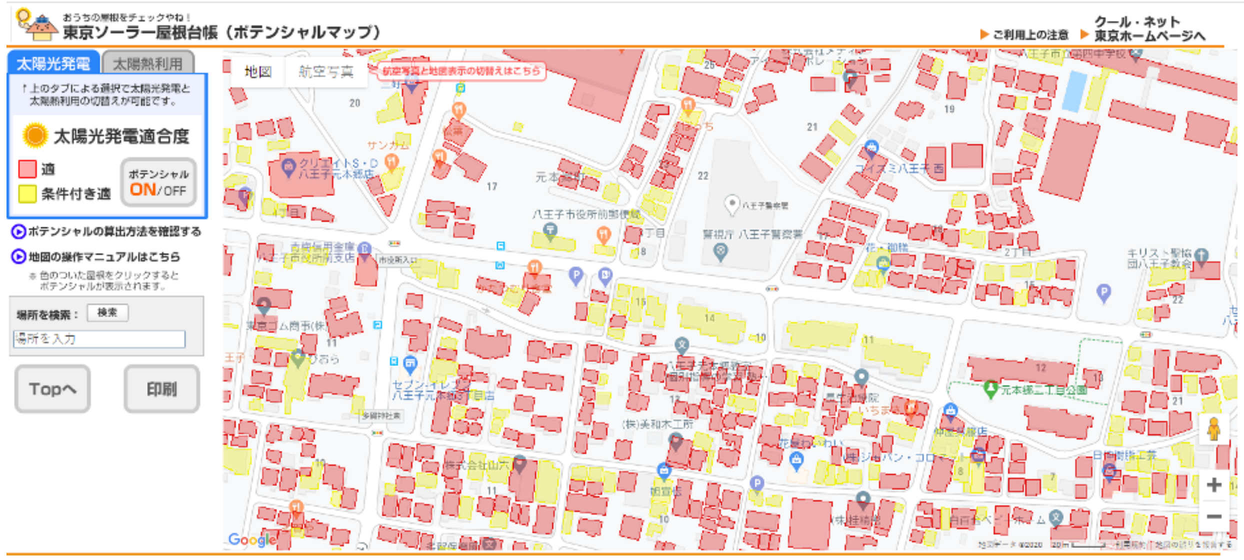


Figure 6. The Tokyo Solar Potential Map
(Source: Tokyo Environmental Public Service Cooperation, n.d., The Tokyo Solar Potential Map, http://tokyosolar.netmap.jp/map/)

Subsidies on Zero-emission Vehicles (ZEVs)

In order to meet the ZEV target (50% of new car sales from ZEVs by 2030)[21], the Tokyo Metropolitan Government has introduced a subsidy to popularised ZEVs in Tokyo. The subsidy is eligible for all Tokyo residents for purchasing selected models of ZEV[22]. Citizens will then receive subsidies from the government to cover part of the purchasing cost. The amount of subsidies varies depends on models.

20 Tokyo Metropolitan Government, 2019, The White Paper of Tokyo Environment 2019 (東京都環境白書 2019)
21 Tokyo Metropolitan Government, 2019, The White Paper of Tokyo Environment 2019 (東京都環境白書 2019)
22 Cool Net Tokyo, 2019, Subsidy on Introducing Fuel Cell Vehicles (電気自動車等の普及促進事業（EV･PHV車両）)

Appendix 4:
Detailed Explanation on the Key Issues of the Solar Future Options

1. Security of Supply

Security of supply refers to whether citizens can reduce reliance on the electricity grids to become less susceptible to future energy price increase. It can also refer to whether people can be protected from power outage caused by natural disasters (e.g. earthquakes).

Installing solar panels on the rooftops can be one potential option to enhance the security of supply as solar panels can provide electricity to families independently[23]. Citizens with solar panels installed are less affected by the rising electricity tariff rate as they are not solely rely on utilities for electricity supply. In addition, solar panels can generate electricity independently for houses and so it can provide an alternative energy source while the grid is damaged and fails to deliver electricity from the power plants in the aftermath of natural disasters[24].

However, solar electricity is an intermittent electricity source. The output of solar electricity varies based on seasons, weathers and time of the day. A local grid can usually allow 15% of renewable energy without affecting the stability of the electricity supply[25]. Adopting solar electricity extensively may not be able to improve the security of supply when there is a low level of output from most of the solar panels in a community.

23 Paul Balcombe, Dan Rigby and Adisa Azapagic, 2013, Motivations and barriers associated with adopting microgeneration energy technologies in the UK
24 Salahuddin Qazi and William Young, 2014, Disaster relief management and resilience using photovoltaic energy
25 Asian Energy Studies Centre, 2016, Deliberative workshop on solar PV development in Hong Kong: Prospects and policy challenges

2. Energy Autonomy

It refers to the degree to which local generation for local consumption can replace grid power or external support in the form of energy import[26]. Solar panels can provide electricity during daytime, which is not sufficient to achieve energy autonomy for citizens. Installing storage batteries with solar panels can enhance energy autonomy by storing the surplus solar electricity during daytime and provide energy supply during nighttime and even natural disaster.

Citizens can choose to switch to self-sustained operation mode which enables surplus solar electricity to be stored into the batteries instead of transferring surplus electricity to receive Feed-in Tariff (FiT). Citizens can then use electricity from the storage batteries during nighttime. It can reduce reliance to grid power and reduce the electricity charges. In addition, citizens can even use electricity from storage batteries during natural disasters and power outage, resulting a more stable electricity supply than installing solar panels without batteries.

However, citizens need to pay the upfront cost for purchasing storage batteries at home. The batteries can also be damaged during natural disaster, and the citizens have to pay the maintenance cost and cannot have a stable electricity supply during a power outage.

Figure 7. Switching to self-sustained operation mode during power outages
(Source: Tokyo Metropolitan Government, 2019, Zero Emission Tokyo Strategy (ゼロエミッション東京戦略))

26 Edward Bentley, Richard Kotter, Yue Wang, Ridoy Das, Ghanim Putrus, Jorden Van Der Hoogt, Esther Van Bergen, Jos Warmerdam, Renee Heller and Bronia Jablonska, 2019, Pathways to energy autonomy – challenges and opportunities

3. Cost

The cost for electricity is subject to change. a.) For the upfront cost for installing solar panels, it will depends on the solar PV system costs in the future. b.) For citizens who have installed solar panels, their electricity charges depend on the amount of FiT received from electricity generation, the amount of electricity consumption from the grid and amount of RE surcharges. Time-of-use tariff can be applied in full scale in the future which people need to pay a higher rate during peak hour and lower rate at off-peak hour[27].

For the upfront cost, the cost of solar PV systems has been decreased for about 86% from 2010 to 2017[28], and it tends to decrease in the future. A lower upfront cost can shorten payback period and attract more people to adopt solar electricity. For the effect to the electricity charges, the average electricity cost for a 3-person families in Japan is JPY 11,204 per months in 2018 (Figure 8). However, other than electricity consumption, the electricity cost for citizens in the future will depend on the FiT rate and the renewable energy (RE) surcharge. For citizens who have installed solar panels, they can gain FiT from selling surplus solar electricity and use them to offset part of the electricity charges. If more people choose to adopt solar electricity, the RE surcharge may increase as the RE surcharge is supposed to finance FiT and the RE surcharge will affect all the electricity consumers in Tokyo.

Other than FiT and surcharge, the electricity cost for Tokyo citizens depends on whether time-of-use tariff will operate in full scale. Citizens will have to pay a higher tariff rate for electricity use during peak hour, and with a lower rate during off-peak hour. At present, TEPCO offers plans that charge differently during daytime and nighttime for citizens to choose. It will affects the cost of electricity for most Tokyo citizens if a time-of-use tariff applies to all homes in Tokyo. However, the electricity charges for citizens who have installed solar panels can be lower as the electricity generated from solar panels reduce the need for them to purchase electricity from utilities.

27 Paul Balcombe, Dan Rigby and Adisa Azapagic, 2013, Motivations and barriers associated with adopting microgeneration energy technologies in the UK

28 Ran Fu, David Feldman, Robert Margolis, Mike Woodhouse and Kristen Ardani, 2017 U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017

	ひと月の平均電気代	年間の平均電気代
2人暮らし	9,559円	114,708円
3人家族	11,024円	132,288円
4人家族	11,719円	140,628円
5人家族	12,846円	154,152円

Figure 8. Average electricity costs for families in Japan in 2018
(Source: Energy Change, 2020, [Newest version in 2020] How much is the average electricity bill for households (【2020年最新版】一般家庭の電気代、平均額ってどのくらい?), https://enechange.jp/articles/average-of-family)

4. Grid Interconnection

Grid interconnection refers to connecting distributed renewable energy facilities to the grid. An interconnected grid can be as simple as connecting a solar panel to a grid. On the other hand, grid interconnection can also refer to connecting grid from utilities that can form a large grid across regional borders and enable regional electricity trading.

On the citizen level, connecting the renewable energy system to the grid is the first step to receive FiT from utilities and to sell electricity to electricity retailer. At present, citizens can sell surplus solar electricity to the utilities and receive FiT. Connecting renewable energy system to the grid can also allow households to reduce the spending on purchasing storage batteries to store surplus solar electricity[29].

On the national level, an interconnected grids mean overcoming a huge technical barrier. At this moment, the electricity transmission networks in Japan are divided into two frequency (50 Hz in Eastern Japan and 60 Hz in Western Japan) due to historical reasons. Also, grids are developed separately by utilities, so there are only a limited electricity transmission capacities between grids. An interconnected grid can allow regional electricity trading and Tokyo citizens can choose electricity suppliers outside Tokyo. In addition, an interconnected grid can also support the development of renewable energy. For instance, places such as Kyushu are suitable for solar electricity, and an interconnected grid can allow renewable energy to be transferred to other parts of Japan. The curtailment on solar electricity generation in Kyushu in 2018 (Box 2) may become less likely to happen in the future[30] as surplus electricity in Kyushu can be transferred to other regions in Japan.

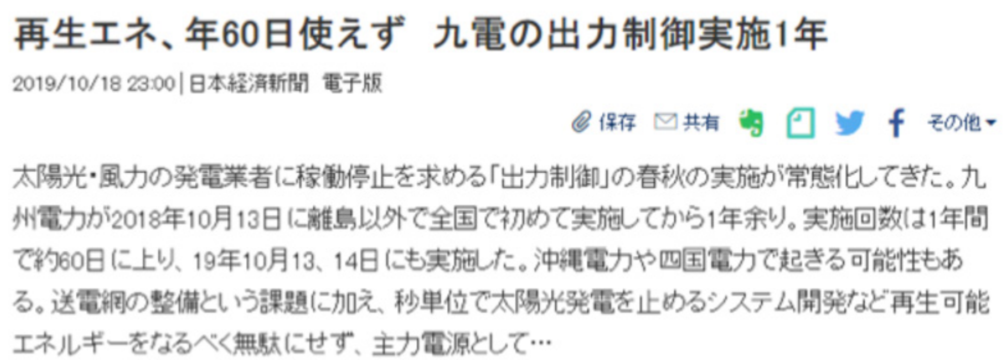
29 IEA-RETD, 2014, Residential Prosumers-drivers and Policy Options (re-prosumers)
30 Tatsuya Shinkawa, 2018, *Electricity System and Market in Japan*

Box 2 A case study of on the curtailment on solar electricity generation in Kyushu in 2018

Curtailment on solar electricity generation in Kyushu in 2018:

On 13 October 2018, a sunny Saturday after, the Kyushu Electric Power Co. (Kyuden) has implied a curtailment (出力制御) on solar electricity generation. It was in autumn when most of the citizens started turning off the air conditioner and the total electricity consumption started to decrease. On the other hand, the solar panels were experiencing a high output due to a sunny weather. At 1 p.m. of the day, the electricity demand (12.5 GW) was significantly lower than the expected electricity supply (12.93 GW).

The overgeneration of solar would cause overloading and it may lead to a power outage in the Kyushu area. Kyuden decided to impose a curtailment and ask solar operators to suspend the power generation to avoid the over-supply of electricity and the potential power outage. It has become the first case in Japan where electricity generation are suspended due to overgeneration. Other than the 13th, Kyuden also suspended solar electricity generation on the 14th as well as the weekend that followed (20th, 21st). Similar output control was undertaken for around 60 days in one year as of October 2019. Kyuden has also produced a guideline to avoid biases in terms of the number of suspension among the generators. Curtailment became one of the major techniques in Kyushu for balancing the supply and demand of electricity.


再生エネ、年60日使えず　九電の出力制御実施1年

2019/10/18 23:00 | 日本経済新聞　電子版

太陽光・風力の発電業者に稼働停止を求める「出力制御」の春秋の実施が常態化してきた。九州電力が2018年10月13日に離島以外で全国で初めて実施してから1年余り。実施回数は1年間で約60日に上り、19年10月13、14日にも実施した。沖縄電力や四国電力で起きる可能性もある。送電網の整備という課題に加え、秒単位で太陽光発電を止めるシステム開発など再生可能エネルギーをなるべく無駄にせず、主力電源として…

Figure 9. Solar electricity curtailment in Kyushu

(Sources: Nikkei News, 2019, One year after Kyuden’s solar output control, no solar electricity for 60 days (再生エネ、年60日使えず 九電の出力制御実施1年); Jiji Kyodo, 2018, Fearing blackouts, Kyushu Electric asks solar power contras to suspend generation, The Japan Times; Nikkei News, 2018, First time in Japan! Kyuden requested solar generator to stop (九電 13日に太陽光制御発電業者に停止要請、国内初); Nikkei News, 2019, Kyuden ‘s revised method on reducing 10% of solar output through curtailment (太陽光の出力制御量1割減、九電が手法見直し); Fumio Nishiwaki, 2018, What is Kyushu’s “Solar generation problem” ? A secret to avoid wasting renewable energy” (九州「太陽光で発電しすぎ問題」とは何なのか せっかくの再エネ発電を無駄にしない秘策))

5. Convenience

From an energy market aspect, convenience refers to the degree for citizens to save time and efforts on e.g. family daily routines. In addition, for adopting renewable energy, convenience then refers to the degree of modifications need to be made by citizens for accommodating the new electricity generation system (e.g. space area required, modification to the rooftops etc.)[31].

Home energy management systems (HEMS) (Box 3) can enhance the level of convenience for citizens when they manage electricity use. Citizens can receive real-time electricity consumption data for each electricity products. Citizens who have installed solar panels can also receive solar electricity generation data through HEMS[32]. Citizens can choose electricity plans by referencing the data provided by the HEMS in the future, which saves time and efforts for citizens to study their electricity consumption patterns.

For adopting renewable energy, the level of convenience may be lowered as installing solar panels can involve a number of modification in citizens' homes. Citizens need to reserve spaces for installing the supporting equipments for the solar panels (e.g. storage batteries), and some citizens may have to make modifications for installing solar panels in their homes. In addition, citizens may have to be responsible for the maintenance cost, resulting citizens may have to spend more time and efforts in managing the solar panels after installation.

31 Paul Balcombe, Dan Rigby and Adisa Azapagic, 2013, Motivations and barriers associated with adopting microgeneration energy technologies in the UK

32 Bin Zhou, Wentao Li, Ka Wing Chan, Yijia Cao, Yonghong Kuang, Xi Liu and Xiong Wang, 2016, Smart home energy management systems: Concept, configurations and scheduling strategies

Appendices

Box 3. Introduction to Home energy management system (HEMS)

Home energy management system (HEMS)

House energy management system (HEMS) is a system which provides energy management services to efficiently monitor and manage electricity generation, storage and consumption in citizens' homes. The HEMS has 5 major functions, which are:

1) Monitoring: Providing real-time data on energy consumption and the energy status of each electricity products at home.
2) Logging: Collecting data information on the electricity use and citizens' consumption pattern for demand-side analysis (e.g. predicting electricity charges)
3) Control: Allowing citizens to monitor and control the electricity products at home remotely through computers or smart phones.
4) Management: Enhancing the efficiency of electricity consumption in citizens' homes, such as switching of all the lights automatically when there is no one at home to prevent electricity waste.
5) Alarm: Alerting citizens and the HEMS operator if there is a system failure detected.

For citizens who have installed solar panels, the HEMS can also help them to monitor the real-time solar electricity generation data, and analyses how can solar panels help to reduce the electricity charges. In addition, HEMS can also help solar panel owners to manage the electricity storage for home batteries to prevent overcharging and electricity waste.

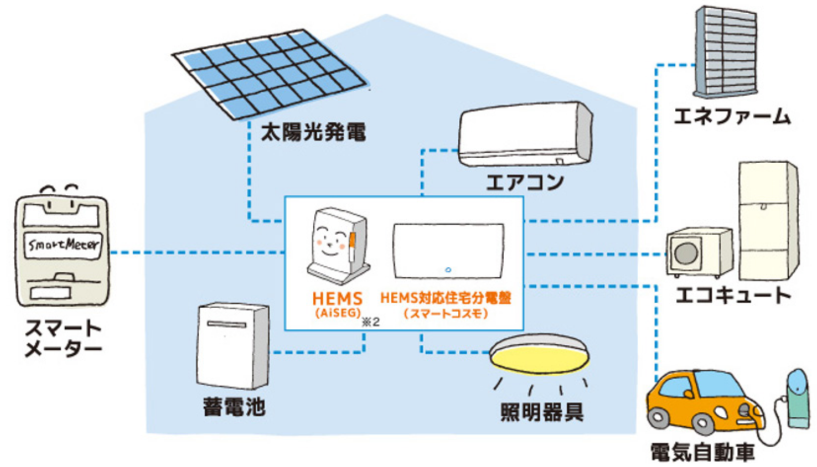


Figure 10. Home energy management system

(Sources: Panasonic, 2020, Smart HEMS: What is HEMS? (スマートHEMS : HEMS(ヘムス)とは?); Bin Zhou, Wentao Li, Ka Wing Chan, Yijia Cao, Yonghong Kuang, Xi Liu and Xiong Wang, 2016, Smart home energy management systems: Concept, configurations and scheduling strategies)

Appendices

6. Demand response

Demand Response (DR) is all intentional electricity consumption pattern modifications by end-use customers that are intended to alter the instantaneous electricity demand, or total electricity consumption. DR usually work in two ways. The first way is peak shifting, using tariff which imposed during peak hour to encourage consumers to use electricity during off-peak hour. The second way is to reduce consumption through encouraging consumers to adopt energy saving practices or encouraging consumers to buy energy efficient products.

For peak shifting, it can reduce the need to build more power plants for the peak load. In the US, 10 to 15% of the capital investment is for the 1% peak load period. Time-of-use tariff system, as mentioned in the "Cost" section can be applied to encourage citizens to change their behaviour to use electricity during off peak hour in the future through charging a higher rate for electricity use during peak hour and a lower rate during off-peak hour.

On the other hand, consumption reduction is also critical in Japan as citizens' electricity demand has shown a significant rise since 1980[33]. The reduction of electricity consumption can be achieved through encourage citizens to adopt energy saving practices and to encourage them to purchase energy efficient. For Tokyo citizens, adopting energy saving habits can effectively reduce their electricity charges. In addition, it can also help Tokyo to reach the energy consumption and greenhouse gases emission targets in 2030.

7. Electricity Market Reform

Japan has been introducing electricity market reform since 1995 to fully liberalise the electricity market. The reform is expected to be completed by 2020. Among a number of major changes, Japan has completed the liberalisation of the retail sector in April 2016 by extending market competition from large (e.g. industrial) electricity end-users to residential end-users.

33 Asian Energy Studies Centre, 2017, Deliberative workshop on electricity tariffs and demand-side management in Kyoto, Japan (京都市の電気料金及び電力需要サイド管理セミナー)

The completion of the retail market liberalisation in April 2016 has led to a noticeable growth in the number of electricity retailers: as of January 2018, there were 453 small electricity retailers (小売電気事業者) and 19 "designated electricity suppliers" (特定送配電事業者) registered in Japan. Japanese residential electricity customers have become relatively more active customers as they now have choices. According to government data, approximately 820,000 customers (about 1% of all residential customers of the 10 electric utilities) switched electricity suppliers by the end of April 2016- a noticeable record that was made only in one month after the retail market was liberalised on the 1st of April. The number of customers switching suppliers increased to 4.6 million by September 2017. About 3 million customers (about 5%) switched to other tariff menus (e.g. time-of-use menus). In the future, it will also become possible for Tokyo citizens to use 100% solar electricity by choosing suppliers which generate electricity solely from solar panels.

The market reform is yet to be fully completed. At present, competition has not been introduced in the transmission and distribution. Japan's electricity market is still dominated by 10 vertically integrated electric utilities which are all privately-owned, except the Tokyo Electric Power Company (TEPCO) which was nationalised in 2012 in the aftermath of the Fukushima nuclear accident. Cross-regional grid interconnection and cross-regional electricity transactions have remained very limited[34].

34 Daphne Ngar-yin Mah, 2020, Conceptualising government-market dynamics in socio-technical energy transitions: A comparative case study of smart grid developments in China and Japan.

New Market Player after the electricity market reform: Retailer A

There are a number of companies in Japan joined the electricity market since the retail market liberalisation (e.g. NEC, Softbank, Tokyu etc.). For example, Retailer A is one of the major telecommunication companies with a high number of customer across Japan. After the market liberalisation, “Retailer A” has set up “Retailer A Electricity” department and join the electricity retail market. “Retailer A Electricity” accepts application across Japan except for some remote islands. It has partnership with major utilities such as TEPCO and KEPCO etc. on energy supply to citizens. For citizens, it will only change the retailers to “Retailer A Electricity”, other items such as transmission service will be as same as before, so it will not affect the quality of electricity supply.

Joining “Retailer A Electricity” will not affect citizens’ electricity charges, they will instead earn club points, which can be used as cash through credit card. “Retailer A Electricity” has provided an alternative choice on electricity retailers for citizens under the newly liberalised electricity market.

Box 4. A case study for small and medium-sized electricity retailers

8. Types of Electricity Markets

Japan’s electricity market reform has created more opportunities for different types of electricity markets to co-exist in Japan. These markets can include: (i) a national electricity market that is supported by enhanced transmission capacity across regional grids; (ii) regional electricity trading markets; and (iii) local electricity markets in which energy companies can buy solar electricity from Tokyo residents and then sell the electricity to other local electricity consumers.

Box 5. A case study on Miyama Smart Energy

Case study on Miyama Smart Energy: A local energy market

The Miyama Smart Energy is another small size electricity retailer established after the retail market liberalisation. The Miyama Smart Energy is operating in a regional area, mainly the Miyama city, but also providing electricity to neighbouring regions, such as public facilities in Oki town.

The Miyama Smart Energy was established by the Miyamashi city government in 2015. The Miyama Smart Energy provides an alternative choices to local solar generators, including solar farm owners and citizens who have installed solar panels to sell solar electricity. Solar generators can sell electricity to Miyama Smart Energy instead of selling solar electricity to Kyuden and receive FiT. The Miyama Smart Energy resells these electricity to local businesses, Miyama citizens and public facilities such as school and city halls in both Miyama and its neighbouring region, providing a model of local generation and consumption of electricity (Figure 11).

As of 2018, Miyama Smart Energy has signed electricity purchase agreement with solar generators with a total installed capacity of 58 MW. About 80% of the electricity sales are for corporations, with about 520 out of 1000 companies have signed agreement with Miyama Smart Energy for electricity supply. For residential sales, Miyama Smart Energy provided electricity to about 2,700 houses in Miyama as of 2017.

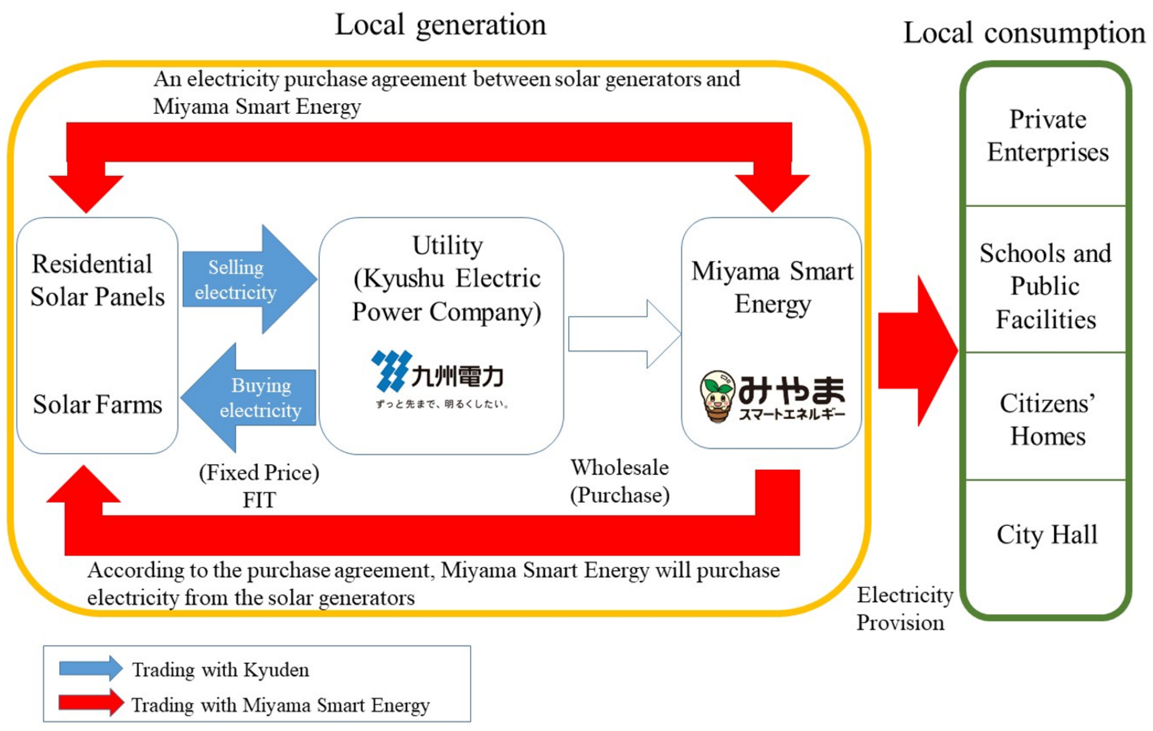


Figure 11: Miyama Smart Energy’s operation flow

(Sources: Kyushu Electric Power, 2020, Connection status of renewable energy in mainland Kyushu (九州本土の再生可能エネルギーの接続状況); Miyama Smart Energy, 2020, Miyama Smart Energy (みやまスマートエネルギー); Miyama City, 2017, Japan’s first local energy consumption city (日本初、エネルギーの地産地消都市); Nikkei News, 2019, Miyama, Fukuoka, challenging the new energy “Ideal and Reality” (福岡県みやま市、挑戦的な地域新電力に見る「理想と現実」)

Appendices

9. Solar Investment

Tokyo citizens without solar panels can still support solar by investing in community-owned/ citizen-owned solar projects (Box 6). Most of these projects are operated by NGOs and community organisations. Citizens can then use the solar electricity produced or receive incomes from selling electricity to electricity retailers depends on projects and locations. Through participating in community solar projects and engaging with NGOs, it provides opportunities for citizens to learn new knowledge on solar panels installation and energy saving practices.

Box 6. A case study on the community owned solar projects: Do it Ourselves model in Tama Region

Do it Ourselves model in Tama Region

The Do it Ourselves model was established by a Tokyo based solar startup, Tama Empower in 2016. The Do it Ourselves model does not only provide solar electricity to the community, but also allow participants to have a deep understanding on solar installation and a sense of community ownership of solar PV.

As a participant of the model, they attended training sessions on how to set up the mounting part and install solar PV panels. After the sessions, participants then started to install the solar PV panels on their rooftops (mostly on commercial buildings, public buildings or private apartment buildings) guided by the professional construction builders. These professionals were also responsible for choosing the solar PV equipments to ensure that the equipments could meet the durability requirements and suitable for lay people to install. In addition, participants of the Do it Ourselves model were also responsible for the maintenance of the solar panels after installation as the professionals would be responsible for the maintenance for the first year.

The Do it Ourselves model has significantly reduced the cost of installation of PV systems by breaking down the process of constructions and sharing the role of installation between professionals and lay people. More importantly, the Do it Ourselves model can serve as an example on engaging local communities in adopting solar electricity in the future.

Figure 12. Participatory solar installation

(Source: Shota Furuya, 2017, Japan's "Do it Ourselves" model for community power)

10. Electricity Vehicles (EVs)

Electricity Vehicles (EVs) play an important role in enhancing energy autonomy. It can serve as “mobile batteries” for citizens’ homes. EVs’ batteries can serve as a storage battery for the solar panels and provide electricity to citizens while parked at home. Using EVs as an electricity supply source can reduce the reliance on grid power and reduce electricity charges. In addition, the storage capacity can provide electricity for two to four days for a family’s consumption in Tokyo, the EVs’ batteries can also serve as an emergency electricity source during natural disaster or power outage[35].

11. Virtual Power Plant (VPP)

VPP as a cloud-based (virtual) power system which collects and integrates the capacities of different distributed energy resources (which include solar electricity) and energy storage systems (which include EVs) for the purposes of optimising electricity generation, as well as trading or selling electricity in electricity markets. VPP can result in cost and loss minimisation. [36].

VPP is still under development in Japan. The Government of Japan launched a VPP trial projects in 2016 which has attracted a number of firms (e.g. utilities, retailers, engineering firms etc.) to join the project (Figure 13)[37]. One of the major purposes for developing VPP in Japan is to integrate the distributed electricity resources, such as rooftop solar panels, storages batteries, EVs etc. to reduce the capital investment for peak hours.

For citizens, subscribing VPP in the future can help aggregating the electricity resources at home and provide electricity management service. For instance, VPP can manage the solar electricity produced from rooftop solar panels and charge the storage batteries and EV during daytime and discharge them for electricity supply during nighttime. It encourages electricity self-consumption and reduce the electricity charges. In addition, VPP can also help selling surplus electricity to the grid during peak hour for profits. The Government of Japan regards the VPP project as one of the potential solutions to make full use of the solar resources after the end of FiT scheme[38].

35 Tokyo Metropolitan Government, 2019, Zero Emission Tokyo Strategy (ゼロエミッション東京戦略)
36 Hedayat Saboori, Mohammad Mohammadi and R. Taghe, 2011, Virtual Power Plant (VPP), definition, concept, components and types
37 Kiyoshi Nishimura, 2019, Latest Issue in Residential Market in Energy Business in Japan

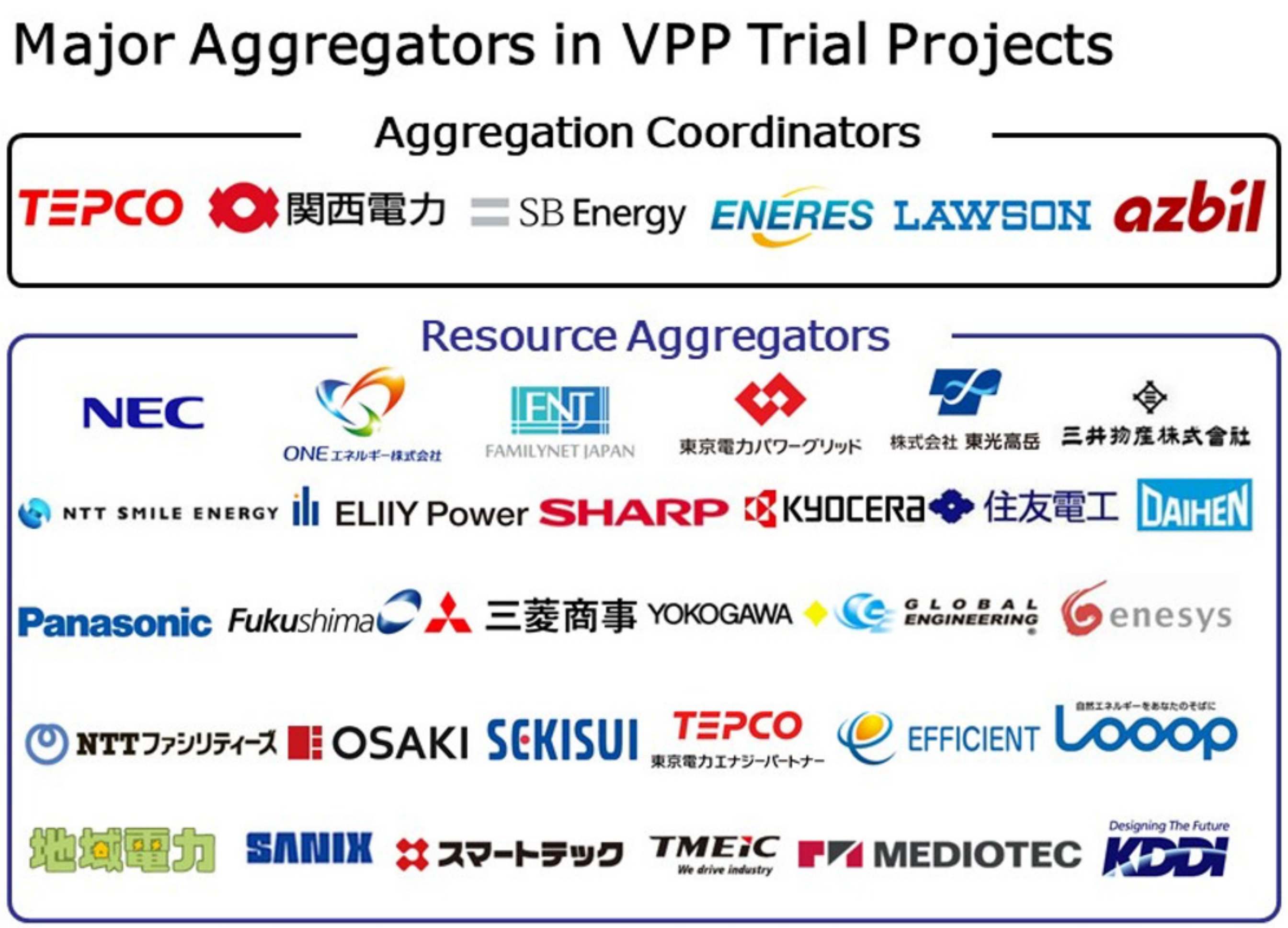


Figure 13: Potential Aggregators of VPP in the future
(Source: Kiyoshi Nishimura, 2019, Latest Issue in Residential Market in Energy Business in Japan)

38 Yasuhiro Sakuma, 2019, VPP/EV Aggregation Project in Japan

Thank you for participating in

the Online Deliberative Poll on

Solar Future in Tokyo!

Designed by Kwok Yik Lam, Emily

If you have any inquiries regarding to this participant guide, please contact us at:

Email: aesc@hkbu.edu.hk
Tel: +852 3411 7187/+852 3411 7753/+852 3411 7032