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World Bank: Developing Sustainable Rooftop PV in Vietnam #1259789

Danang

June 2020

Solar Rooftop Strategy Report

pwc

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Abbreviation

Acronym	Definition
BIDV	Bank for Investment and Development of Vietnam
BAU	Business as Usual
CAGR	Compounded Annual Growth Rate
CAIDI	Customer Average Interruption Duration
CAIFI	Customer Average Interruption Frequency Index
CIT	Corporate Income Tax
COD	Commercial Operation Date
CPC	Central Power Corporation
DOIT	Department of Industry and Trade
DPI	Department of Planning and Investment
DPPA	Direct Power Purchase Agreement
EIA	Environmental Impact Assessment
EPC	Engineering Procurement and Construction
ERAV	Electricity Regulatory Authority Vietnam
ESCO	Energy Service Company
EVN	Vietnam Electricity
EVNHCMC	Vietnam Electricity Ho Chi Minh City
FIT	Feed in Tariff
GDP	Gross Domestic Product
GTI	Global Tilted Irradiation/Irradiance
HCMC	Ho Chi Minh City
MOF	Ministry of Finance
MOIT	Ministry of Industry and Trade
MPI	Ministry of Planning and Investment
MVA	Mega Volt Amp
PDP	Provincial Development Plan
PPA	Power Purchase Agreement
PPC	Provincial People's Committee
RRP	Recommended Retail Price
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition
TOR	Terms of Reference
USD	United States Dollar
VAT	Value Added Tax
VND	Vietnamese Dong

1. Executive Summary

Electricity consumption in Vietnam is on a rapid rise with a growth rate of 11% over the last 5 years and is expected to nearly triple from 2018 through to 2030[1]. In large metropolitan areas like Danang and HCMC, energy supply system is facing challenges due to increasing urbanization, aging infrastructure and increased dependency on external grid. Rooftop solar PV systems offer competitive economics and reliable solutions to these challenges, integrating with other developments in cities including flexible load requirements from EVs, other smart devices etc. With nearly 30% of the roofs in HCMC and Da Nang capable of installing rooftop solar energy systems effectively (World Bank study), Rooftop solar PV systems provide a viable alternative to address these challenges in these two cities.

The key scope of this document is to provide rooftop PV strategy for implementation considering the consumer dynamics of Danang city.

Globally, deployment of utility-scale solar PV projects have enabled countries to meet their climate change commitments and renewable energy targets. However, small – scale rooftop solar PV systems also represent an important part of the market and are bringing the benefits of Solar PV to residents, small businesses and cities. Further, Cities have taken a leading role in renewable energy deployment and have formulated wider urban planning efforts/ initiatives to transition to more sustainable and low carbon cities. City action plan driving renewables both supplement and complement frameworks that exist at the national and provincial levels. Many cities have used their direct regulatory and purchasing authority to shape renewable energy pathways within their jurisdictions.

Rooftop Solar PV has also enabled addressing the energy requirements in these cities and reducing their dependence on transmission network capabilities. Potential objectives of cities for Rooftop PV deployment are

- Climate Change: Large scale adoption of rooftop PV to meet the global/national commitments
- Promote new investments (Domestic and International) into Solar Rooftop thereby supporting the local ecosystem
- Integrated deployment to reduce peak hour requirement in cities and hence reduction in cost of supply
- Power procurement alternative for cities hence reducing the import bill for energy replaced from Coal/Gas purchases for EVN (indirect impact on reduction in BST for cities)
- Potential non wire solutions to meet load growth i.e. reduce need for transmission upgrades by developing distributed generation at load centers

A variety of business models exist that enable city governments, local businesses, households and large corporations to deploy rooftop solar meeting these objectives. These diverse business models have emerged in response to a mix of factors, including price reductions in solar PV modules, supportive incentives and policies, new digital technologies and changes in consumer awareness towards climate change. A brief summary of these business models is provided below. Detailed analysis can be followed in Section 3.2.

[1] MOIT, EVN Annual Report and National Power Development Plan VII - Revised

Self Consumption model	• California example on how the state scaled up using net metering scheme • Rapid upscaling by given consumer category can impact electricity tariff and grid operational issues
Third Party/RESCO model	• India example and success of aggregated tendering • Procurement savings for consumers buildings without upfront investment however may need government subsidy to trigger large scale adoption
Community model	• Hawaii example on how net metering was discontinued due to impact on daytime system loading • New models adopted to incentivize consumers to export to grid using storage inline with grid requirements
Utility driven model	• New York Coned example: Rooftop PV a viable alternative for grid upgrades in urban cities • Mix of technologies with Rooftop Solar PV like storage, smart inverters for deployment to address solar intermittent generation and reduce network upgrade costs

Apart from learning from these global developments one needs to consider the developments in these respective city (Danang and HCMC) power scenario, and review of existing regulations for rooftop PV in Vietnam to determine an implementable Rooftop PV strategy.

Vietnam Regulatory Framework

Decision No. 13/2020/QD-TTg ("Decision No. 13") dated 6 April 2020

- New FiT for rooftop solar systems is indexed to dollar and fixed at 8.38 US cent per kWh
- Rooftop solar systems may sell all or part of power generated to EVN, or to other purchasers in case the EVN's grid is not used.
- A system is considered a "rooftop solar system" if it (i) has capacity not exceeding 1 MW and (ii) is connected to a grid with voltage of 35kV or less.
- If the purchaser is not EVN (i.e. private consumers), the power sale/purchase price and contract term is subject to the parties' negotiation

Based on general wording under Decision No. 13, the following four (4) rooftop solar models may be implemented in Vietnam, subject to the specific guidance on rooftop solar models to be issued by the MOIT or other relevant state authorities.

	Power Consumption model	Entire power sale business model	Direct power sale and purchase model	Excess power sale business model
Consumer	• Energy generated is utilized for self-consumption	• Additional income generation	• Enters PPA with seller/developer • Replace consumption with Rooftop PV	• Enters PPA with seller/developer
EVN/ PCs	• Excess energy output after self-consumption will be backfed onto the grid • Agreement for tariff for excess power sale	• Enter PPA with consumer for procurement	• Ensure isolation of PV system from grid	• Excess energy output after consumption will be fed onto the grid • Agreement for tariff for excess power sale
Third Party Solar developer	• May lease suitable rooftops and/or sell the PV system to the consumer	• May lease suitable rooftops and/or sell the PV system to the consumer	• Setup solar plants under RESCO to sell power to consumers	• May lease suitable rooftops and/or setup solar plants under RESCO to sell power to consumers

Each of these models can be adopted/promoted in the city for rooftop PV deployment considering the objectives of the city.

1. If the key driver for Rooftop PV deployment for the city is to reduce power procurement costs of utility

"**Entire power sale business model**" is best suited in such scenarios where utility purchases the entire power generated from Rooftop PV at a lower FiT. This could mean potential savings in replacement of power purchases from Bulk supply tariff. However, the FiT level needs to be remunerative for consumers to adopt such model more prominently. The rapid scaling under this model depends on the profitability to consumers based on the system costs and FiT levels.

2. If the key driver for Rooftop PV deployment for the city is to address growing demand in the city

"**Power Consumption model**" and "**Excess Power Sale model**", provides the maximum replacement of energy consumption with Rooftop PV generation. Thus, it enables the utility to manage the demand growth and plan for its generation resources accordingly. However, the utility may need to define technical limits on feeder level integration of such Rooftop PV to check the capacity installations to enable stable operations of distribution grid. Further, levels of cross subsidy in electricity retail tariff could also impact the profitability of the utility due to reduced consumption of high paying consumers, thus requiring tariff rationalization.

3. If the key driver for Rooftop PV deployment for the city is T&D investment deferral of utility

Third-party based models such as "**Direct Power Sale and Purchase model**" and "**Excess Power Sale model**" provides the required rapid scaling up required to meet the immediate network demand, there by allowing deferral of investments required in transmission and distribution to meet the demand growth. Utilities in cities where network expansion pose larger challenges due to congestion or RoW costs, such Rooftop PV models provides the required upscaling of distributed generation in the city to meet the electricity demand. It would also require integrated deployment with other technologies like storage, EV deployment to better replace the demand required across the consumption hours. However, this model also requires electricity retail tariff rationalization to reduce the impact of cross subsidy on utility's profitability due to rapid upscaling of rooftop PV by higher retail tariff paying consumers.

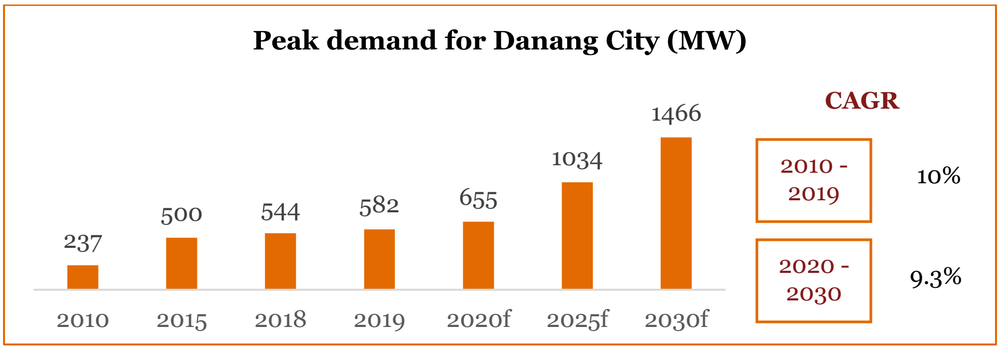
4. If the key driver for Rooftop PV deployment for the city is loss reduction and improving system reliability for utility

Utilities having network with unreliable power supply and/or loss-making feeders having high commercial losses, can adopt third-party based models such as "**Direct Power Sale and Purchase model**" to reduce the dependence of grid and thereby improving system performance. However, right scale and bankability issues for third party may need to be addressed by utility through relevant procedures and agreements. The impact on tariff due to consumers moving out is quite insignificant since the remuneration to utility through reduction in losses recues the overall cost of supply for utility.

Thus, based on the utilities' power procurement costs, tariff structure, loss levels and consumer mix each of these models could be promoted by the utility to meet its end objectives through a targeted Rooftop PV deployment.

Danang Rooftop Strategy

Da Nang is completely dependent on the National Grid for electricity with no localized generation capacity in the city. In 2019 peak demand recorded was 581.7 MW for the month of June at around 13:00 hours. The chart below depicts the past and projected balance of the city's peak demand.



Source: PDP VII, Danang's Power Development Plan, PC Danang

The peak load without the steel factory is estimated to grow at 9.3% with annual electricity consumption expected to grow at ~10% in near term. Commercial services category is likely to see the highest growth with around 13% along with public offices/other categories at 15%. This growth requires significant investments in transmission (110 kV level) and distribution grids (22 kV level). The total investment capital for new construction and renovation of power grid works with a voltage of 220 kV or lower is estimated at VND 8,211.7 billion till 2025 to meet the growing demand.

Scenario Analysis of Rooftop PV for Danang

Considering the solar generation profile in the city and the cumulative demand during daytime following three scenarios for solar replacement through solar rooftop PV in Danang has been analyzed.

Scenario A: City installs 150 MWp solar PV rooftop systems in next 3 to 5 years

Scenario B: City installs 250 MWp solar PV rooftop systems in next 3 to 5 years

Scenario C: City installs 350 MWp solar PV rooftop systems in next 3 to 5 years

Summary of scenario analysis of different capacity for Danang is as below

Rooftop deployment scenarios	Ramp up requirement (MW per hour) in evening hours wet season	Flexible operation required in base load plant (reduction in offtake)	Potential storage requirement to meet generation variability
Scenario A (150 MWp Rooftop PV)	20 MW (ramp up)	0 MW	40 - 60 MWh
Scenario B (250 MWp Rooftop PV)	26 MW (ramp up)	30 MW	80 - 100 MWh
Scenario C (350 MWp Rooftop PV)	33 MW (ramp up)	70 MW	140 - 160 MWh

Thus, with higher rooftop PV penetration, city needs to plan an integrated deployment with alternative technologies like storage to reduce this ramping requirement for the evening peak providing for a flat load curve to be met through purchases from EVN. Considering Danang is expected to have a load growth of 10%, city can target a cumulative rooftop PV capacity addition of **250 MWp – 350 MWp in next 5 years** to meet such growing demand.

This higher penetration of rooftop PV shall provide associated benefits along with procurement savings for the city. A summary of potential savings to different stakeholders is provided below. Elaborate analysis can be followed in section 5.4

Entity	Key role in energy value chain	Potential savings
EVN	Energy production and energy procurement	Cost savings from meeting additional energy requirement thereby reducing marginal cost of generating additional unit for EVN. Considering cost levels of 2018, such rooftop PV installation could result in potential cost reduction of VND 263 billion to 615 billion (i.e. USD 11 million to USD 26 million by 2025) annually
EVNNPT	Transmission system deployment and maintenance	With rooftop scenarios, the peak demand projected is likely to reduce by 7% - 17% , this could mean the renovations and capacity augmentations planned for future growth could be deferred considering the normal operation mode with load of 65% - 70%. Thus, NPT could re-evaluate deferral of VND 7,061 million planned for 220 kV/110 kV considering such rooftop scenarios adopted for Danang.
Danang PC	Power procurement from EPTC and distribution network investments	An integrated deployment of Rooftop PV to replace energy consumption from EVN can provide a cumulative savings of USD 20 – 48 million from savings in power procurement for PCs (difference of Bulk Supply Tariff payable by PC and low cost FiT from solar rooftop PV)

Solar irradiance potential (GTI) levels for Danang is between 1550 kWh/m2 to 1750 kWh/m2, indicating a high potential for solar PV generation. Despite such high solar potential, at the end of 2019, the installed capacity of rooftop solar in Danang was only 6.99 MW with almost entire capacity being commissioned in 2019. Based on stakeholder consultations during our workshop visits, we have identified 5 key barriers for rooftop PV deployment in Vietnam. These needs to be addressed through appropriate policy interventions for rapid upscaling of rooftop PV deployment in the city.

Key Barriers for rapid upscaling of rooftop PV deployment

1. Lack of Standardization:
    a. Construction code does not have standards and technical specifications on connection point for RTS system, frame structure, mounting positions. Such lack of standardization has impacted approvals from DOC and not provided consumers the required comfort to select developers accordingly.
    b. As a result, there are lots of players in the market offering different quality of products/services for the rooftop system, leading to wide range of price points.
2. Financing required:
    a. Investment in RTS requires high upfront cost and consumer categories like residential require additional support in financing for larger scale deployment.
    b. Further, industrial and commercial consumer have limited collateral options thus restricting the corporates' accessibility to project financing.
3. Regulatory uncertainty:
    a. Lack of clear legal regulations for 3rd party to sell power to EVN has often limited the options available with consumers for developing RESCO or leasing models.
    b.
    c. Further, government offices don't necessarily have a power selling permit thus restricting participation in deployment of RTS system in public buildings to self-consumption model.
4. Roof availability:
    a. Certain districts having limited real estate space and thus do not have enough rooftop space to install RTS system. This is particularly true for commercial buildings which host multiple consumer category
    b. Buildings with multiple meter connections also face similar challenges in obtaining multiple approvals on a single roof space. EVN often considers single rooftop system for a building.
5. Capacity restriction
    a. Currently the rooftop system is considered for 1 MWp and below system. Industrial consumers having higher contracted load and energy consumption do not have market alternatives to purchase power from such renewable sources.

Thus, we recommend a phase wise approach to achieve such capacity addressing these key barriers for adoption of rooftop PV. The rooftop strategy for Danang and role of each stakeholder is as provided below

Recommendations on Rooftop Strategy for Danang

	Short term (2021 – 2022)	Medium term (2023 – 2025)	Long term (2025 – 2030)
Cumulative Rooftop Capacity	100 MWp	200 MWp + 50 MWh storage	250 MWp – 350 MW+ 150 MWh storage
Stakeholder driving Rooftop PV deployment	PC/City drives deployment through defined technical limits for capacity additions + Investments from private i.e. consumers in rooftop PV	PC/City drives deployment through defined technical limits for capacity additions + Investments from private i.e. consumers in rooftop PV and public i.e. PC/EVN in grid storage	PC/City drives deployment through defined technical limits for capacity additions + Investments from private i.e. consumers in rooftop PV + consumer storage and public i.e. PC/EVN in grid storage
Stakeholder roles			
City/PCs	• Define technical limits along with feeder specifications/availability for potential rooftop PV deployment capacity • Standardization and adoption of rooftop PV across consumer categories • Enable provisions for centralized procurement of rooftop system at city level for government buildings/office, thus reducing the RTS system cost and enabling market creation	• Support policies for residential consumers such as capital subsidy, property tax incentives, low cost financing/home loans • Pilot storage at grid level operations to manage RE penetration	• Reinvest procurement savings from rooftop into storage systems to help integrate higher penetration of rooftop solar into the select grid networks
EVN/MOIT	• Strengthen the PPA terms to more bankable terms enabling low-cost long-term financing for industrial consumers. • Standardization of specifications and codes (potential empanelment of developers to give more comfort to consumers)	• Evaluate potential new FiT for storage-based rooftop PV systems • Retail tariff rationalization for cross subsidy to reduce impact on higher penetration of rooftop by cross subsidizing consumers	• Streamline ancillary service market to manage and incentivize grid operations • Define incentives in retail tariff for consumer premises storage deployment thus enabling DSM participation by

	Short term (2021 – 2022)	Medium term (2023 – 2025)	Long term (2025 – 2030)
			consumers to manage evening peak load
Consumers	• Rooftop deployment through purchase, leasing or PPA with developer	• Rooftop deployment through purchase, leasing or PPA with developer and behind the meter storage solutions	• Rooftop deployment through purchase, leasing or PPA with developer • Deploy grid interactive storage solutions
Developers	• Localize development and standardize installations	• Scale up deployment and storage solutions	• Participate in grid services through DERs
Business models for Consumer category			
Household	Entire power sale model "Lower payback period and lack of upfront financing needs to be addressed. Support policies for residential consumers such as capital subsidy, property tax incentives, low cost financing/home loans"		
Commercial	Excess power sale model "Since commercial consumer category are cross subsidizing consumers (~140% of cost of supply), large scale deployment of rooftop under this business model would need to be monitored to reduce the revenue impact on Power Corporations For large scale adoption of this consumer category, rationalization of retail supply tariff maybe required"		
Public buildings	Power-Consumption model and Excess power sale model "To encourage larger deployment, the PCs/city could roll out specific support policies through centralized procurement of rooftop system and thus reducing the RTS system cost. Provide capital subsidy, financing support for deployment"		
Industrial	Power-consumption and Direct power purchase & sale model "PCs can strengthen the PPA terms to more bankable terms enabling low-cost long-term financing for industrial consumers."		

Legal Considerations on Rooftop PV Strategy

There is currently no specific legal framework for installation of storage systems for solar projects in Vietnam. Under Decision No. 13, the Prime Minister instructed EVN to "*study on investments in power storage solutions for the power systems in order to ensure the power system's stable operation when absorbing renewable energy sources*". Under the current regulations, there is no higher FiT, or any incentives offered to encourage the use of power storage system. The use of such systems is subject to commercial and technical considerations.

In order to effectively implement the proposed deployment scheme, the Government will need to amend the current regulations to provide technical requirements and/or offer incentives for the use of this technology.

- For Short Term (Large scale rooftop deployment): Decision No. 13 of the Prime Minister is silent on the use of power storage system/technology for rooftop solar projects. If the Government wishes to offer a higher FiT for projects using power storage system, the current FiT policy under Decision No. 13 may need to be amended or replaced.
- For Medium Term (Integrated power system deployment): The Government may need to provide additional guidance on storage systems (as instructed under Decision No. 13 as cited above). The current regulations on types of ancillary services for the power system operation under Circular No. 45/2018/TT-BCT may need to be revised.
- For Long Term (Deployment at consumer end): The relevant state authorities (e.g. the MOIT) may issue legal documents to provide certain technical standards or provide guidance for consumers to install and use power storage systems.

2. Background

World Bank has appointed PricewaterhouseCoopers (PwC) as the "Consultant" under selection #1259789 to provide strategic advice to World Bank, Ministry of Industry and Trade (MOIT) and Vietnam Electricity (EVN) for the Development of Sustainable Rooftop PV Program in Da Nang and Ho Chi Minh City. Under this program, PwC along with Baker McKenzie (BM) shall provide support in developing business models for rooftop solar PV deployment in a sustainable and cost-competitive manner leveraging private sector investments and integrating rooftop PV along with other disruptive technologies into Development Plan for the cities of Danang and Ho Chi Minh City (HCMC).

Electricity consumption in Vietnam is on a rapid rise with a growth rate of 11% over the last 5 years and is expected to nearly triple from 2018 through to 2030[2]. The Revised National Power Development Plan VII (Revised PDP VII) in 2016 sets long-range goals for the power generation capacity. The anticipated generation capacity mix by 2030 is coal (55 GW), hydro (22 GW), gas (19 GW), nuclear and imports (6 GW) and renewables (27 GW). GoV has set a target[3] of Solar PV development in the country at 850 MW by 2020, 4 GW by 2025 and 12 GW by 2030, the current levels of solar capacity are 4.46 GW.

Globally, deployment of utility-scale solar PV projects have enabled countries to meet their climate change commitments and renewable energy targets. However, small – scale rooftop solar PV systems also represent an important part of the market and are bringing the benefits of Solar PV to residents, small businesses and cities.

In large metropolitan areas, energy supply system is facing challenges due to increasing urbanization, aging infrastructure and increased dependency on external grid. Thus, requiring utilities to focus on quality and reliability of power more than ever before. Rooftop solar PV systems offer competitive economics and reliable solutions to these challenges, integrating with other developments in cities including flexible load requirements from EVs, other smart devices etc.

With nearly 30% of the roofs in Ho Chi Minh City and Da Nang capable of installing rooftop solar energy systems effectively (World Bank study), Rooftop solar PV systems provide a viable alternative to address these challenges in the two cities.

The key elements of this engagement are:

- Rooftop Strategy: Understanding development barriers and suggest business models for implementation of Rooftop PV program in Vietnam considering the consumer dynamics of Danang and HCMC city. Covered as part of the scope of this report
- Pilot Deployment Scheme: Develop the mechanism of a pilot deployment scheme in these two cities based on recommended business models and distribution network capabilities study being undertaken by World Bank.

[2] MOIT, EVN Annual Report and National Power Development Plan VII - Revised
[3] According to the Revised Power Development Plan VII; Current Installed capacity as per NLDC

3. Global Learnings

3.1. Rooftop PV objectives

Overall growth of rooftop solar across the globe saw an annual increase in capacity and is expected to rise further. Microeconomic factors enabling rooftop deployment include rooftop financial incentives (PACE scheme in USA) and risk-sharing business models (FiT scheme in Germany, rooftop auction mechanism for government buildings in India)

While most capacity additions continued to be in large utility scale projects in Solar PV, there is an evident shift toward distributed solar PV. The governments have also started emphasis on distributed projects – particularly rooftop systems for self-consumption – to lessen the burden on transmission network and to reduce curtailment issues with Renewables.

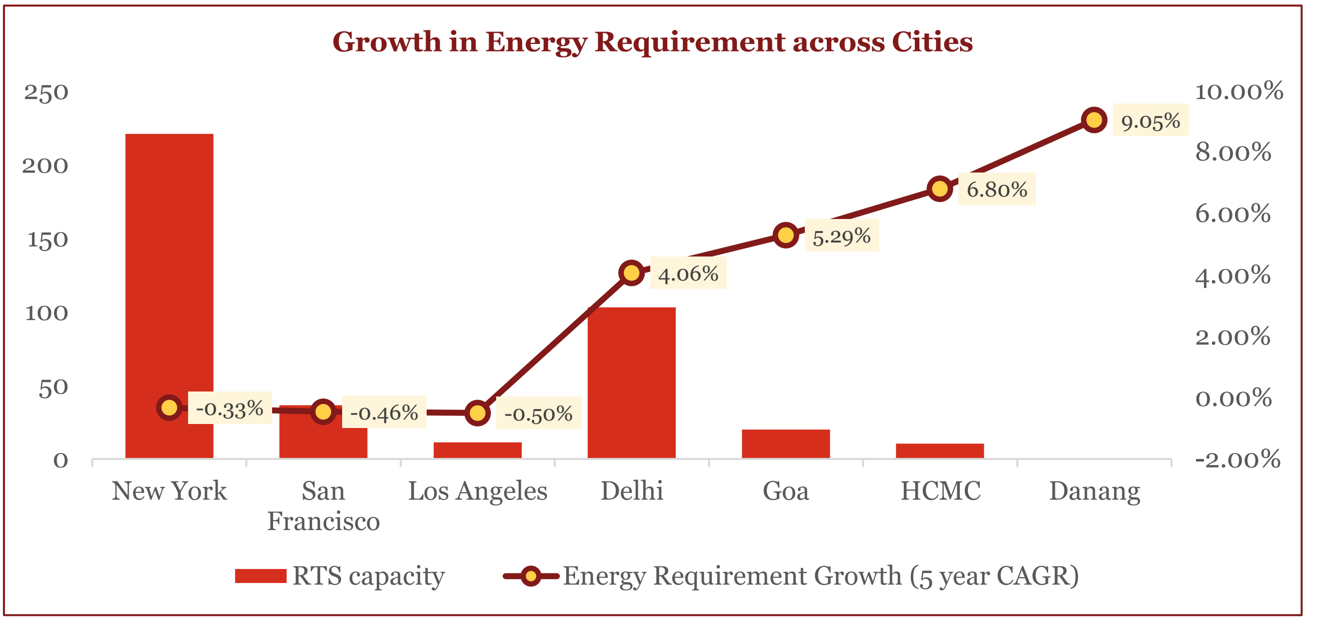


Figure 1: Cities Rooftop Solar capacity and energy requirement growth

Further, Cities have taken a leading role in renewable energy deployment and have formulated wider urban planning efforts/ initiatives to transition to more sustainable and low carbon cities. City action plan driving renewables both supplement and complement frameworks that exist at the national and provincial levels. Many cities have used their direct regulatory and purchasing authority to shape renewable energy pathways within their jurisdictions.

Rooftop Solar PV has also enabled addressing the energy requirements in these cities and reducing their dependence on transmission network capabilities. A demand growth and installed rooftop solar PV capacity for select cities indicate how cities have been able to address their energy security needs through Rooftop Solar.

Partially address 2 Mega Trends – Climate change & resource scarcity and Rapid urbanization. By 2050, 75% of the world population will live in cities. Increase in built infrastructure to support this influx will render urban areas as critical venues for rooftop solar deployment. Cities have committed to ambitious renewable energy targets. Cities are using a diverse mix of policy mechanisms to achieve these targets. Globally, 26% of the demand is met through renewable generation

Potential objectives of cities for Rooftop PV deployment are

- Climate Change: Large scale adoption of rooftop PV to meet the global/national commitments
- Promote new investments (Domestic and International) into Solar Rooftop thereby supporting the local ecosystem
- Integrated deployment to reduce peak hour requirement in cities and hence reduction in cost of supply
- Power procurement alternative for cities hence reducing the import bill for energy replaced from Coal/Gas purchases for EVN (indirect impact on reduction in BST for cities)
- Potential non wire solutions to meet load growth i.e. reduce need for transmission upgrades by developing distributed generation at load centers

3.2. Globally adopted business models for Rooftop solar

A variety of business models exist that enable city governments, local businesses, households and large corporations to deploy rooftop solar. These diverse business models have emerged in response to a mix of factors, including price reductions in solar PV modules, supportive incentives and policies, new digital technologies and changes in consumer awareness towards climate change. These models can be categorized under four main categories:

1. **Self-Consumption model**

The most prevalent model for rooftop solar installations where the rooftop owner buys the rooftop solar system and uses the benefit of the generation for internal consumption. Excess energy generated from rooftop solar system may or may not be fed back to the grid based on local regulations.

This model has various advantages such as quick payback period, risk-adjusted returns over longer duration, low payment risks and sole ownership of all rooftop system. However, key challenges are mainly the requirement of upfront capital and technical capacity limits leading to reduced rooftop capacity over the potential.

California state in United States has pioneered this model with large scale adoption by consumers under net metering scheme. The state has a cumulative installed Rooftop PV capacity of 7.28 GW as on March 2019 with Residential having nearly 4.62 GW of Rooftop installation.

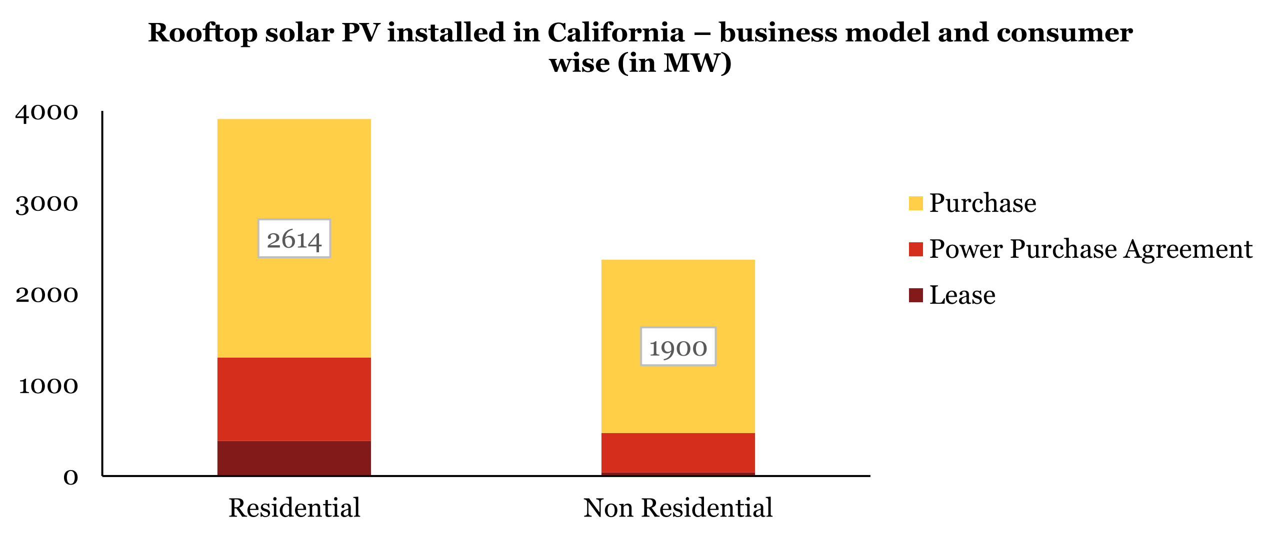


Figure 2: Self consumption model in California

Both non-residential sector and residential sector have major installation through direct purchase or self-consumption model. This has also resulted in lower Rooftop System size with only 35% of the total installed capacity having rooftop system capacity of more than 100 kW dc. The average installed capacity of the Rooftop system across the state is 8.74 kWp.

Since 2015, EV and Rooftop Solar PV systems have also been installed together. Of the total 128.3 MW installed for EV infrastructure, 72% of them has been in Residential sector.

Incentives provided for large scale adoption of rooftop solar under net metering scheme in the state.

- Financial packages made available for households including schemes such as
    - Property Assessed Clean Energy (PACE) program – property tax-based repayments
    - Single family solar affordable program (SASH) – incentive for low income households
    - Mortgage loans - cost of solar rooftop considered into the price of the home and paid through mortgage.
- Regulatory changes made to building code requiring houses built in the state from 2020 to include rooftop solar panels.

Key learnings from California

- Rapid upscaling by incentivizing households led to meeting climate change targets, 12 GW by 2020.
- However, such rapid upscaling resulting in grid operation issues with excess day time generation against required load – Duck curve.
- Such rapid upscaling by a given consumer category can also impact electricity tariffs (due to higher cross subsidization in the tariff structure across consumer categories)

2. Third Party/RESCO model

A third party invests capital in the rooftop solar system and sells power to the rooftop owner/ occupier at a rate lower than their grid tariff. This model is often called the OPEX or PPA model because the rooftop owner pays for the system over several years during its operation. This model has been quite prevalent in the US, where the model along with tax breaks proved attractive to many consumers. It also allows innovative structures like aggregation of various consumer demand to enable higher rooftop solar PV installations.

The key advantage of this model is the developer (third party) takes up the technical risk, and the rooftop owner does not need to invest upfront capital. It also reduces the liquidity risk and provides better usage of tax incentives made available under policies. However, payment risks, legal challenges on ownership of land/roof are some of the key challenges under this model.

India adopted this model for deployment of rooftop PV on government buildings to upscale the deployment and benefit from economies on system cost due to larger capacity.

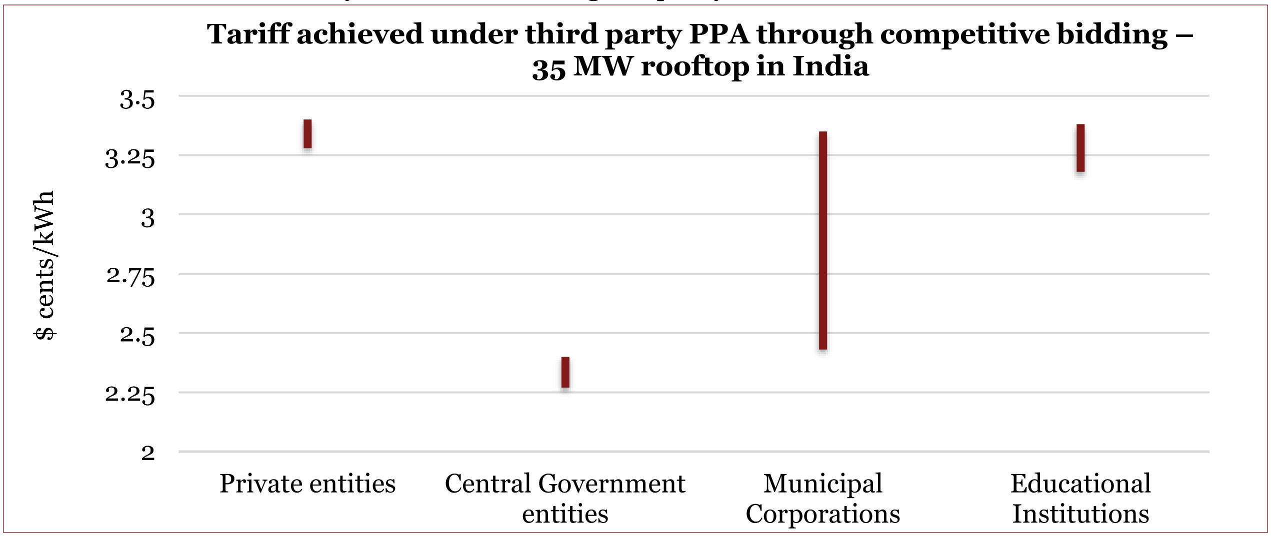


Figure 3: RESCO tender in India

Deployment of Rooftop PV scheme under a tender mechanism in India to aggregate 35 MW of grid connected rooftop solar systems. The tender covered rooftop installation on 291 government colleges, 159 police establishments, Municipal Corporation and private entities. The bid winners were entitled to capital subsidy (29% to 50% for different consumer-type) for setting up rooftop projects under central and state level policies. The lowest tariff quoted was INR 1.58/kWh ($ 0.022/kWh) with an escalation by 3 percent per year over a period of 25 years.

Few of the key highlights of this RESCO tender are listed below:

- *Better risk profiling:* The group capacity ranges from 50 kW (individual private organization) to 5.4 MW (all projects of a genre across the state under one government department). For each consumer category, separate bidding was undertaken, and the winner must implement all the projects in that group. It enabled better project execution planning, efficient material procurement and efficient financing.
- *Providing extensive detail in the data room* - Unique data room was created and made accessible to interested/prospective bidders to address information asymmetry. This included information like Google coordinates of the buildings, indicative solar PV array layout superimposed on Google image and electricity consumption history of probable consumers. Such information enabled developers to size the Rooftop capacity accurately and thus lower overall price discovery.
- *Aggregation to gain scale* - Pre-identification of numerous project sites and grouping them into project groups created the much-needed market for interested project developers. This saved the bidders from spending their energy in identifying procurers that have enough electricity demand and space for rooftop solar solutions.
- *Robust payment security mechanisms* – A robust payment security mechanism was designed which was a win-win for all key stakeholders: consumer, developer, and government

Key learnings from India RESCO model

- Project bundling to achieve scale and tariff benefits in third party PPA can translate more savings to utility and consumers
- Procurement savings for government/city buildings without upfront investment
- However, requires capital subsidy or government incentives for successful deployment of such tender to attract private participation.

3. Community Model

Consumers can actively shape the energy infrastructure of their cities in a range of ways, including by making direct investments in renewable energy technologies and by opting into renewable energy purchasing programs offered by local utilities. In recent years, the number of community energy projects using solar PV and other renewable sources has increased steeply and is no longer limited to European countries but are being adopted in places like Thailand, North America etc. Community energy that has been more prevalent in rural areas in the past are now increasingly being adopted in the urban projects as well. Rooftop PV are being deployed in portfolios where large aggregations of rooftop installations are coordinated to meet the grid needs reducing the overall capacity needs for the utility.

In some cities, customers that generate from their own rooftop supply can sell excess energy with their neighbors, making it possible to monitor and exchange energy among peers. Participants often receive better financial return than what is available through traditional net metering or feed-in tariff policies that compensate producers for the excess energy supplied to the grid.

These can often be linked to energy trading platforms which are active in very few cities around the world namely in London (United Kingdom), Pennsylvania (United States) and few cities in Germany. The key challenge is typically the market maturity, integrated deployment with smart inverter/storage solutions and size of individual plants that are often too small to efficiently direct/ trade energy.

Hawaii (State in United States of America) Experience

In 2008, Hawaii Clean Energy Initiative (HCEI) had targeted to achieve 70% clean energy by 2030 and announced deployment of distributed solar PV system through net metering scheme. However due to rapid upscaling and grid operations issues the net metering scheme was discontinued in 2015. During its peak deployment the PV capacity was greater than 50% of the system peak load requirement thus leading to integration issues for daytime operations.

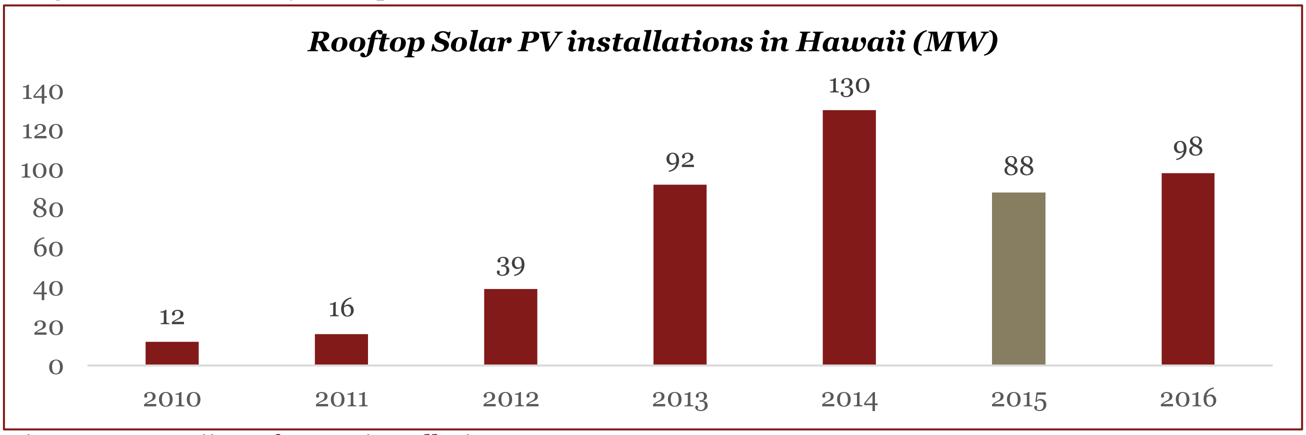


Figure 4: Hawaii Rooftop PV installations

Considering the integration issues the net metering scheme was successfully replaced with

- Customer Grid Supply Plus (regulated export of power post consumption),

- Smart export (integrated with storage devices incentivize consumers with credit during non-daylight hours)
- Community model

This has resulted in Hawaii contributing to renewable generation through rooftop PV during non-daylight hours enabling the state to achieve its Renewable target.

Key Learnings from Hawaii experience

- Rapid upscaling of Rooftop PV installation can lead to system integration issues for daytime loads.
- New models adopted to incentivize consumers to export to grid in line with grid requirements.

4. Utility Driven Model

Utilities are successfully and proactively engaging in conversation on non-wires solutions within their traditional distribution planning process. ConEd in New York is one of the first utility projects in US to source local Distributed Energy Resources from Rooftop PV to reduce its cost of network expansion.

New York state has a cumulative installed rooftop PV capacity of 1.37 GW with nearly 1 GW in pipeline as on March 2019.

The non-residential sector has major installation through Power Purchase Agreement Model, or the Third-Party Ownership model as compared to Residential where majority of Rooftop PV investments is through direct purchase or leasing model. This has also resulted in higher rooftop PV system size with 65% of the total installed capacity having rooftop system capacity of more than 100 kW dc. The average installed capacity of the rooftop PV system across state was 25 kWp

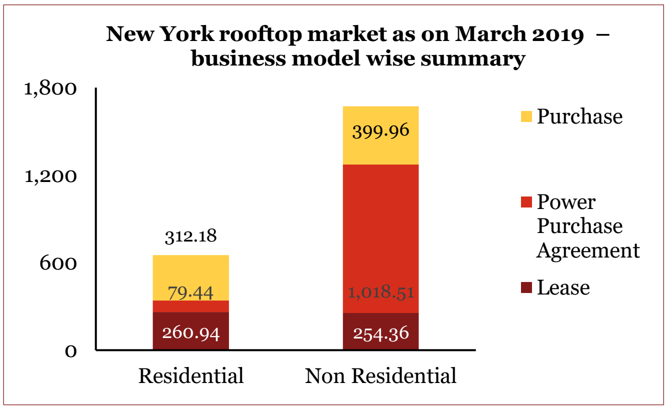


Figure 5: New York Rooftop PV installations

- Consolidated Edison's (New York utility) in Brooklyn projected a grid overload of 69 MW with estimated expenditure towards grid upgrades- $1.2 billion.
- ConEd addressed the overload requirement through Distributed resource generations like solar rooftop with storage and other demand response measures.
- Utility provided monetary support to consumers towards interconnection cost for distributed energy sources.
- Consumers receive performance payments based on load reduction/exports to grid made during periods required by utility.
- System deployed with integration of other technologies like storage, smart inverters.

Key learnings from Con Ed Experience

- Integrated deployment of Rooftop PV with storage/DER solutions can be a viable alternative for grid upgrades in urban cities where new investments could be costly.
- Cities need to encourage mix of technologies with Rooftop Solar PV like storage, smart inverters for deployment to address solar intermittent generation.

Thus, it is important to adapt these global developments while considering the Vietnam Power scenario, existing and proposed regulations to develop a suitable rooftop PV deployment model for HCMC and Danang.

4. Regulatory framework for rooftop PV deployment in Vietnam

4.1. Key regulatory updates on rooftop PV decision

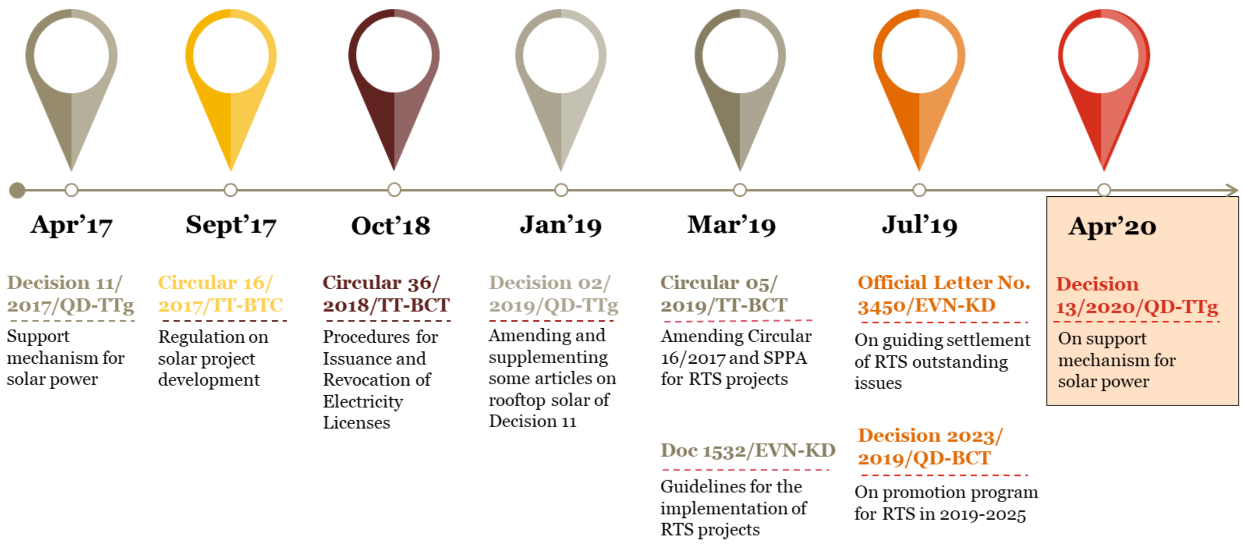


Figure 6: Regulatory timelines

Key takeaways from regulations

Regulations	Description
Decision 11/2017/QD-TTg ("Decision 11") dated April 2017	• FiT for solar projects is pegged to dollar and fixed at 9.35 cents per kWh. This FiT is applicable for both type of solar projects- Rooftop and Ground mounted.
Circular 16/2017/TT-BCT ("Circular 16") dated September 2017	• The use of model PPAs is mandatory for the sale and purchase of power generated from rooftop projects between the owner of a rooftop project and the power purchaser (i.e., the relevant local / regional EVN's Power Corporations).
Decision No. 02/2019/QD-TTg ("Decision 02") dated January 2019	• Rooftop solar power projects shall be entitled to a mechanism for purchase and sale of electricity that separates the direction of delivery of electricity from the direction of receipt of electricity in two-way/bidirectional meters. This mechanism replaced the previous net-metering scheme under Decision No. 11.
Decision No. 13/2020/QD-TTg ("Decision No. 13") dated 6 April 2020	• Rooftop solar systems may sell all or part of power generated to EVN, or to other purchasers in case the EVN's grid is not used. • If the purchaser is EVN, new FiT for rooftop solar systems is indexed to dollar and fixed at **8.38** US cent per kWh, fluctuated based on the VND-USD exchange rate announced by the State Bank at the end of the preceding year

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Regulations	Description
	for energy payment for the following year. This FiT applies to rooftop solar systems that achieve a COD and have its meter readings confirmed between 1 July 2019 and 31 December 2020. A system is considered a "rooftop solar system" if it (i) has capacity not exceeding 1 MW and (ii) is connected to a grid with voltage of 35kV or less. This means that large scale solar rooftop systems with capacity more than 1 MW may be disqualified from the FiT of 8.38 US cent per kWh. • If the purchaser is not EVN (i.e. private consumers), the power sale/purchase price and contract term is subject to the parties' negotiation subject to compliance with the laws. This may facilitate the direct power sale & purchase model between power developers and private consumers.

Decision No. 13 does not provide for specific categories of rooftop solar models (although during the drafting process, four different models were proposed to be included in the Decision). Decision No. 13 generally allows rooftop solar systems to "sell all or part of power generated to EVN, or to other purchasers in case the EVN's grid is not used".

In addition, a proposal for development of renewable energy in Da Nang and HCMC till 2025, with a vision to 2035 has been approved. The project is formulated to collect, evaluate and identify potential areas and reserves for investing and developing scalable renewable and new energy projects.

4.2. Business models for Rooftop PV deployment

Based on general wording under Decision No. 13, the following four (4) rooftop solar models may be implemented, subject to the specific guidance on rooftop solar models to be issued by the MOIT or other relevant state authorities.

1. **"Power Consumption" model**

   Defined as a model of rooftop solar power projects installed with a two-way metering system together with the household’s power consumption system for directly consuming power generated from the household's rooftop solar power system, simultaneously receiving power directly from the grid of EVN/the Power Purchaser.

   Under this model, any excess energy output after self-consumption by the household will be backfed onto the grid. Payment and invoicing will be made separately between power output delivered/exported and power output received/imported by the household/business. This model may be relevant to residential consumers.

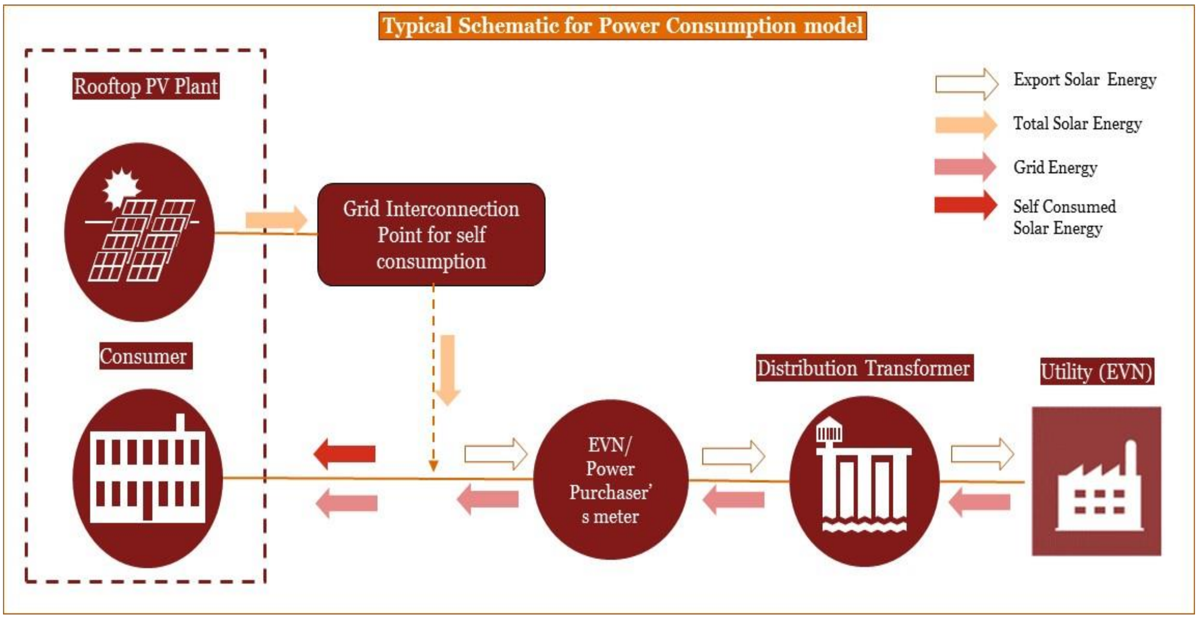


Figure 7: Schematic of Power Consumption model

2. **"Entire power sale business" model**

Defined as a model of rooftop solar power project installed and measured independently from the power consumption. This system is directly connected to the Power Purchaser's grid and selling the entire generated power output to the Power Purchaser, and the household/business does not directly consume any power generated from its rooftop solar power system.

The Power Seller/generator and EVN/Power Purchaser may freely reach an agreement for the connection point to be either in front of, or behind, the Power Purchaser's meter. Under this model, costs of investments and installation of meters and costs for upgrading interconnection systems/facilities shall be borne by the Power Seller. This model may be relevant to third party developers leasing rooftops to sell power to EVN.

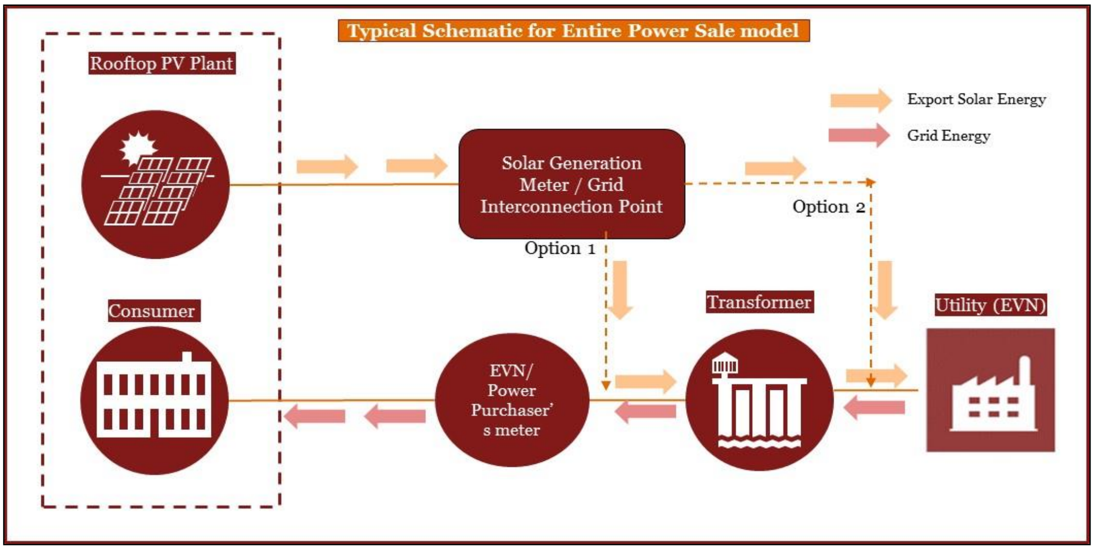


Figure 8: Schematic of Entire Power Sale model

3. **"Direct power sale and purchase" model**

Defined as a model of rooftop solar power project under which individuals and organizations invest, generate and sell power from their rooftop solar power projects to other individuals and organisations not connecting or utilizing national grid systems

If the Power Seller does not use the national grid at all, the Power Seller and the private Power Purchaser may freely reach an agreement on metering and interconnection arrangements in accordance with applicable regulations on civil and commercial transactions.

If the rooftop solar power system is indirectly connected to the national grid, the Power Seller must reach an agreement with the provincial-level Power Corporation/Utility for installing a bidirectional meter to record power output consumed and power output generated from the solar power system on a monthly basis.

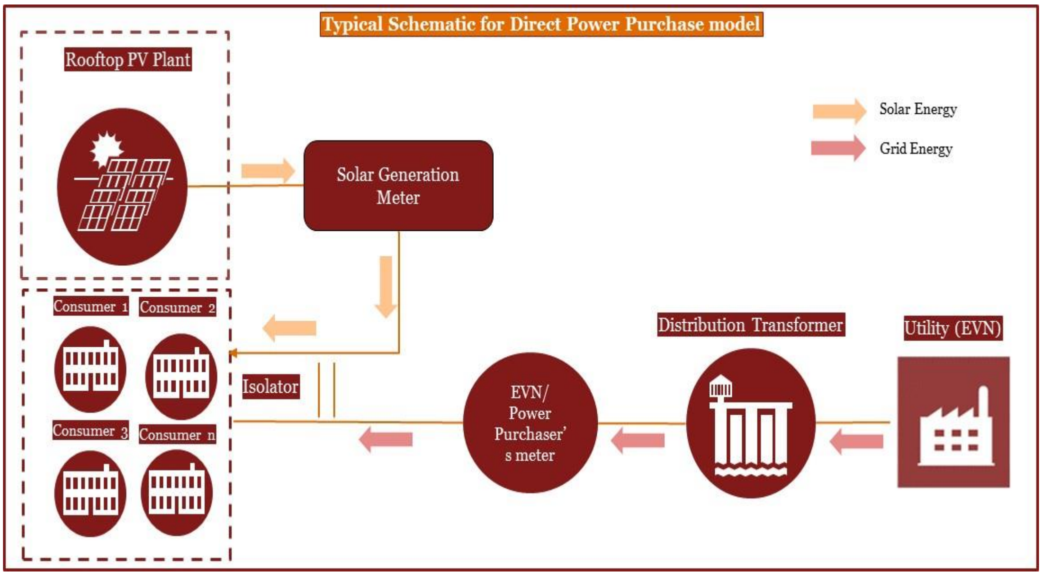


Figure 9: Schematic of Direct Power Purchase model

Under this option, costs of investments and installation of meters and costs for upgrading interconnection systems/facilities shall be agreed between the power developer and the consumer. This model may be relevant to third party developers leasing rooftops to sell power to private consumers.

4. "Excess power sale business" model

Defined as a model of rooftop solar power systems under which organizations and individuals invest in and install rooftop solar power systems to (i) sell parts of power energy outputs to other organization and individuals and (ii) sell excess power energy output to the national grid.

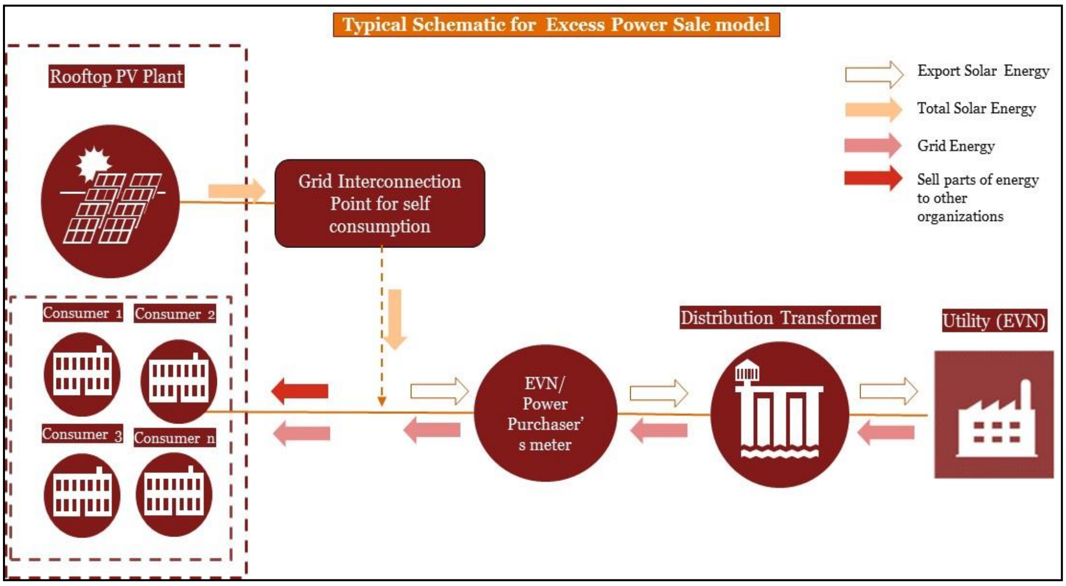


Figure 10: Schematic of Excess Power Sale Model

Key summary of stakeholder roles under these models are:

	Power Consumption model	Entire power sale business model	Direct power sale and purchase model	Excess power sale business model
Consumer	• Energy generated is utilized for self-consumption	• Additional income generation	• Enters PPA with seller/developer • Replace consumption with Rooftop PV	• Enters PPA with seller/developer
EVN/ PCs	• Excess energy output after self-consumption will be backfed onto the grid • Agreement for tariff for excess power sale	• Enter PPA with consumer for procurement	• Ensure isolation of PV system from grid	• Excess energy output after consumption will be fed onto the grid • Agreement for tariff for excess power sale
Third party developer	• May lease suitable rooftops and/or sell the PV system to the consumer	• May lease suitable rooftops and/or sell the PV system to the consumer	• Setup solar plants under RESCO to sell power to consumers	• May lease suitable rooftops and/or setup solar plants under RESCO to sell power to consumers

Objectives/Key drivers for selecting the business model

Based on the driver for rooftop PV in the city, each of these models can be adopted/promoted in the city for rooftop PV deployment.

5. If the key driver for Rooftop PV deployment for the city is to reduce power procurement costs of utility

"**Entire power sale business model**" is best suited in such scenarios where utility purchases the entire power generated from Rooftop PV at a lower FiT. This could mean potential savings in replacement of power purchases from Bulk supply tariff. Other models of excess power sale could also be promoted to meet such objectives of the utility; however, the reduction potential of power procurement cost could be minimal. Further, the FiT level needs to be remunerative for consumers to adopt such model more prominently with rapid scaling depending on the profitability to consumers based on the system costs and FiT levels.

6. If the key driver for Rooftop PV deployment for the city is to address growing demand in the city

"**Power-Consumption model**" and "**Excess Power Sale model**", provides the maximum replacement of energy consumption with Rooftop PV generation. Thus, it enables the utility to manage the demand growth and plan for its generation resources accordingly. However, the utility may need to define technical limits on feeder level integration of such Rooftop PV to enable stable operations of distribution grid. Further, levels of cross subsidy in electricity retail tariff could also impact the profitability of the utility due to reduced consumption of high paying consumers, thus requiring tariff rationalization.

7. If the key driver for Rooftop PV deployment for the city is T&D investment deferral of utility

Third-party based models such as “**Direct Power Sale and Purchase model**” and “**Excess Power Sale model**” provides the required rapid scaling up required to meet the immediate network demand there by allowing deferral of investments required in transmission and distribution to meet the future growth. Utilities in cities where network expansion pose larger challenges due to congestion or RoW costs, such Rooftop PV models provides the required upscaling of distributed generation in the city to meet the electricity demand. It requires integrated deployment with other technologies like storage, EV deployment to better replace the demand required across the consumption hours. However, this model requires electricity retail tariff rationalization to reduce the impact of cross subsidy on utility’s profitability due to rapid upscaling of rooftop PV by higher retail tariff paying consumers.

8. If the key driver for Rooftop PV deployment for the city is loss reduction and improving system reliability for utility

Utilities having network with unreliable power supply and/or loss-making feeders having high commercial losses, can adopt third-party based model such as “**Direct Power Sale and Purchase model**” to reduce the dependence of grid and thereby improving system performance. However, right scale and bankability issues for third party may need to be addressed by utility through relevant procedures and agreements. The impact on tariff dur to consumers moving out is quite irrelevant since the remuneration to utility through reduction in losses recues the overall cost of supply for utility.

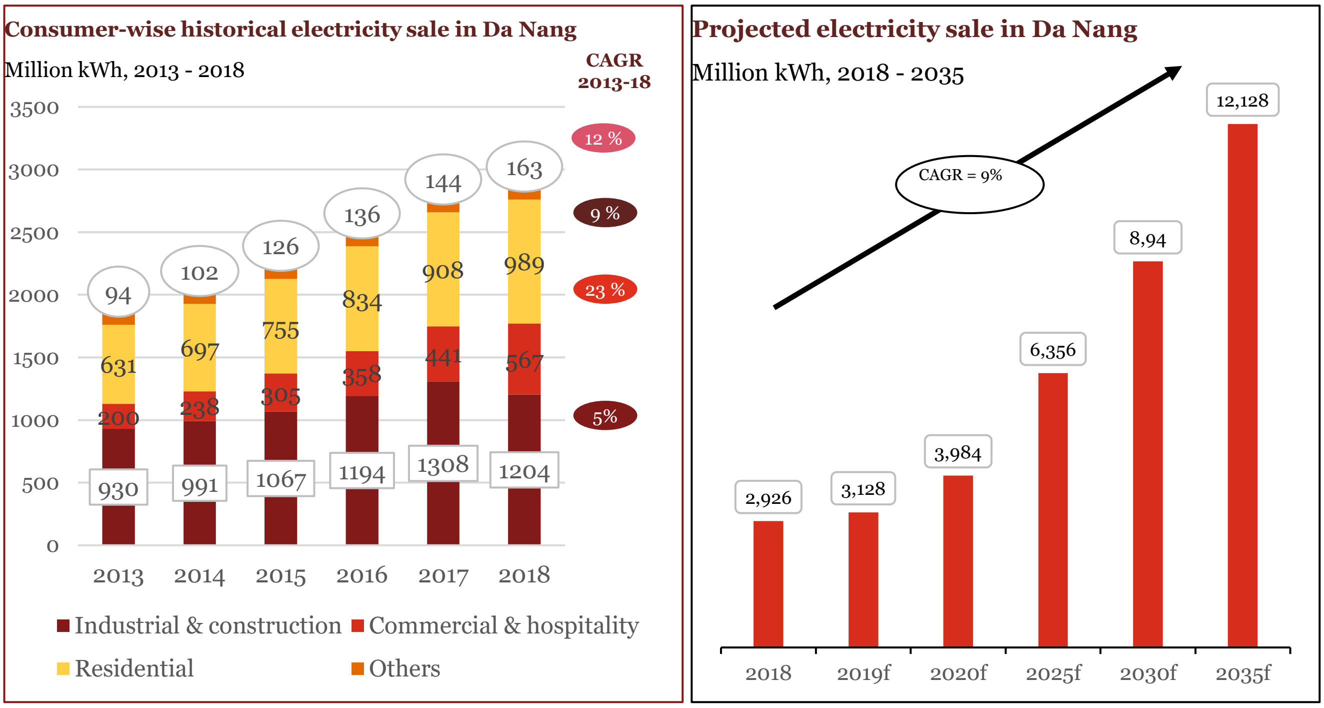
Thus, based on the utilities’ power procurement costs, tariff structure, loss levels and consumer mix each of these models could be promoted by the utility to meet its end objectives through a targeted Rooftop PV deployment.

5. Da Nang PC

5.1. Electricity Consumption Overview

Da Nang is a socio-economic center and a popular tourist destination in the central region of Vietnam. With the fourth largest seaport in the country, Da Nang is set to become one of the country's major urban centers and has recorded remarkable changes in its economic development. The charts below depict the electricity sold to each consumer group in Da Nang as well as the outlook for the city's electricity consumption in the medium to long-term.

Figure 11: Electricity sale (Million kWh) in Da Nang - historical and future scenario



Source: PC Danang, Danang's Power Development Plan

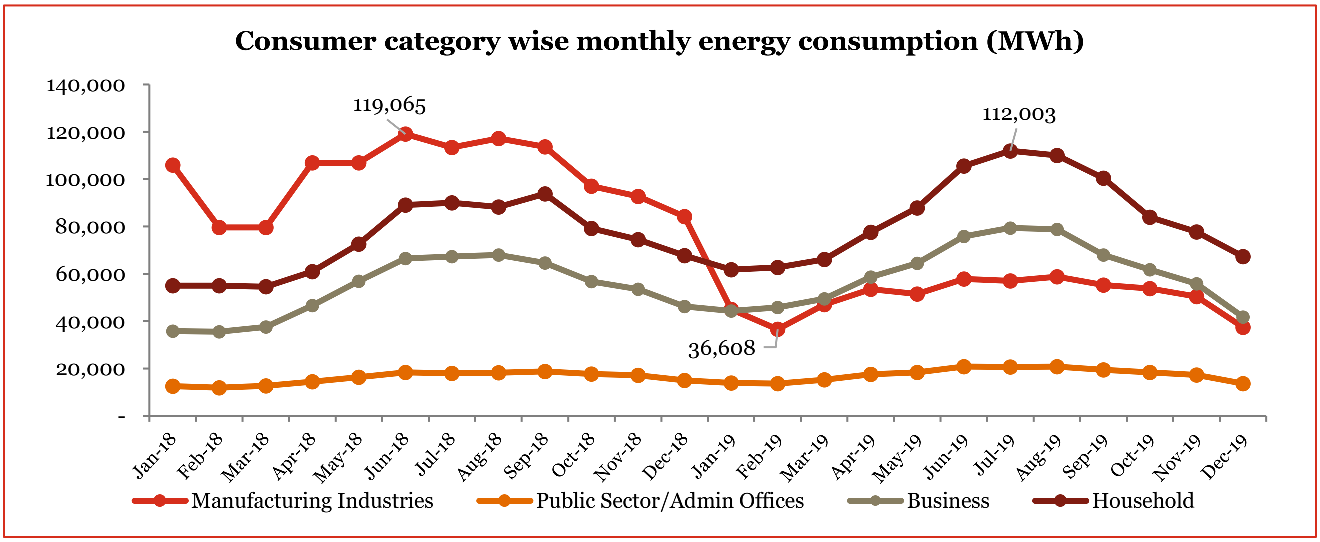
Service sector has been one of the largest economic drivers in the city followed by industry and construction sectors respectively. Growth in service sector is likely to drive rapid increase of energy consumption in the commercial category. This is largely driven by tourism sector which is undergoing growth leading to higher occupancy rates. Further, the electricity consumption of tertiary buildings is estimated to increase from 204 GWh in 2013 to about 688 GWh in 2025[4], of which hotels account for about 25 percent of the electricity consumption.

It is observed that energy consumption in Da Nang for 2018- 2019 is dominated by Industrial and commercial consumers (54%) with household/residential at around 38% electricity consumption. This energy mix share of industries and service sector has been larger in previous years and total electricity sale in Da Nang decreased by 13% in 2019 compared to 2018. This decline in electricity consumption was contributed by manufacturing industries segment which witnessed 50% decrease in electricity consumption 2019 (604.5 MU) compared to 2018 (1216.8 MU). This can be attributed to shutdown of two steel factories ordered by administration of Da Nang as a result of environmental pollution in the province.

[4] World Bank report- Energizing Green Cities in Southeast Asia – Da Nang

A snapshot of category wise monthly variation in energy consumption provided below indicates such reduction in electricity consumption for manufacturing industries from January 2019.

Figure 12: Energy consumption seasonality among consumer categories



Due to such closure of factories in 2019, overall growth rate of electricity consumption in the city has reduced. However, all other remaining consumer categories witnessed growth in electricity consumption in 2019 – Public sector/admin offices (~10%), Commercial/business (~ 14%) and residential (~15%) respectively.

Further analysis of category wise monthly energy consumption provides a seasonality trend in energy consumption among consumer categories. Residential, Business and Public sector offices follow similar energy consumption patterns i.e. the energy consumption starts to peak from the month of April and peaks during the month of July/August and starts to ramp down gradually. The demand starts to taper off gradually till the month of February.

This seasonality in electricity consumption has a very high correlation with the weather pattern in the city which has higher temperatures (**dry season**) during May to August followed by higher rainfall during October to January months (**wet season**). This seasonality shall allow the city to plan their energy purchase mix accordingly which complements the higher energy requirements during dry season. The city has limited land resources and does not have any power plant within the province (neither existing nor planned under revised PDP VII). Hence, the demand is being met through import from other regions through the EVN grid. Thus, Solar Rooftop provides an ideal opportunity for the city to meet such seasonal energy requirement more effectively.

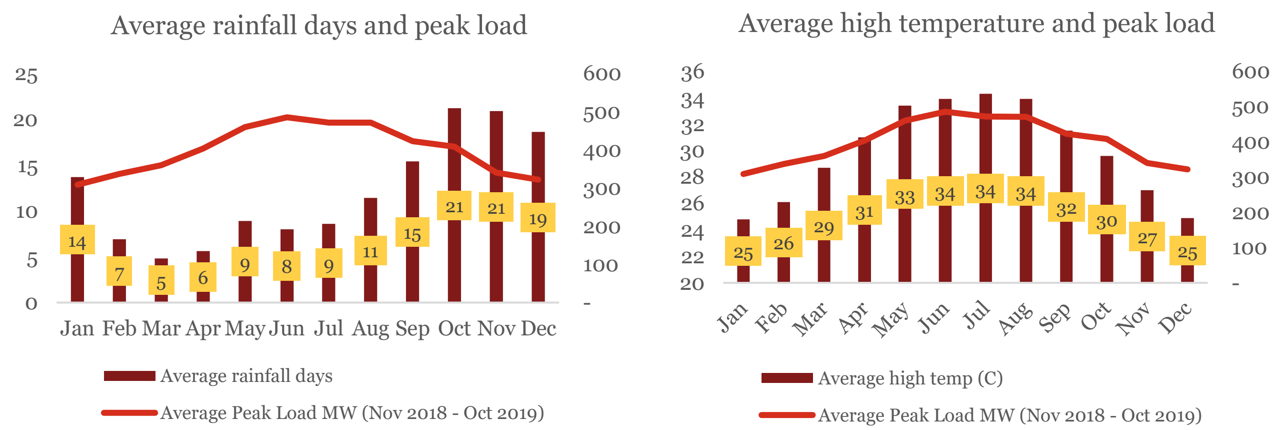


Figure 13: Rainfall and Temperature analysis for Danang

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District wise consumption analysis

Da Nang has six districts namely Hoa Vang, Lien Chieu, Cam Le, Son Tra, Ngu Hanh Son, Hai Chau and Thanh Khe managed by five power corporations namely Hoa Vang PC, Lien Chieu PC, Cam Le PC, Son Tra PC (which also covers Ngu Hanh Son), Hai Chau PC and Thanh Khe PC. A summary of consumer categories and electricity consumption is provided below

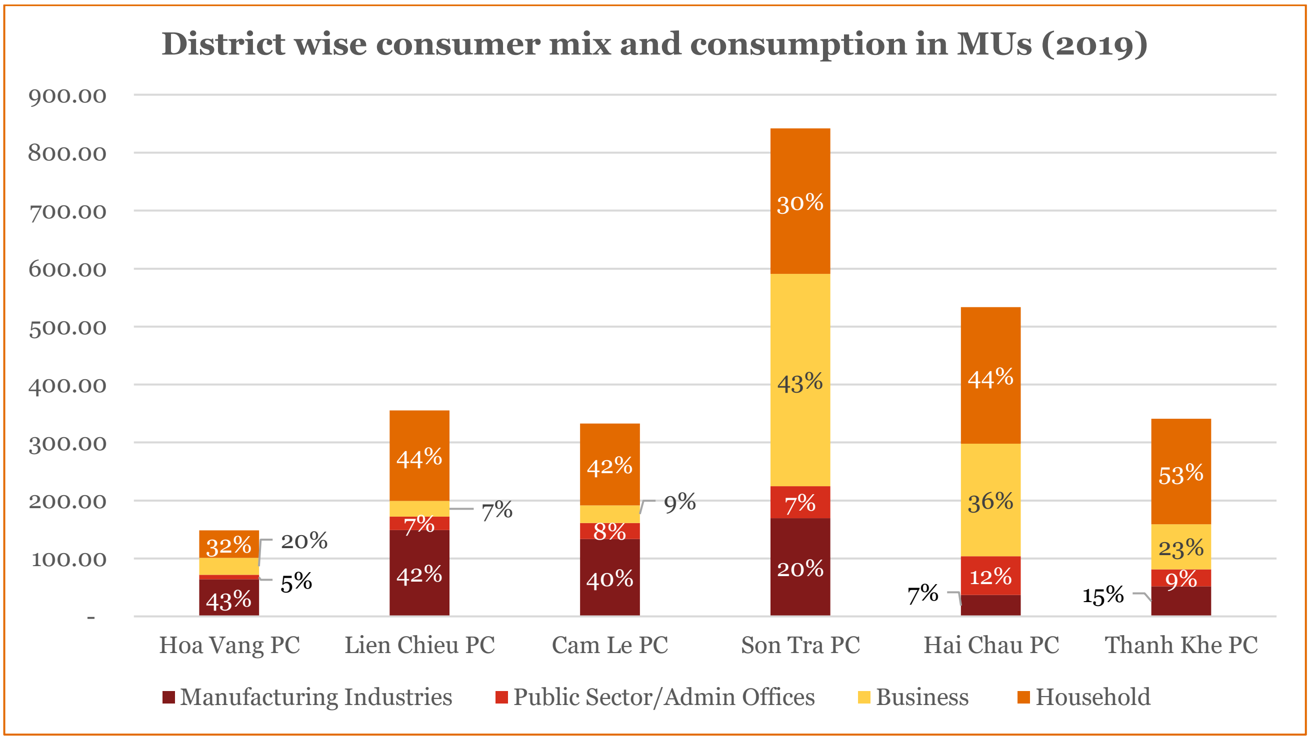


Figure 14: Consumption profile district wise map

Power Corporations Son Tra and Lien Chieu account for nearly 55% of total energy consumptions for the city with Son Tra having higher commercial consumer category i.e. business, hospitals, restaurant (43%) and Lien Chieu having higher industrial consumers i.e. manufacturing & construction industries (42%).

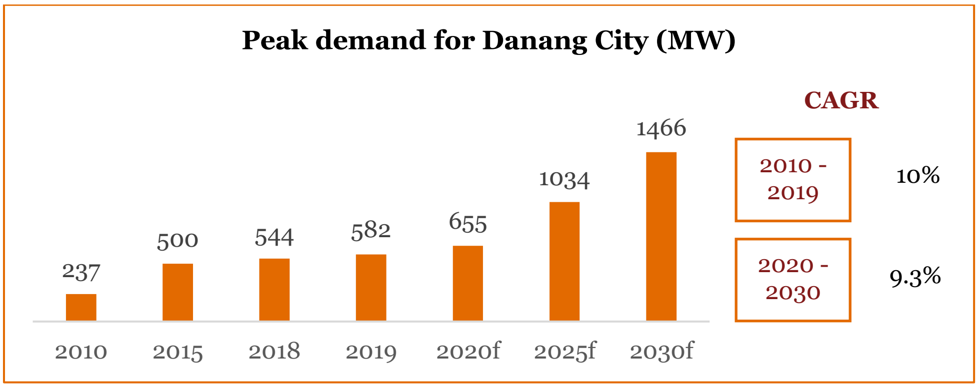
Hai Chau PC and Son Tra PC contributes the highest for both residential and public offices consumer category in the city, Residential category is 48% and Public offices represent 58% of the total energy consumption in the city for their respective consumer category.

This diverse mix of consumer categories across districts is important to determine the pilot deployment model for the city. In Task 3, based on above district wise analysis, business models finalized in this report and the technical study of the city for feeder analysis we shall recommend the suitable district and consumer category for a pilot deployment as per the rooftop strategy identified in this report. There are clear directions in terms of the district with higher consumption profile like Son Tra PC and Hai Chau PC which could be candidate districts for pilot deployment.

5.2. Daily Load Curve

Da Nang is completely dependent on the National Grid for electricity with no localized generation capacity in the city. In 2019 peak demand recorded was 581.7 MW for the month of June at around 13:00 hours. The chart below depicts the past and projected balance of the city's peak demand.

Figure 15: Peak Demand requirements in Danang



Source: PDP VII, Danang's Power Development Plan, PC Danang

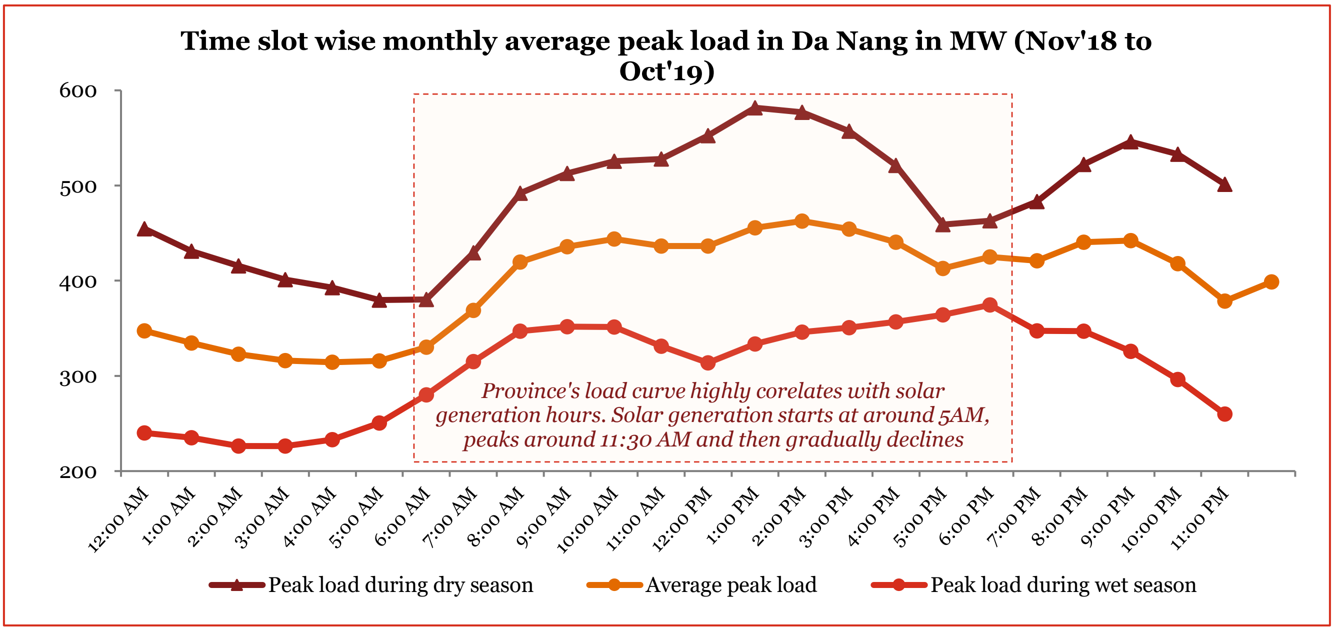
The peak load without the steel factory is estimated to grow at 9.3% with annual electricity consumption expected to grow at ~10% in near term. Commercial services category is likely to see the highest growth with around 13% along with public offices/other categories at 15%. This growth requires significant investments in transmission (110 kV level) and distribution grids (22 kV level). The total investment capital for new construction and renovation of power grid works with a voltage of 220 kV or lower is estimated at VND 8,211.7 billion till 2025 to meet the growing demand.

Apart from monitoring annual consumption growth, intraday variations in load also needs to be analyzed for solar rooftop PV deployment. The load curve reflects the activity of a population with respect to electrical power consumption over the given time slot. It gives an insight into the consumption pattern of an area for time of the day and enables planning/scheduling of the generation sources accordingly. To propose relevant business models to deploy rooftop PV in Da Nang, it is important to first study the load pattern as it is an important tool to optimize electricity sourcing.

In Vietnam, the climate is subtropical in the north and tropical in the center and south, and it's influenced by the monsoons. The average, maximum and minimum demand met during the winter is lower than that of the summer respectively because in tropical to subtropical climates, like that of Vietnam, cooling load dominate heating loads.

Further, electricity consumption does not happen at a constant rate in a typical day. Consumption varies based on time-of-day, weather and profile of the consumer. The chart below depicts average peak load in Da Nang for the 12-month period from November 2018 to October 2019 and load curve during dry and wet seasons.

Figure 16: Time slot wise monthly average peak load



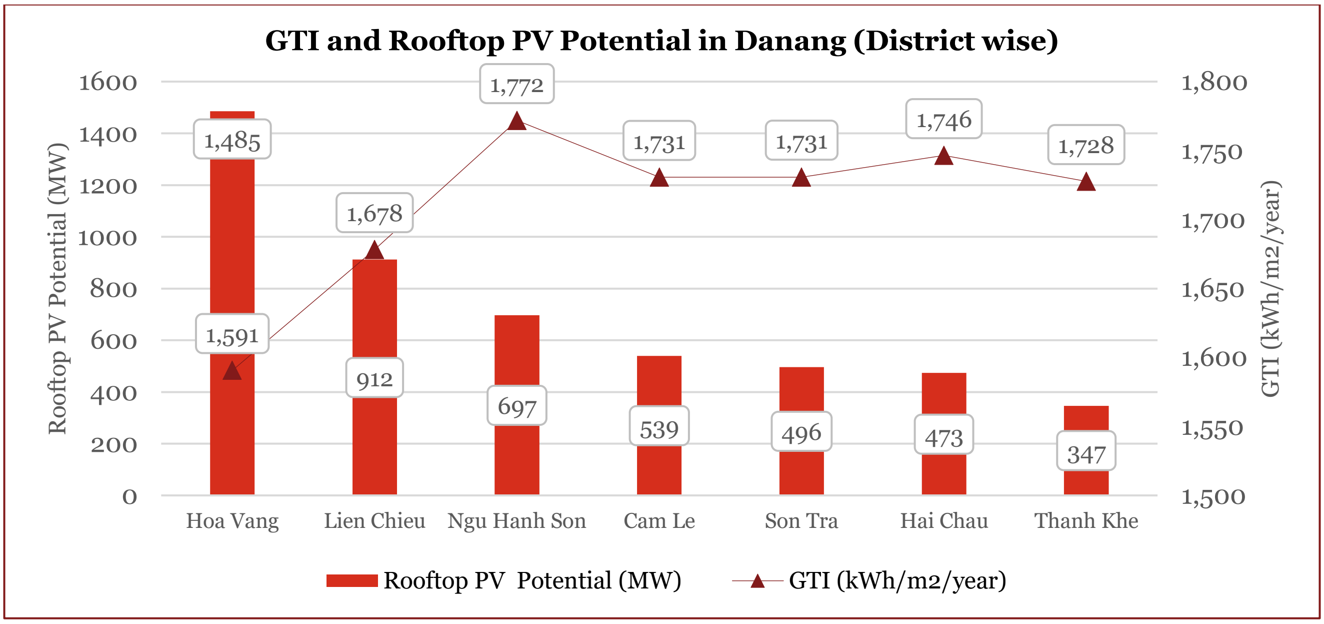
Some of the key insights that can be drawn from the load curve are listed below:

- The load curve in Da Nang peaks during two-time blocks within the day: in the morning hours (9:00AM to 11:00AM) which remains high till evening hours i.e. (4:00 PM) and night hours (9:00PM to 10:00PM).
- First Peak – Daytime Peak: The day-time peak can be attributed to commercial and public offices consumptions along with residential consumer category. During summers the load requirements by these categories are even higher due to higher temperatures requiring cooling systems.
- Second Peak – Nighttime Peak: The night peak can be attributed to the increased load requirement of residential consumers with industrial and construction load peaking due to off- peak tariff slots.
- In 2018, the highest average peak load was recorded as 543.7 MW at 10 PM during month of July. But in 2019, the highest average peak load was 581.7 MW at 1 PM in the afternoon. There was lower recorded peak load in nighttime due to closure of two steel factories as discussed in earlier sections.

Such load curve provides a promising business case for rooftop solar to address the daytime peak and if deployed with suitable relevant technologies can address the nighttime peak as well. Design of optimal capacity of rooftop solar can meet both the short-term and long-term energy requirements of the city.

This could also reduce the ramping requirements for purchases from EVN thus providing an additional commercial savings to EVN due to reduced ramp up/ramp down requirements.

5.3. Scenarios for Solar Rooftop



Source: Data extracted from http://rooftoppvpotential.effigis.com/, Global Solar Atlas

Figure 17: Solar Irradiation level and Rooftop potential for Danang

The graph above presents the total Rooftop PV potential in a district and its annual GTI levels. There is a variance of more than 10% across districts in GTI, varying from 1590 kWh/m2/year to 1780 kWh/m2/year.

Against this high potential, at the end of 2019, the installed capacity of rooftop solar in Danang was only 6.99 MW with almost entire capacity being commissioned in 2019.

Table 1: Rooftop PV installed capacity in Danang

Year	Residential/Household (MWp)	Non-residential (MWp)	Total (MWp)
2018 & before	0.40	0.04	0.44
2019	4.02	2.53	6.55
Total	4.42	2.57	6.99

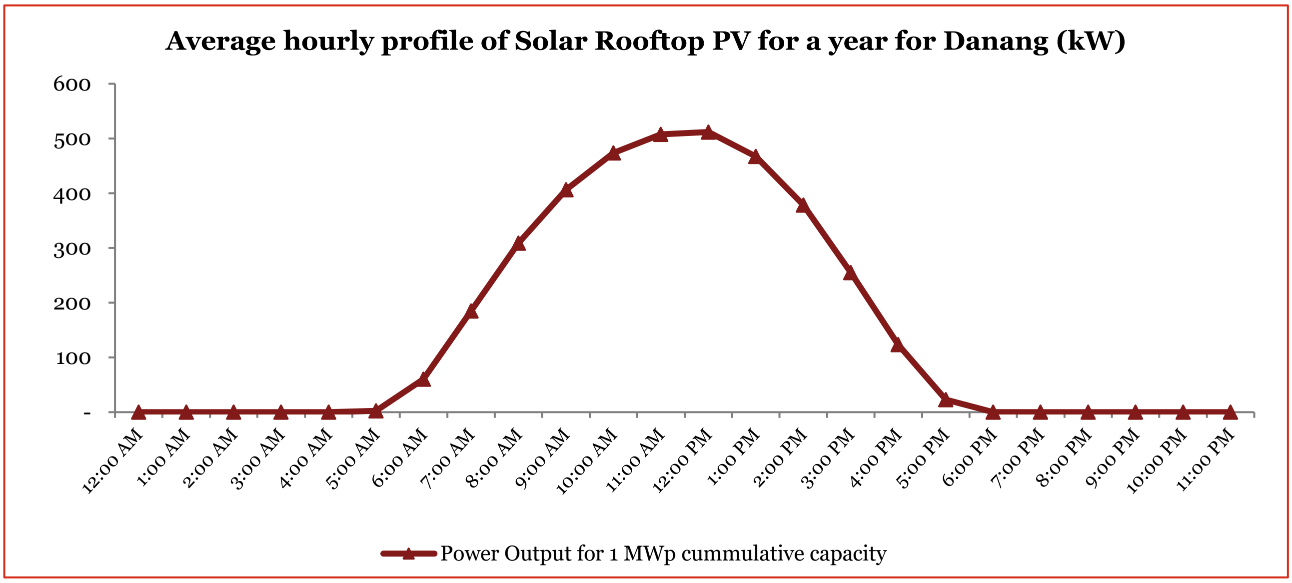
Source: Danang PC

The average system size in 2019 for the residential segment is around 5.24 kWp while for non-residential system the system size is around 19.30 kWp. This is largely a factor of the energy consumption of the consumer and available rooftop area. Based on the geospatial analysis from Effigis[5] the average suitable rooftop area for setting up solar plant within Da Nang was approximately 17% of the total available area. The suitable rooftop area ranged from 0.2% to 30%.

As of 2019, the adoption of rooftop has been rather slower as compared to the potential capacity in the city.

The typical average hourly generation profile for 1 MWp capacity with average system size of 20 kWp in Danang is as below.

[5] Data extracted from http://rooftoppvpotential.effigis.com/



Source: Global Solar Atlas

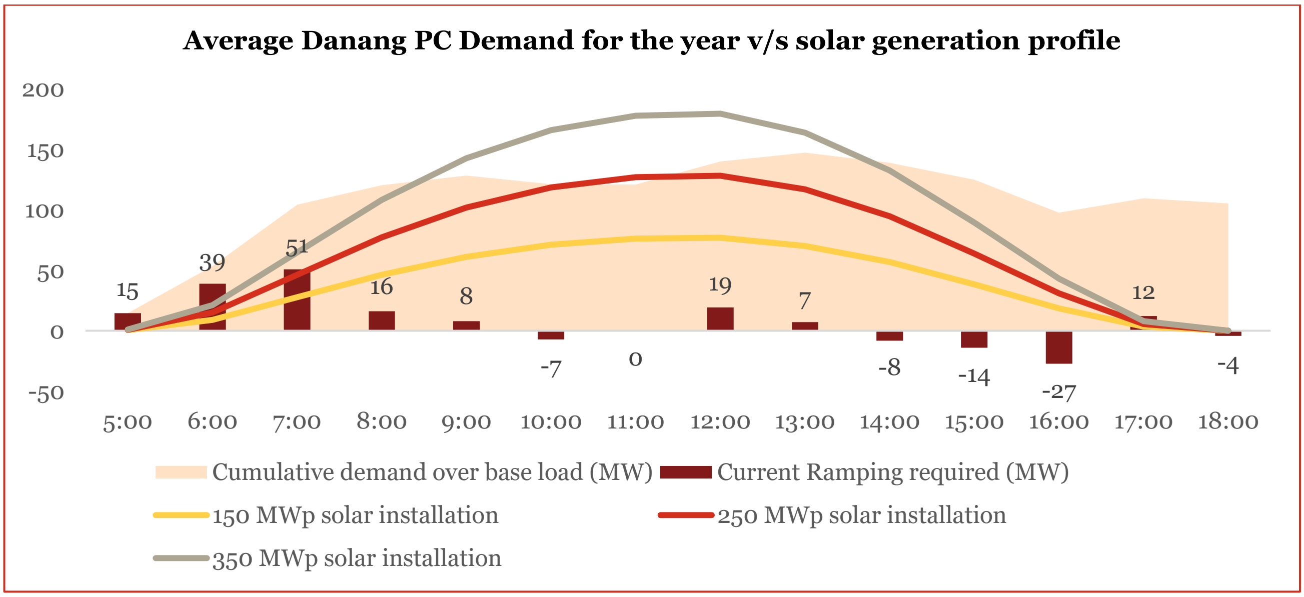
Figure 18: Solar generation profile for a day in Danang

Considering such solar generation profile and the cumulative demand during daytime with 5:00 am as the minimum base load requirement for the PC, the graph below provides following three scenarios for solar replacement through solar rooftop PV in Danang.

Scenario A: City installs 150 MWp solar PV rooftop systems in next 3 to 5 years

Scenario B: City installs 250 MWp solar PV rooftop systems in next 3 to 5 years

Scenario C: City installs 350 MWp solar PV rooftop systems in next 3 to 5 years



Source: Danang PC

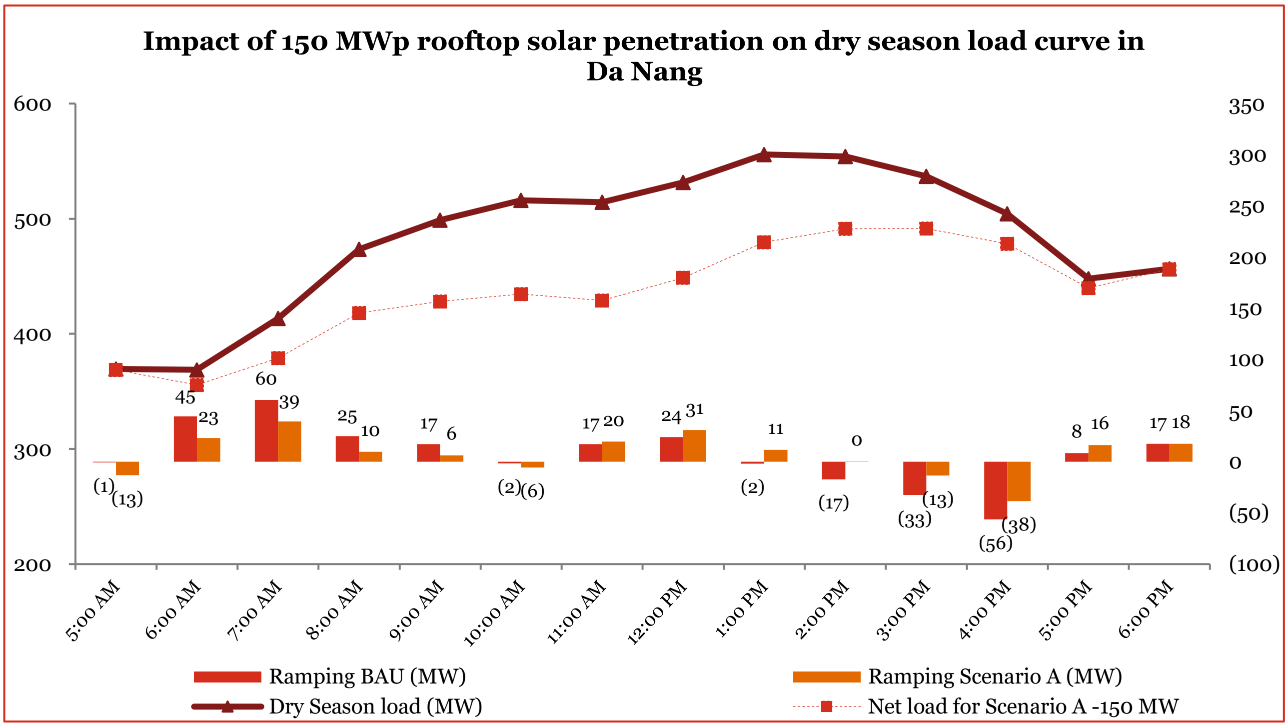
Figure 19: Average hourly ramping requirement and solar rooftop scenarios (MW)

At present with relatively lower rooftop penetration, the ramping requirement during early morning hours is higher (ramp up of 51 MW at 07:00 hours) while lower during evening (ramp down of 27 MW at 16:00 hours).

For each of these scenarios, we analyse below the impact on this ramping requirement for the city for the dry season (which has relatively higher demand requirement) and wet season (which has relatively lower demand requirement).

Scenario A: City installs 150 MWp solar PV rooftop systems in next 3 to 5 years

Figure 20: Impact of rooftop solar on load requirement in dry season in scenario A



Source: PwC Analysis[6]

With 150 MWp rooftop penetration following requirements are addressed in dry season

- Morning peak ramp up required is reduced from 60 MW to 39 MW. This benefits the city in reduced procurement costs and EVN in managing grid effectively.
- Evening peak ramp down required is reduced from 56 MW to 38 MW. This helps flatten the load curve for the city thereby allowing EVN to schedule base load plants accordingly minimizing variability in load requirement.
- The ramping requirement is still significant and is not completely met by rooftop generation considering 150 MWp generation.
- 150 MWp rooftop penetration does not create a duck curve i.e. min net load requirement is higher than the nighttime load requirement and entire solar generation can be consumed by the city.

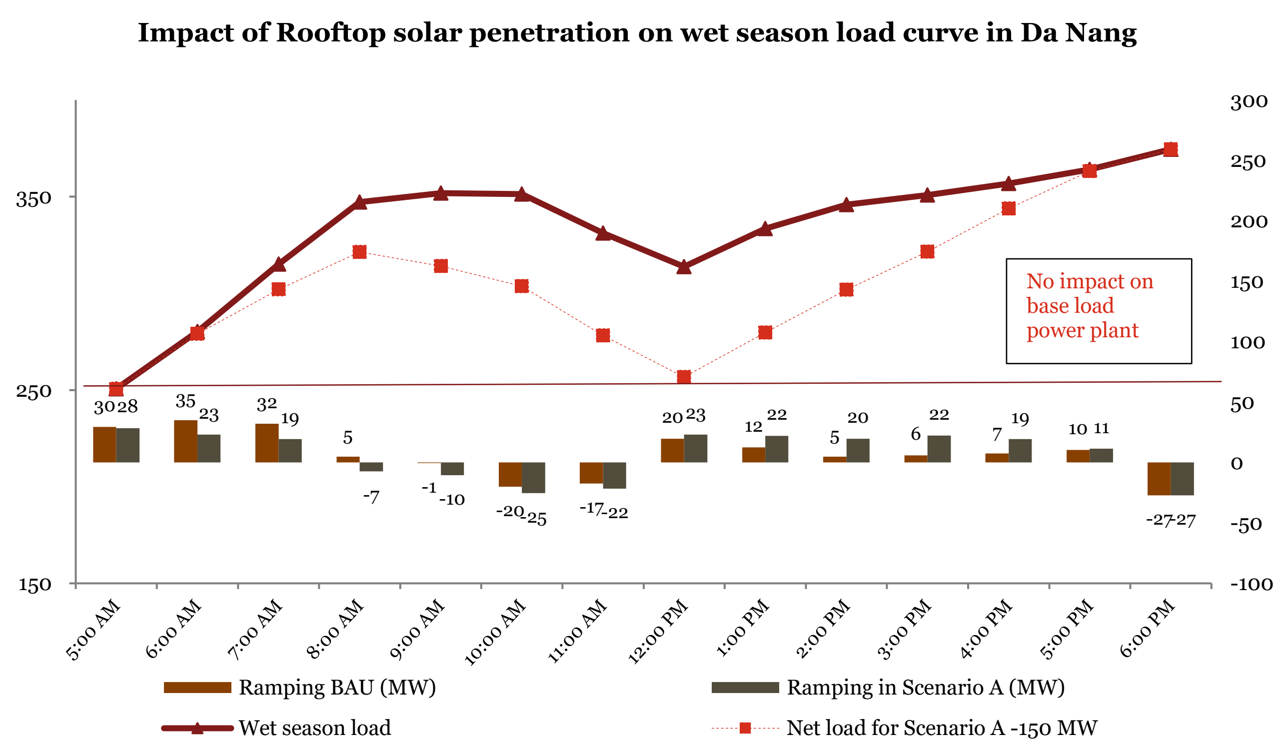
Summary of ramping requirements on energy procurement for the city based on average load curve is as below

Scenario impact based on load for the dry season	Morning Hours (6:00 am to 9:00 am) average ramping required per hour	Evening Hours (2:00 pm to 5:00 pm) average ramping required per hour
Business as usual (existing lower penetration of rooftop PV)	37 MW (ramp up)	24 MW (ramp down)
Scenario A (150 MWp Rooftop PV)	20 MW (ramp up)	9 MW (ramp down)

[6] The solar generation profile for Dry season has been considered for month of July when demand is at its peak

A similar analysis of load curve and solar rooftop generation during wet season when overall demand is lower is presented below.

Figure 21: Impact of rooftop solar on load requirement in wet season in Scenario A



Source: PwC analysis[7]

With 150 MWp rooftop penetration following requirements are addressed in wet season

- Morning peak ramp up required is reduced from 35 MW to 23 MW. This benefits the city in reduced procurement costs and EVN in managing grid effectively due to reduced ancillary services for load following.
- Evening peak ramp up required is increased from 20 MW to 23 MW. This increase in ramping required to meet load increase would require EVN to identify peaking plants/ancillary services to meet the load requirements.
- 150 MWp rooftop penetration does not create a significant duck curve i.e. min net load requirement is higher than the nighttime load requirement, however the evening peak load ramping is further increased due to decreasing solar generation during those hours.

Summary of ramping requirements on energy procurement for the city based on average load curve is as below

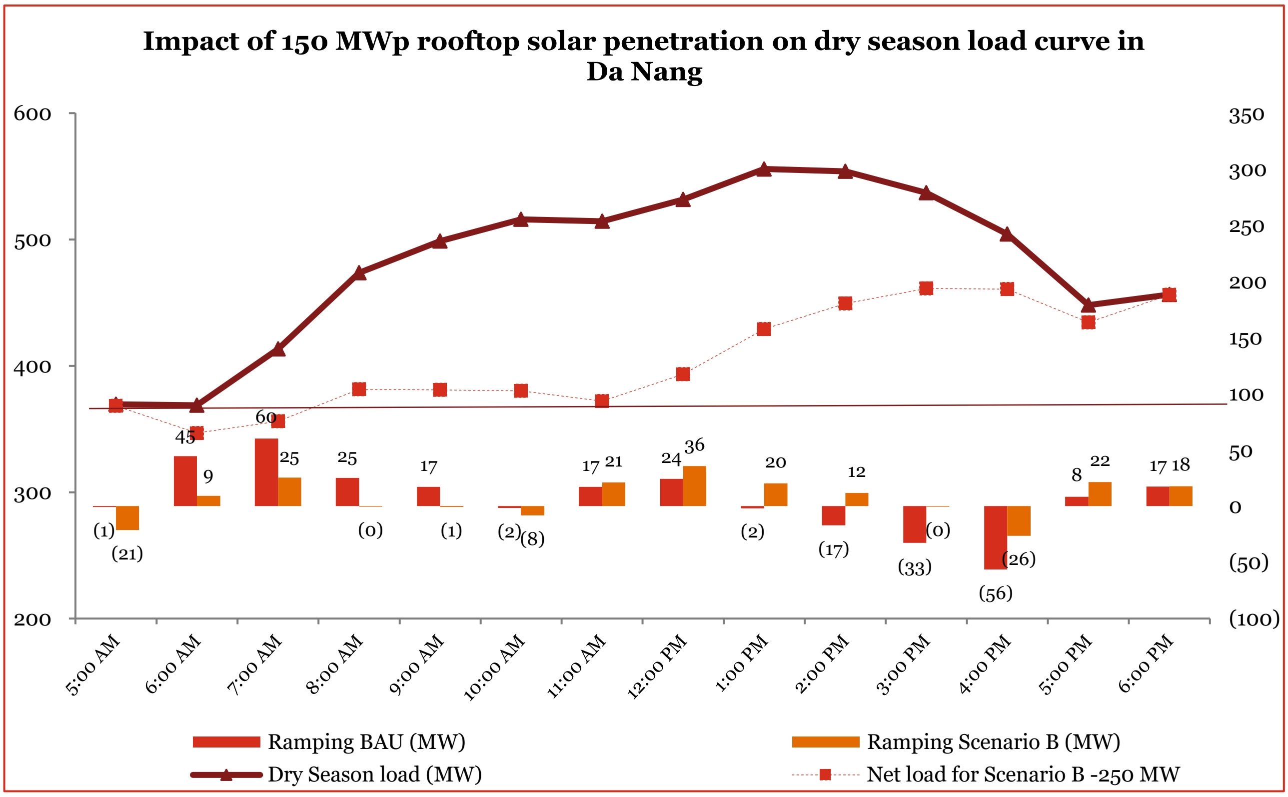
Scenario impact based on load for the wet season	**Morning Hours (6:00 am to 9:00 am) average ramping required per hour**	**Evening Hours (2:00 pm to 5:00 pm) average ramping required per hour**	**Flexible operation required in base load plant (reduction in offtake)**
Business as usual (existing lower penetration of rooftop PV)	18 MW (ramp up)	7 MW (ramp up)	0 MW
Scenario A (150 MWp Rooftop PV)	15 MW (ramp up)	20 MW (ramp up)	0 MW

[7] Solar generation profile for wet season considered for January when the demand is at the lowest

Thus, with 150 MWp rooftop PV system, city load requirements during daytime can be met leading to reduced peak demand during daytime. However, during evening hours especially in wet season when demand is relatively lower during daytime, higher ramping is required due to higher rooftop penetration.

Scenario B: City installs 250 MWp solar PV rooftop systems in next 3 to 5 years

Figure 22: Impact of rooftop solar on load requirement in dry season in scenario B



Source: PwC Analysis

With 250 MWp rooftop penetration following requirements are addressed in dry season

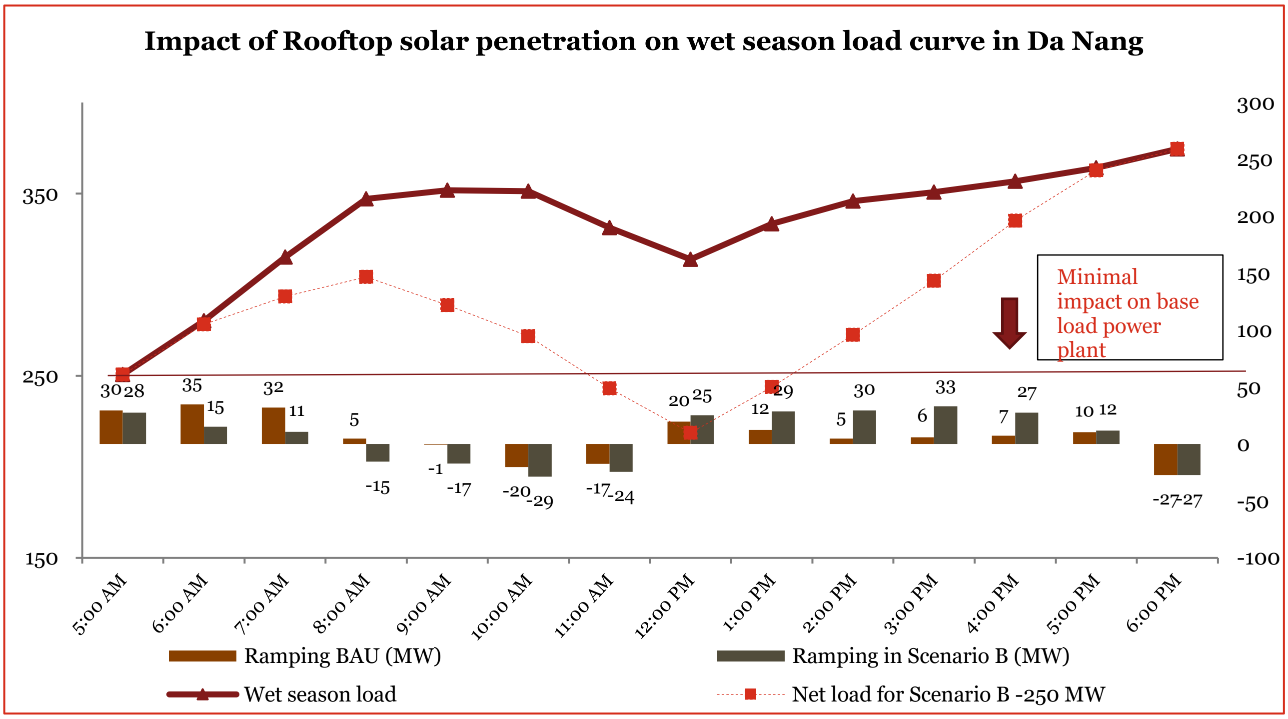
- Morning peak ramp up required is significantly reduced from 60 MW to 25 MW. This benefits the city in reduced procurement costs and EVN in managing grid effectively due to reduced ancillary services for load following.
- Evening peak ramp down required is reduced from 56 MW to 26 MW. This helps flatten the load curve for the city thereby allowing EVN to schedule base load plants accordingly minimizing variability in load requirement.
- With this rooftop penetration, the load requirement is relatively flattened during the morning hours except for evening ramp up required to meet the load.

Summary of ramping requirements on energy procurement for the city based on average load curve is as below

Scenario impact based on load for the dry season	Morning Hours (6:00 am to 9:00 am) average ramping required per hour	Evening Hours (2:00 pm to 5:00 pm) average ramping required per hour
Business as usual (existing lower penetration of rooftop PV)	37 MW (ramp up)	24 MW (ramp down)
Scenario B (250 MWp Rooftop PV)	8 MW (ramp up)	2 MW (ramp up)

A similar analysis of load curve and solar rooftop generation during wet season when overall demand is lower is presented below.

Figure 23: Impact of rooftop solar on load requirement in wet season in Scenario B



With 250 MWp rooftop penetration following requirements are addressed in wet season

- Morning peak ramp up required is reduced from 35 MW to 15 MW. This benefits the city in reduced procurement costs and EVN in managing grid effectively.
- Evening peak ramp up required is increased from 6 MW to 33 MW. This increase in ramping required to meet load increase would require EVN to identify peaking plants/ancillary services to meet the load requirements.
- Further 250 MWp rooftop penetration does create a significant duck curve with reducing load at peak generation hours. This load curve can be managed through deployment of storage technology to absorb this additional generation which can be used to reduce the load requirement during evening peak.

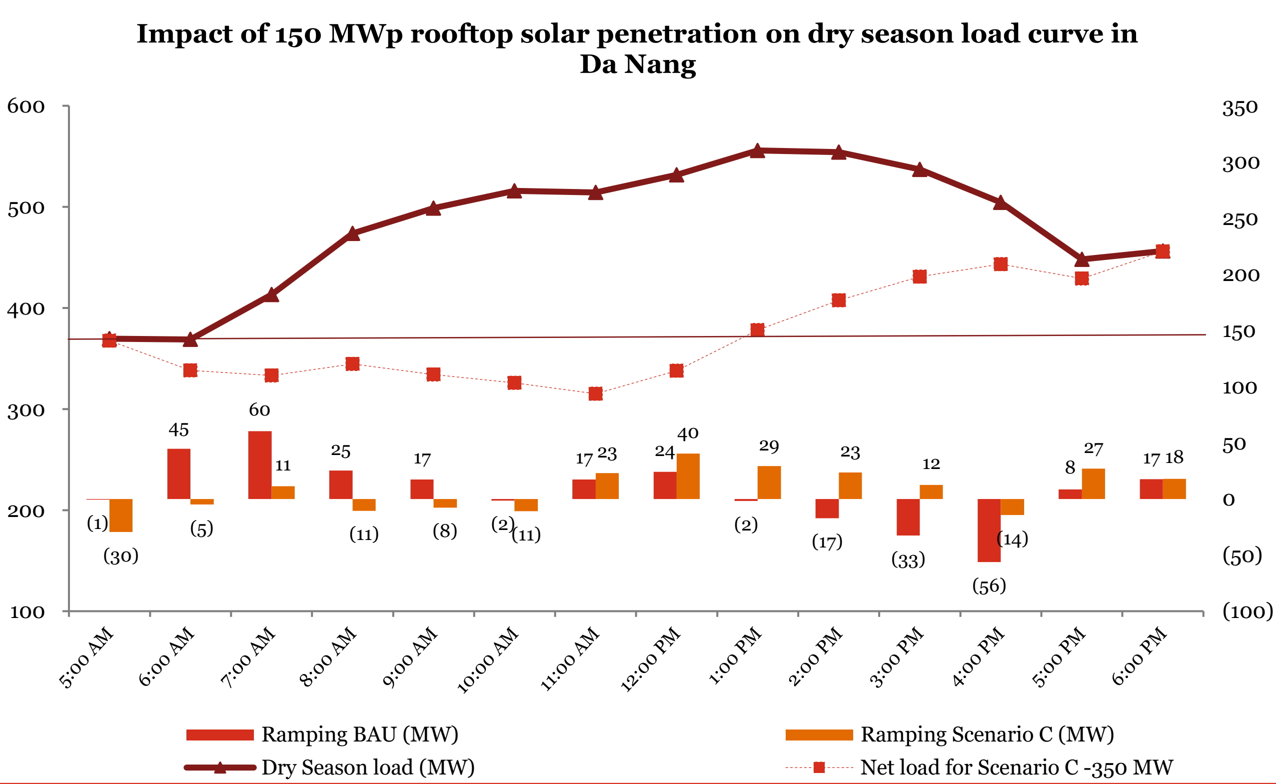
Summary of ramping requirements on energy procurement for the city based on average load curve is as below

Scenario impact based on load for the wet season	Morning Hours (6:00 am to 9:00 am) average ramping required per hour	Evening Hours (2:00 pm to 5:00 pm) average ramping required per hour	Flexible operation required in base load plant (reduction in offtake)
Business as usual (existing lower penetration of rooftop PV)	18 MW (ramp up)	7 MW (ramp up)	0 MW
Scenario B (250 MWp Rooftop PV)	2 MW (ramp down)	26 MW (ramp up)	31 MW

Thus, with 250 MWp rooftop PV system, city load requirements during daytime can be met significantly leading to reduced peak demand during daytime. However, during evening hours especially in wet season when demand is relatively lower during daytime, higher ramping is required due to higher rooftop penetration. With potential duck curve scenario during wet season, this level of rooftop penetration would require co deployment with other technology sources like storage to reduce the impact on grid.

Scenario C: City installs 350 MWp solar PV rooftop systems in next 3 to 5 years

Figure 24: Impact of rooftop solar on load requirement in dry season in scenario C



Source: PwC Analysis

With 350 MWp rooftop penetration following requirements are addressed in dry season

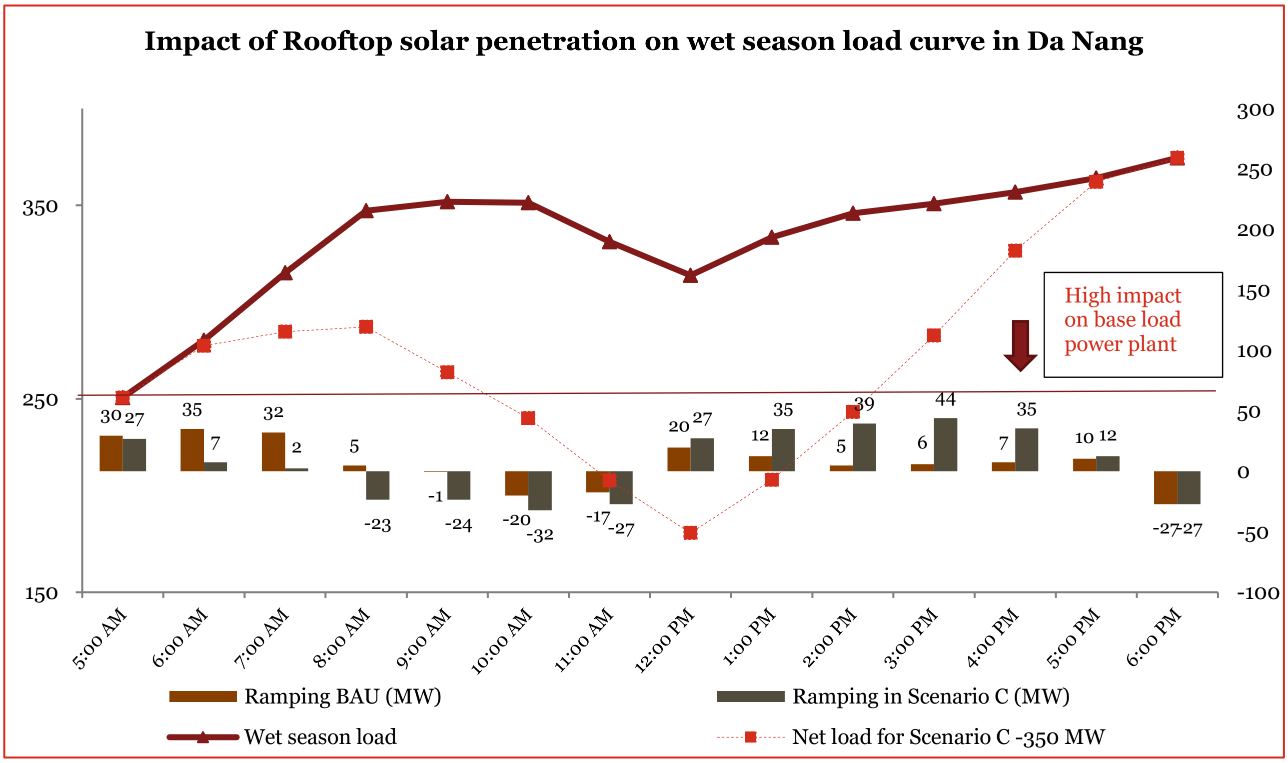
- Morning peak ramp up required is significantly reduced from 60 MW to 11 MW. This benefits the city in reduced procurement costs and EVN in managing grid effectively.
- Evening peak ramp down required is reduced from 56 MW to 14 MW. This helps flatten the load curve for the city thereby allowing EVN to schedule base load plants accordingly minimizing variability in load requirement.
- With this rooftop penetration, the load requirement in dry season is relatively flattened during the morning hours except for evening ramp up required to meet the load.

Summary of ramping requirements on energy procurement for the city based on average load curve is as below

Scenario impact based on load for the dry season	Morning Hours (6:00 am to 9:00 am) average ramping required per hour	Evening Hours (2:00 pm to 5:00 pm) average ramping required per hour
Business as usual (existing lower penetration of rooftop PV)	37 MW (ramp up)	24 MW (ramp down)
Scenario C (350 MWp Rooftop PV)	3 MW (ramp down)	12 MW (ramp up)

A similar analysis of load curve and solar rooftop generation during wet season when overall demand is lower is presented below.

Figure 25: Impact of rooftop solar on load requirement in wet season in Scenario C



With 350 MWp rooftop penetration following requirements are addressed in wet season

- Morning peak ramp up required is reduced from 35 MW to 7 MW. This benefits the city in reduced procurement costs and EVN in managing grid effectively due to reduced ancillary services for load following.
- Evening peak ramp up required is increased from 6 MW to 44 MW. This increase in ramping required to meet load increase would require EVN to identify peaking plants/ancillary services to meet the load requirements.
- Further 350 MWp rooftop penetration does create a significant duck curve with reducing load at peak generation hours. This load curve can be managed through deployment of storage technology to absorb this additional generation which can be used to reduce the load requirement during evening peak.

Summary of ramping requirements on energy procurement for the city based on average load curve is as below

Scenario impact based on load for the wet season	**Morning Hours (6:00 am to 9:00 am) average ramping required per hour**	**Evening Hours (2:00 pm to 5:00 pm) average ramping required per hour**	**Flexible operation required in base load plant (reduction in offtake)**
Business as usual (existing lower penetration of rooftop PV)	18 MW (ramp up)	7 MW (ramp up)	0 MW
Scenario C (350 MWp Rooftop PV)	9 MW (ramp down)	33 MW (ramp up)	70 MW

Thus, with 350 MWp rooftop PV system, city load requirements during daytime can be met significantly leading to reduced peak demand during daytime. However, during evening hours especially in wet season when demand is relatively lower during daytime, higher ramping is required due to higher rooftop penetration. With potential duck curve scenario during wet season, this level of rooftop penetration would require co deployment with other technology sources like storage to reduce the impact on grid.

Summary of Scenario analysis

The ramping requirements on energy procurement for the city based on average load curve in dry season is as below. The ramping requirement for Danang during morning hours (i.e. average of 35 MW) can be flattened using solar rooftop generation during dry season.

Scenario impact based on load for the dry season	Morning Hours (6:00 am to 9:00 am) average ramping required per hour	Evening Hours (2:00 pm to 5:00 pm) average ramping required per hour
Business as usual (existing lower penetration of rooftop PV)	35 MW (ramp up)	17 MW (ramp down)
Scenario A (150 MWp Rooftop PV)	20 MW (ramp up)	9 MW (ramp down)
Scenario B (250 MWp Rooftop PV)	8 MW (ramp up)	2 MW (ramp up)
Scenario C (350 MWp Rooftop PV)	3 MW (ramp down)	12 MW (ramp up)

Further, even though a higher penetration of rooftop PV system i.e. Scenario C addresses the morning peak requirements of the city effectively, a higher rooftop capacity shall also require higher ramping requirements in the evening hours. The ramping impact for evening hours when solar generation starts to reduce is more than 30 MW per hour i.e. from 17 MW ramp down requirement to nearly 12 MW ramp up requirement for Scenario C.

Summary of ramping requirements on energy procurement for the city based on average load curve in wet season is as below

Scenario impact based on load for only wet season	Morning Hours (6:00 am to 9:00 am) average ramping required per hour	Evening Hours (2:00 pm to 5:00 pm) average ramping required per hour
Business as usual (existing lower penetration of rooftop PV)	18 MW (ramp up)	7 MW (ramp up)
Scenario A (150 MWp Rooftop PV)	15 MW (ramp up)	20 MW (ramp up)
Scenario B (250 MWp Rooftop PV)	2 MW (ramp down)	26 MW (ramp up)
Scenario C (350 MWp Rooftop PV)	9 MW (ramp down)	33 MW (ramp up)

A higher penetration of rooftop PV system i.e. Scenario C significantly impacts the ramping requirements for the city in wet season. The ramping impact for evening hours when solar generation starts to reduce is more than 26 MW per hour i.e. from 7 MW ramp up requirement to nearly 33 MW ramp up requirement for Scenario C. Also, it creates a duck curve during peak generation hours leading to potential grid operational issues.

Thus, with higher rooftop PV penetration, city needs to plan an integrated deployment with alternative technologies like storage to reduce this ramping requirement for the evening peak providing for a flat load curve to be met through purchases from EVN.

This higher penetration of rooftop PV shall provide associated benefits along with procurement savings for the city as analyzed in the next subsection.

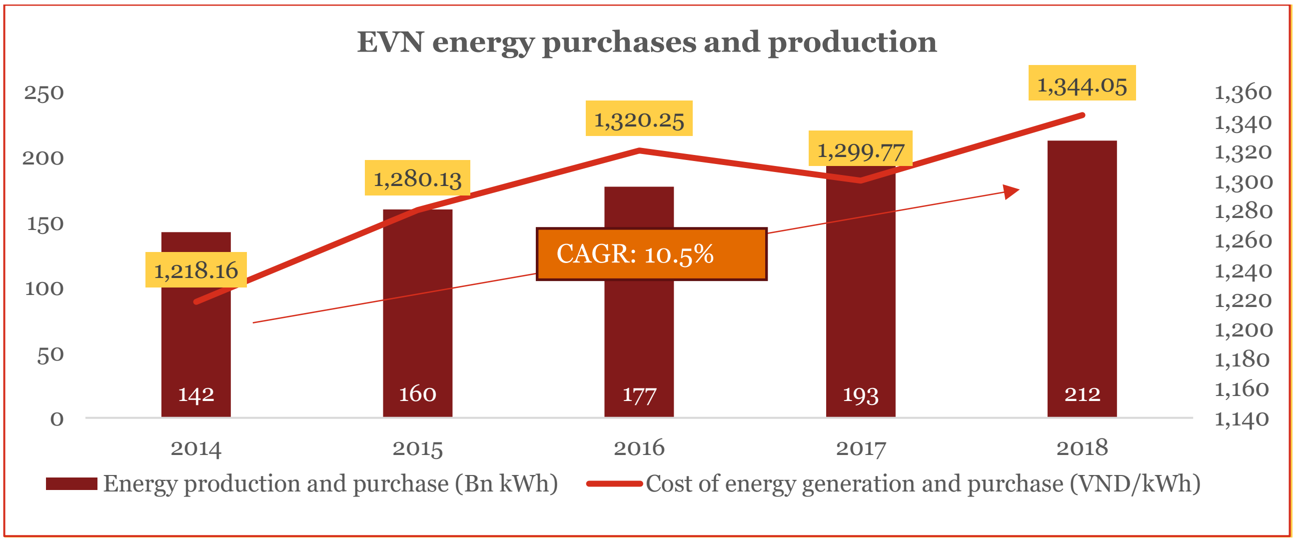
5.4. Commercial Assessment/Potential Savings

Rooftop PV deployment is likely to benefit across the value chain from generation to Transmission/Distribution to consumers. We have assessed the potential savings to each of the stakeholder in the following sections

1. EVN
2. EVNNPT
3. Danang Power Corporation (Danang PC)
4. Consumers (across all categories)

Entity	Key role in energy value chain	Potential savings
EVN	Energy production and energy procurement	Cost savings from meeting additional energy requirement thereby reducing marginal cost for EVN
EVNNPT	Transmission system deployment and maintenance	Transmission network investment deferrals considering integrated deployment of rooftop with storage
Danang PC	Power procurement from EPTC and distribution network investments	Reduced power procurement cost for PCs
Consumers	Electricity consumption (historical growth rate of ~ 10%)	Income generation alternative and savings in electricity bill (analyzed in detail for each consumer category in next sub- section)

Savings analysis for EVN



Source: EVN annual reports

Figure 26: EVN energy production and purchase trend

Historical growth in energy production and purchases to meet the demand in the country has been at 10.5%. With Danang electricity consumption expected to grow at 9.8% in 2021 – 2025, the investments and additional cost required for meeting this additional energy requirement by EVN is likely to further increase the marginal cost for energy generation for EVN. This is also likely to be enhanced by recent price increases in the primary fuel like coal which are further likely to impact the production cost for such additional energy required to meet the energy growth.

Thus, meeting energy requirement through a lower procurement cost alternative like solar rooftop PV at consumption end is likely to benefit EVN in addressing the demand growth. The energy replacement for Danang city through solar rooftop PV under various scenarios is presented below. Such energy replaced at source through rooftop PV can directly translate to reduction in marginal cost of generation for EVN (which as of 2018 is 1,344 VND per kWh).

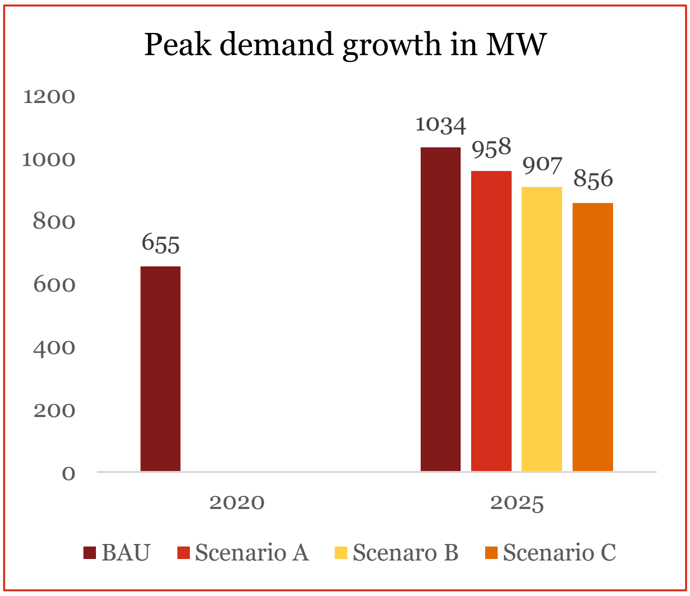
Rooftop Scenarios by 2025	Annual energy generation potential for rooftop (MWh)	Energy reduction for EVN by 2025 for Danang[8] due to solar rooftop PV
Scenario A (150 MWp Rooftop PV)	195,110	3.3%
Scenario B (250 MWp Rooftop PV)	326,850	5.4%
Scenario C (350 MWp Rooftop PV)	457,590	7.6%

Thus, the expected energy growth of 9.8% for Danang PC will reduce due to solar rooftop PV installation, which is likely to result in cost savings for EVN (savings from cost of energy production for additional energy). Thus, considering cost levels of 2018 for EVN, such rooftop PV installation could result in potential cost reduction of VND 263 billion to 615 billion (i.e. USD 11 million to USD 26 million by 2025)

Saving analysis for EVNNPT

220, 110 kV power grid are designed to ensure the reliability of power supply and power quality in normal working mode. The peak demand is estimated to increase by 379 MW in 2025 and an investment of VND 7,061 billion is envisaged in 110 kV and 220 kV grid infrastructure upgrades to meet the growing demand. These upgrades include substation improvements such as

- Newly build 220 kV Lien Chieu substation with a capacity of 2x250 MVA
- Renovate and raise the capacity of Ngu Hanh Son 220 kV substation
- Build one new substation with a total capacity of 126 MVA
- Renovating and scale up the capacity of eight substations with a total increase of 401 MVA



As per current practices of NPT, capacity of each substation is selected in accordance with the capacity needs of the downstream load that ensures the normal operation mode carrying a load of 65-70% of the rated capacity. With rooftop scenarios the peak demand projected is likely to reduce by 7% - 17%[9], this could mean the renovations and capacity augmentations planned could be deferred considering the normal operation mode with load of 65% - 70%. Thus, NPT could evaluate deferral of VND 7,061 million considering such rooftop scenarios adopted for Danang.

[8] Energy consumption scenario considered without steel factory at 6030 MUs energy requirement by 2025 for Danang
[9] Peak demand growth for 2025 estimated assuming that peak continues occur at day time peak at 1 pm as in 2019

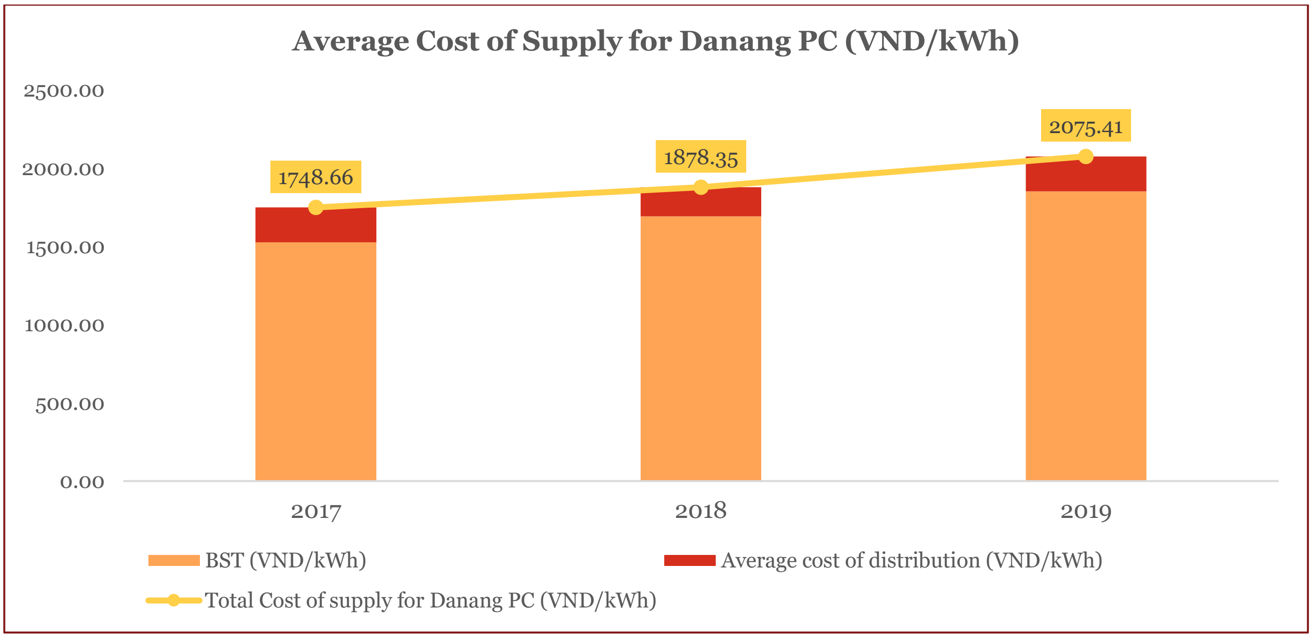
Saving analysis for Danang PC

Electric Power Trading Company (EPTC) of EVN performs the role of the Single Buyer in the market (subject to implementation of VWEM). EPTC is responsible for executing Power Purchase Agreements (PPAs) in Vietnam and selling electricity to Power Corporations (PCs) at the Bulk Supply Tariff (BST) rates. The PCs purchase power from EPTC at the BST and sell electricity to their customers at regulated uniform tariffs determined for the country.

We understand that this BST payable to EVN by PCs is a single part tariff linked to the amount of energy consumption by the city. Currently there are no fixed charges for demand nor additional specific charges for ancillary services if required under BST.

Thus, alternative power purchases from rooftop PV by PCs can provide significant savings to the city through reduced power procurement cost and distribution cost (since rooftop generation is at the consumption end). The current level of BST rates and Distribution cost for Danang is provided below.

Figure 27: Average cost of supply for Danang PCs

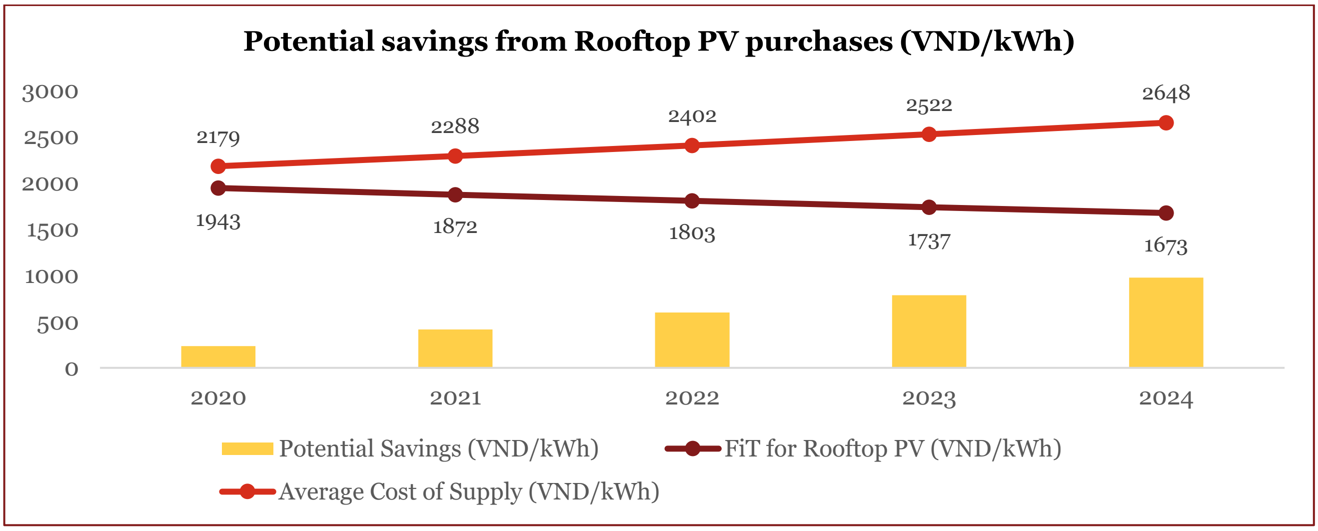


The average cost of supply over the years have increased by 9% CAGR for Danang PC largely contributed by higher BST rates payable to EVN. Through integrated deployment of Rooftop PV, city can effectively reduce both the power purchases from EVN and the cost of distribution of energy to consumers due to availability of the distributed generation at the consumer end/premises.

Considering the FiT of USD 8.38 cents per kWh i.e. VND 1,943 per kWh as per decision 13 (which is likely to be lower in coming years due to increased competitiveness and reduced system cost for solar rooftop PV) and the historical growth of cost of supply, increased rooftop PV purchases can provide potential savings to the city.

Danang city's cost-benefit analysis of rooftop solar PV integration

Figure 28: Potential savings from Rooftop PV for Danang PC



Considering historical growth in cost of supply[10] for future years, cost of supply could be ~ VND 2648/kWh by 2024 as against FiT[11] under solar at VND 1673/kWh (considering currency fluctuations and system cost improvements). The above graph shows the potential savings from purchases from rooftop solar FiT and reduced cost of supply for the PCs. This analysis does not consider the potential reduction in FiT tariff for rooftop beyond 2020.

The below table indicates a broad level cost-benefit analysis of procuring rooftop solar for Danang city under different rooftop penetration scenarios elaborated in previous section. The below cost-benefit analysis[12] considers three scenarios of rooftop solar additions by 2024 (i.e. next 5 years) – 150 MW, 250 MW and 350 MW respectively.

Savings from reduced procurement cost scenarios[13]	Potential savings on implementation over next 5 years (in VND billion)	Potential savings over next 5 years (in USD million)
Scenario A (150 MWp Rooftop PV)	427	~20
Scenario B (250 MWp Rooftop PV)	711	~34
Scenario C (350 MWp Rooftop PV)	996	~48

Hence an integrated deployment of Rooftop PV to replace energy consumption from grid can provide a cumulative savings of USD 20 – 48 million from savings in power procurement for PCs. This savings can be reinvested to integrate with new grid technology solutions like storage to reduce ramping requirements during evening peak loads and managing base load for the city.

[10] Assumption: Cost of supply increase considered for analysis is 5% as against historical CAGR of 9% due to initiatives on RE for lower power purchase costs by EVN
[11] Assumption: Considering VND depreciation of 1.4% as per historical exchange rate, Source: Bloomberg and FiT rate reduction 5% year on year considering improvement in system costs
[12] 5kWp system in Da Nang with PVout of 6.5 MWh per year, Source: Global Solar Atlas
[13] The savings are calculated assuming cost of procurement from EVN continues historical growth, improvements in procurement cost for EVN and loss reduction are not considered in assessment which could reduce the potential savings

5.5. Business models for consumer categories

The objective of this section is to assess the commercial feasibility of setting up rooftop solar systems in Da Nang, in order to propose relevant business models to deploy rooftop PV for different types of customers. Since rooftop solar is a decentralized distributed power generation system, all four consumer categories namely manufacturing industries, public sector/administrative offices, business/commercial and household are considered for the analysis separately.

Key Barriers for rooftop deployment for consumers

1. Lack of Standardization:
    a. Construction code does not have standards and technical specifications on connection point for RTS system, frame structure, mounting positions. Such lack of standardization has impacted approvals from DOC and not provided consumers the required comfort to select developers accordingly.
    b. As a result, there are lots of players in the market offering different quality of products/services for the rooftop system, leading to wide range of price points.
2. Financing required:
    a. Investment in RTS requires high upfront cost and consumer categories like residential require additional support in financing for larger scale deployment.
    b. Further, industrial and commercial consumer have limited collateral options thus restricting the corporates' accessibility to project financing.
3. Regulatory uncertainty:
    a. Lack of clear legal regulations for 3rd party to sell power to EVN has often limited the options available with consumers for developing RESCO or leasing models.
    b. Further, government offices don't necessarily have a power selling permit thus restricting participation in deployment of RTS system in public buildings to self-consumption model.
4. Roof availability:
    a. Certain districts having limited real estate space and thus do not have enough rooftop space to install RTS system. This is particularly true for commercial buildings which host multiple consumer category
    b. Buildings with multiple meter connections also face similar challenges in obtaining multiple approvals on a single roof space. EVN often considers single rooftop system for a building.
5. Capacity restriction
    a. Currently the rooftop system is considered for 1 MWp and below system. Industrial consumers having higher contracted load and energy consumption do not have market alternatives to purchase power from such renewable sources.

Business Model Evaluation

Different business models provide the required direction to PCs to meet the proposed strategy of deployment of rooftop PV for the city across consumer categories. Each business model can be commercially more attractive to specific consumer category considering the existing barriers as discussed above.

The critical component of a business model is the remuneration i.e. how does revenue/tariff is accounted for remunerating the energy generated from rooftop. The revenue model is calculated either by:

- Revenue from sale of power output to power purchaser (EVN) at the prevailing rate for power procurement (US 8.38 cents per unit as per decision 13)

  Or

- Savings to the consumer from displacement of grid-based electricity at prevailing retail tariff (decision 468)

The other key component in determining the business model is the investment model i.e. who makes the investment for setting up the rooftop system

- Purchase: Consumer invests and purchases the rooftop system through self-procured financing

  Or

- Leasing: Leases the rooftop system from a developer for specified period for the energy generation

  Or

- Power Purchase Agreement: Procures power under a power purchase agreement with a rooftop PV developer for self-consumption. Developer invests and maintains the system.

Considering such revenue model and investment model, we have evaluated four business models as discussed previously in its draft discussions as well by MOIT. These models are not explicitly specified in decision 13, however it does provide provisions to adopt such models for the consumers.

Solar Rooftop business model summary is as below:

Type of Business Model	Description	Revenue Model *(How is energy generation remunerated)*	Investment Model *(Who makes the investment)*
Entire power sale	Entire power output is sold to the Power Purchaser, and the household/business does not directly consume any power generated from its rooftop solar power system.	FiT with utility	Purchase/ Leasing
Direct power sale & purchase	Individuals and organizations invest, generate and sell power from their rooftop solar power projects to other individuals Rooftop System not connecting or utilizing national grid systems	Retail tariff, savings from displacement of electricity	Power Purchase Agreement/ Leasing
Power consumption model	Any excess energy output after self-consumption by the household will be back fed onto the grid. Payment and invoicing will be made separately between	FiT for energy sold to utility Retail tariff, savings from displacement of electricity on self-consumption	Purchase/Leasing

Type of Business Model	Description	Revenue Model *(How is energy generation remunerated)*	Investment Model *(Who makes the investment)*
	power output delivered/exported and power output received/imported by the household/business.		
Excess power sale business	Organizations and individuals invest in and install rooftop solar power systems to (i) sell parts of power energy outputs to other organization and individuals and (ii) sell excess power energy output to the national grid.	FiT for energy sold to utility Retail tariff, savings from displacement of electricity on self-consumption	Power Purchase Agreement/Leasing

Considering the above business models and the cost of rooftop solar system[14] we have done commercial assessment for each of the consumer category. The revenues and costs are discounted over the lifetime i.e. 20 years and NPV, internal rate of return (IRR) and payback period are calculated for analysis. Common assumptions considered for commercial assessment of rooftop solar business models is listed in Annexure A.2

Business model for Commercial/Business Consumers

For analysis, a specific use-case has been considered here is a shopping establishment (business consumer) with a rated load of 50 kVA and a potential rooftop solar system of 20 kWp.

The payback and internal rate of return for each of the business model is depicted below:

Potential impact	Entire power sale	Direct power sale & purchase	Power consumption model[15]	Excess power sale business[16]
Project payback period	~ 8.4 years	~ 5.6 years	~ 6 years	~ 6.7 years
Equity payback period	~ 9.7 years	~ 5.5 years	~ 6.2 years	~ 7.5 years
Project IRR	12.3%	20.5%	19.1%	16.6%
Equity IRR	13.4%	25.5%	23.1%	19.4%

Commercial analysis of different business models indicates that for commercial/business category, direct power sale & purchase model is the most remunerative. This is mainly because the retail tariff for commercial consumers is higher and any displacement of energy consumption from rooftop solar is commercially more attractive. The weighted average retail tariff payable from 6AM to 6PM after accounting for higher time of use tariff for day time peak for commercial/business consumers is VND 3146.3 per kWh. This weighted average retail tariff is significantly higher than the cost of generation from rooftop solar.

[14] Capital cost includes solar panels, inverter, mounting structure, evacuation costs (cabling), energy meters, determined based on interviews/questionnaires conducted with rooftop EPCs, commercial and industrial establishments
[15] 80% energy generated considered for self-consumption remaining 20% sale to utility
[16] 50% energy for sale to consumers for self-consumption remaining 50% sale to utility

Power consumptions model and excess power sale business model are variants of the direct power sale where the higher savings is driven by the replacement of higher retail tariff energy consumption of commercial consumers.

Rooftop PV adoption is economically remunerative for commercial consumer category and are likely to adopt the rooftop PV system in large numbers subject to PCs/EVN addresses the potential barriers discussed above.

Commercial consumer category are cross subsidizing consumers (~140% of cost of supply) i.e. the retail tariff for commercial category is higher and cross subsidizes lower tariff for other consumer categories like households. Large adoption of rooftop PV system by commercial category with existing retail tariff structure is likely to have revenue impact on Power Corporations since the high paying consumer energy consumption needs will significantly reduce. Thus, for large scale adoption of rooftop PV system in commercial category, the PCs need to address the following

- Guide rooftop PV deployment in network areas which enables savings in network expansion costs for the PCs thereby reducing the cost of distribution.
- Rationalization of retail supply tariffs i.e. reduction in cross subsidy to ensure PCs do not incur loss of revenue if such high paying consumers reduces their net consumption through large scale adoption of rooftop PV.

Legal Considerations

Direct power sale & purchase model:

- Decision No. 13 has removed the definition of "Direct power sale & purchase model" which was proposed in earlier drafts. Decision No. 13 only provides for general wordings that "*rooftop solar systems may sell all or part of power generated to EVN, or to other purchasers in case the EVN's grid is not used*". Parties may agree on the power sale/purchase price and contract term, subject to compliance with the laws. This may provide grounds for rooftop project/system owners and consumers to implement the Direct power sale & purchase model.

Net metering mechanism:

- Under Decision No. 11, rooftop solar systems are eligible for net-metering mechanism using bi-directional power meters. However, the Ministry of Finance of Vietnam (MOF) disagrees with this mechanism. According to the MOF (Official Letter No. 14489/BTC-CST), the current tax regulations of Vietnam does not provide basis for implementation of net-metering mechanism. Further, the tax regulations require that power sellers pay income tax calculated as a percentage of the revenue generated from the power output, thus they cannot directly set off the power consumed, and the power sold in order to calculate income tax. This leads to the issuance of Decision No. 02 on 8 January 2019, which replaces the net-metering mechanism by the gross-metering mechanism (i.e. separating the direction of delivery of electricity from the direction of receipt of electricity in two-way/bidirectional meters). Decision No. 13 continues to impose the gross-metering mechanism on rooftop solar projects.

Rationalization of retail supply tariffs:

- Under the Electricity Law, the MOIT is required to coordinate with the MOF to formulate and propose to the Prime Minister to approve (i) the framework for the average electricity retail price, (ii) mechanisms to revise the electricity retail price and (iii) structure of electricity retail price. Currently, the general framework for electricity retail price is regulated by the Prime Minister, with further detailed regulations issued by the MOIT (e.g. Decision No. 648 in Annex A1). Thus, depending on the degree of the required change to the existing retail prices, the MOIT or both the MOIT and the Prime Minister may have to revise their respective issued regulations on retail electricity tariff to accommodate the proposed rationalization.

Business model for Residential Consumers

For analysis, a specific use-case is considered with a typical level 4 household/residential consumer (i.e. more than 200 units consumption) with a rooftop solar system of 5 kWp.

The payback and internal rate of return for each of the business model is depicted below:

Financial parameters	Entire power sale	Direct power sale & purchase	Power consumption model	Excess power sale business
Project payback period	~ 9.2 years	~ 7.5 years	~ 7.7 years	~ 8.2 years
Project IRR	10.6%	13.9%	13.4%	12.4%

Commercial analysis of different business models indicates that for household category, none of the business models are remunerative with payback period in all the models more than 7.5 years. Thus, it is not lucrative for households to adopt unless specific interventions are available to remunerate or support the consumer category to adopt rooftop business model.

As analyzed in section 3.4, adoption of rooftop PV by households is likely to give savings to PCs through reduced power procurement cost and hence it is an attractive option for PCs to encourage households to adopt rooftop PV.

To encourage larger residential deployment, the PCs/city could roll out specific support policies for residential consumers. These support mechanisms could be

- Capital subsidy: Partial public investment/grant to reduce the system cost for households
- Property tax incentives: Incentives on revenue collected by province on adoption of rooftop system
- Project development funds: Specific identified fund for rooftop system for households with low cost financing
- Mortgage/home loans: Enable banks to package financing required for rooftop system with home loans

These incentives/interventions would be required for improving the commercial attractiveness of the RTS for residential consumers. This is critical for larger adoption by residential consumers.

Legal Considerations

Decision No. 13 has removed the definition of "Entire power sale" model, which was proposed in earlier drafts. However, the general wordings of Decision No. 13 still permit implementation of this model, subject to further guiding regulations to be issued by the MOIT or other competent state authorities.

In relation to the proposed incentives to be provided by PC to residential consumers:

- Capital subsidy: The legal basis to provide capital subsidy depends on the capital source. The procedures to approve and reimburse such capital can be time-consuming, especially if the capital is state capital or foreign-sponsored capital. For instances: (i) ODA or foreign loan provided by a governmental organization or international organizations (e.g. World Bank) is subject to Decree No. 16/2016/ND-CP; (ii) foreign non-governmental aid is subject to Decree No. 93/2009/ND-CP; (iii) any capital which is considered state capital is subject to the laws on State Budget, public investment law, etc. For each of these cases, the relevant stakeholders must formulate a program/project on the use of such capital and such program/project must be approved by a competent authority before implementation. EVN/PC, as the proposed recipient of the capital source, should consider how to implement such capital subsidy and the impacts of this arrangement from their internal management perspectives.

On the other hand, if the capital source is from EVN/PC itself, the reimbursement procedure may be less complicated and will be subject to the charter and relevant internal regulations of EVN/PC. As a matter of practice, it is not likely that EVN/PC is willing to spend their own capital to subsidy rooftop projects.

- Property tax incentives: It is not legally feasible for EVN PCs to provide rooftop projects in Da Nang with tax incentives in thresholds more preferred than those provided under Decision No. 11 (which has now been replaced by Decision No. 13). This is because the tax policy is determined by the State authorities and applies nation-wide. If the Government wishes to improve the tax treatments for rooftop solar projects, the National Assembly may need to revise the relevant tax regulations and such regulations will apply to all rooftop projects mentioned therein in a national scale. In terms of VAT, if the Government would like to offer a lower tax rate for rooftop power (i.e. 5% instead of 10%), then the VAT law and its guiding documents will need to be revised to include rooftop power to the lists of goods and services enjoy such VAT rate. Before that, any amendments to the tax legal framework needs to be reported to and supported by the Ministry of Finance as the regulatory tax authority.
- Low cost financing/home loans: Vietnam's Land Law permits most residential owners to mortgage their houses for loan. Specific procedures for such mortgage are subject to the relevant laws and policies of the banks providing the loans.

Business model for Manufacturing Industries

For analysis, a specific use-case is considered for industrial consumer with a rated load of 500 kVA, connected to 6 kV and a rooftop solar system of 100 kWp.

The payback and internal rate of return for each of the business model is depicted below:

Financial parameters	Entire power sale	Direct power sale & purchase	Power consumption model	Excess power sale business
Project payback period	~ 8.2 years	~ 8.5 years	~ 8.4 years	~ 8.3 years
Equity payback period	~ 8.6 years	~ 9.6 years	~ 9.4 years	~ 9 years
Project IRR	12.6%	11.5%	11.9%	12.2%
Equity IRR	16.2%	14%	14.6%	15.4%

Commercial analysis of different business models for manufacturing industries category indicates that at revised FiT tariff the potential IRR is around 14%-16%. This is considering availability of financing to such industries to fund the capital investment at low cost leading to higher equity returns.

Thus, to enable larger adoption of rooftop PV system, bankability of FiT PPAs under rooftop system needs to be addressed. With bankable PPA, consumers can further improve viability for equity stakeholders through longer term financing with lower interest costs in the market, currently market only provides a medium-term loan of 5 – 7 years for rooftop PV projects. EVN/PCs can strengthen the PPA terms to more bankable terms enabling larger adoption of rooftop systems among industrial category.

Legal Considerations

In relation to the PPA:

- For power developers who sell power to other entities not using EVN's grid: Under Decision No. 13, the terms of the PPA is subject to negotiations between the seller and purchaser, subject to compliance with the laws.
- For power developers who sell power to EVN/PC:

  Currently, the PPA for rooftop systems selling power to EVN/PC must use the MOIT's template PPA (issued under Circular No. 05/2019/TT-BCT). This model PPA only provides details on FiTs and metering mechanisms and general rights and obligations of the parties. EVN/PC is not willing to negotiate on other material issues on which the template PPA remains silent, such as termination, dispute resolution, curtailment. Under the recent Decision No. 13, the MOIT has been instructed to issue a new PPA template for rooftop systems selling power to EVN/PC. To improve bankability of the new model PPA for rooftop projects, the MOIT may consider adding more detailed provisions on matters such as curtailment, lender step-in right, termination compensation in case the termination was caused by EVN/PC's contractual breach, EVN/PC's insolvency and bankruptcy, dispute resolution (arbitration), etc. The MOIT may also consider issuing separate model PPA for each type of consumer categories, taking into account the variations discussed above.

Business model for Public sector/Administrative offices

For analysis, a specific use-case is considered for administrative office building with a rated load of 50 kW connected at 6kv and a rooftop solar system of 10 kWp.

The payback and internal rate of return for each of the business model is depicted below:

Financial parameters	Entire power sale	Direct power sale & purchase	Power consumption model	Excess power sale business
Project payback period	~ 9.2 years	~ 9.8 years	~ 9.6 years	~ 9.4 years
Project IRR	10.6%	9.2%	9.6%	10.1%

Commercial analysis of different business models indicates that for public offices/schools' category, none of the business models are remunerative with payback period in all the models more than 9 years. Thus, it is not lucrative for this category to adopt unless specific interventions are available to remunerate or support the consumer category to adopt rooftop business model.

As analyzed in section 3.4, adoption of rooftop PV is likely to give savings to PCs through reduced power procurement cost and hence it is an attractive option for PCs to encourage offices/schools/hospitals to adopt rooftop PV.

To encourage larger rooftop PV deployment among this consumer category, the PCs/city could roll out specific support policies similar to residential consumers and the PCs/city could roll out specific support policies through centralized procurement of rooftop system thus reducing the RTS system costs.

These incentives shall further improve the commercial attractiveness of the RTS for public offices leading to larger adoption of rooftop PV.

Legal Considerations

The centralized procurement of rooftop system can be implemented based on the Bidding Law No. 43/2013/QH13 and its guiding legal documents. The Provincial People's Committee of Da Nang Province may preside over the bidder selection process or hire a third-party professional bid organizer to organize the selection process.

Under the bidding regulations, goods eligible for centralized procurement must have certain characteristics and must be included in the list of centralized procured goods issued by a competent state authority. In particular, the goods that can be included in the list of centralized procured goods must meet the following conditions: (i) the goods must be procured in a great amount, or the goods are commonly used in several state agencies; or (ii) the goods require synchronization and modernity. The Provincial People's Committee of Da Nang Province will need to issue a new decision or amend the existing decision on the list of centralized procured goods of Da Nang City to include rooftop solar equipment/service if they can justify that rooftop solar equipment/service meet one of the above conditions.

Due to the existing power supply arrangements between EVN/PC and the local authorities, engagement of third-party rooftop solar goods/service providers may affect the long-term relationship between state authorities and EVN/PC. Therefore, from commercial perspective, such issue should also be taken into account.

For capital subsidy and other incentives please refer to the legal considerations for capital subsidy for Residential Consumers.

5.6. Solar Rooftop Strategy for the City

Summary of the three potential scenarios for rooftop PV deployment in Danang

Rooftop deployment scenarios	Potential savings over next 5 years (in USD million)	Ramp up requirement (MW per hour) in evening hours wet season	Flexible operation required in base load plant (reduction in offtake)
Scenario A (150 MWp Rooftop PV)	~20	20 MW (ramp up)	0 MW
Scenario B (250 MWp Rooftop PV)	~34	26 MW (ramp up)	30 MW
Scenario C (350 MWp Rooftop PV)	~48	33 MW (ramp up)	70 MW

Increased rooftop penetration in scenario C can provide higher savings however the same requires a higher ramping requirement in evening hours due to increase load and reducing solar generation. Further, it would require flexibility in base load operations where reduction of offtake upto 70 MW from base load plants may be required to meet the net load of the city. To reduce the impact of such duck curve, adoption of storage system by consumers and utility can flatten the impact on ramping in evening hours.

Globally policy makers have increased focused on the development and deployment of enabling technologies to facilitate the higher integration of variable renewable energy due to such potential savings. Policies to integrate VRE can address both supply & demand and increase the flexibility of the overall system. The deployment of technologies offering ancillary grid services, or new and emerging technologies such as battery storage at consumption end are emerging trend encouraging the joint installation of renewables and energy storage systems globally.

Energy storage devices can enable the use of excess power from renewable onsite generation during peak generation hours and use that stored energy to shave demand peaks during non-generation hours. It also addresses buffer variations in demand to stabilize generation schedules for EVN and avoid the significant ramping of capacity. It can also save generation capacity reserves required to meet daily, weekly, and seasonal demand peaks for the city. Storage

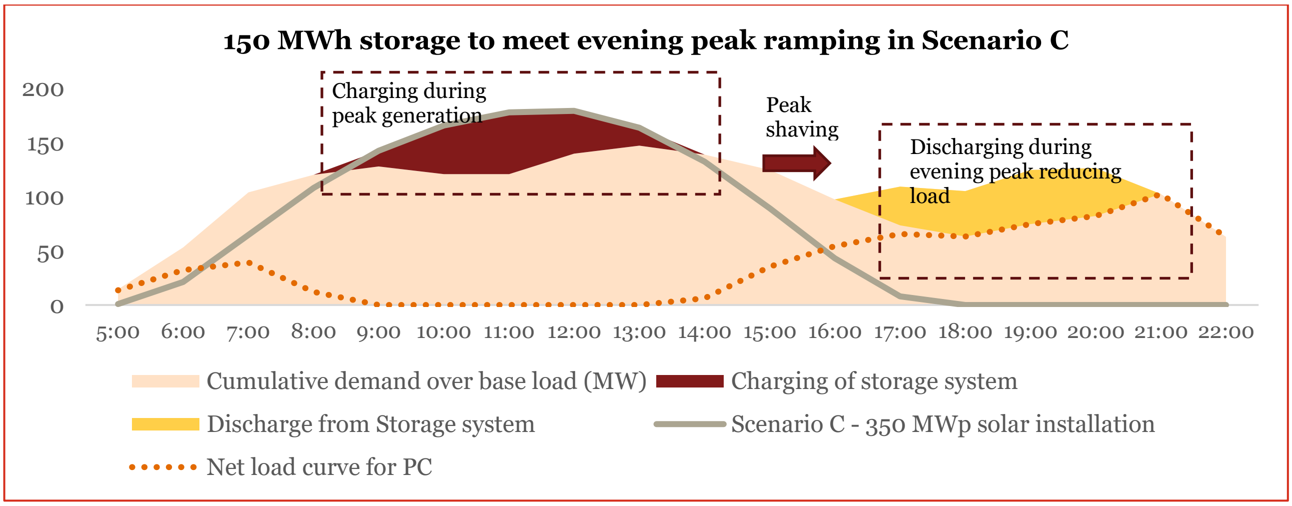


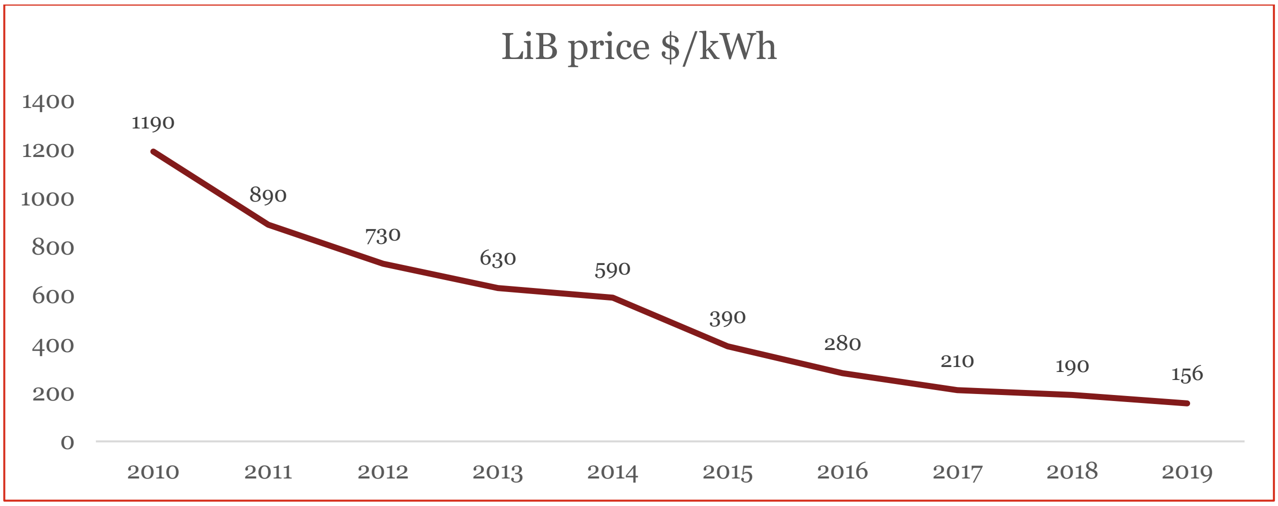
Figure 29: Storage analysis to reduce evening peak in Scenario C

Based on such peak shaving potential to reduce evening peak and ramping requirement, the storage requirement in different rooftop scenarios is as below

Rooftop deployment scenarios	Potential storage requirement to reduce the ramping and integrated deployment
Scenario A (150 MWp Rooftop PV)	40 - 60 MWh
Scenario B (250 MWp Rooftop PV)	80 - 100 MWh
Scenario C (350 MWp Rooftop PV)	140 - 160 MWh

Considering such integrated deployment with storage systems and historical load growth of 10%, Danang city can target a cumulative rooftop PV capacity addition of **250 MWp – 350 MWp in next 5 years**.

For adoption of storage deployment along with rooftop, the grid (6 kV and 35 kV network) needs to be aligned to allow energy flows from consumers to the network. Additionally, the city and utility would also need to provide policy support to make it viable at the current battery prices. However, with the price trend of Lithium Ion Battery pack rapidly falling since 2009 at the rate of - 20% CAGR, this support is likely required in the initial years beyond which battery prices are likely to be commercially viable.



Source: Bloomberg New Energy Finance

Figure 30: Lithium ion battery price trend

Considering the current commercial costs for storage and potential savings for city through rooftop deployment, city can also consider redeploying the savings from power procurement through rooftop PV to deployment of storage systems in the form of incentives to consumer or PC investments for implementation of storage systems on select network/ grid. Such integrated deployment of rooftop shall align the city towards a clean, resilient and renewable power corporation.

Recommended rooftop strategy for city to adopt

Based on the above analysis for rooftop and storage for Danang, we recommend having a phase wise approach to this integrated deployment of Rooftop PV and storage.

Considering the existing lower level of maturity in the market for both rooftop PV and storage, city could adopt only rooftop PV deployment in the initial phase (short term) across consumer categories. Further, with Decision 13, the rooftop FiT has been maintained higher than ground mounted solar by US 1.29 cents per kWh. This could kickstart developer's investment in rooftop space due to available higher margins. This shall allow market creation and consumer awareness along with standardization of installation of rooftop PV. This however may require policy support and interventions based on the consumer category to enable higher adoption of rooftop by consumers.

Once rooftop PV deployment is sizable, the second phase (medium term) involves integrated power system deployment with segmented grid having its own capacity of DERs and storage capacity. This requires public investments in storage systems in the grid along with rooftop DERs to support such integrated grid. This solution can maintain an electrified segment where the distribution grid is separated from transmission grid and reduces the requirement of incremental investments in transmission grid for growing demand in the city

The third phase (long term) involves deployment of rooftop solar PV and battery storage systems at consumer end. This could be aligned with specific incentives to consumers to support load management during peak hours. However, storage systems at consumer premises alone does not have the capability to support a larger utility segment or supply power to other consumers on the distribution grid during an outage. This needs to be supported through continued public investments in storage systems in the grid.

	Short term **(2021 – 2022)**	**Medium term** **(2023 – 2025)**	**Long term** **(2025 – 2030)**
Cumulative Rooftop Capacity	100 MWp	200 MWp + 50 MWh storage	250 MWp – 350 MW+ 150 MWh storage
Stakeholder driving Rooftop PV deployment	PC/City drives deployment through defined technical limits for capacity additions + Investments from private i.e. consumers in rooftop PV	PC/City drives deployment through defined technical limits for capacity additions + Investments from private i.e. consumers in rooftop PV and public i.e. PC/EVN in grid storage	PC/City drives deployment through defined technical limits for capacity additions + Investments from private i.e. consumers in rooftop PV + consumer storage and public i.e. PC/EVN in grid storage
Stakeholder roles			
City/PCs	• Define technical limits along with feeder specifications/availability for potential rooftop PV deployment capacity • Standardization and adoption of rooftop PV	• Support policies for residential consumers such as capital subsidy, property tax incentives, low cost financing/home loans	• Reinvest procurement savings from rooftop into storage systems to help integrate higher penetration of rooftop solar into the select grid networks

	Short term (2021 – 2022)	Medium term (2023 – 2025)	Long term (2025 – 2030)
	across consumer categories • Enable provisions for centralized procurement of rooftop system at city level for government buildings/office, thus reducing the RTS system cost and enabling market creation	• Pilot storage at grid level operations to manage RE penetration	
EVN/MOIT	• Strengthen the PPA terms to more bankable terms enabling low-cost long-term financing for industrial consumers. • Standardization of specifications and codes (potential empanelment of developers to give more comfort to consumers)	• Evaluate potential new FiT for storage-based rooftop PV systems • Retail tariff rationalization for cross subsidy to reduce impact on higher penetration of rooftop by cross subsidizing consumers	• Streamline ancillary service market to manage and incentivize grid operations • Define incentives in retail tariff for consumer premises storage deployment thus enabling DSM participation by consumers to manage evening peak load
Consumers	• Rooftop deployment through purchase, leasing or PPA with developer	• Rooftop deployment through purchase, leasing or PPA with developer and behind the meter storage solutions	• Rooftop deployment through purchase, leasing or PPA with developer • Deploy grid interactive storage solutions
Developers	• Localize development and standardize installations	• Scale up deployment and storage solutions	• Participate in grid services through DERs
Business models for Consumer category			
Household	Entire power sale model “Lower payback period and lack of upfront financing needs to be addressed. Support policies for residential consumers such as capital subsidy, property tax incentives, low cost financing/home loans”		
Commercial	Excess power sale model “Since commercial consumer category are cross subsidizing consumers (~140% of cost of supply), large scale deployment of rooftop under this business model would need to be monitored to reduce the revenue impact on Power Corporations		

	Short term (2021 – 2022)	Medium term (2023 – 2025)	Long term (2025 – 2030)
	For large scale adoption of this consumer category, rationalization of retail supply tariff maybe required"		
Public buildings	Self-Consumption model and Excess power sale model "To encourage larger deployment, the PCs/city could roll out specific support policies through centralized procurement of rooftop system and thus reducing the RTS system cost. Provide capital subsidy, financing support for deployment"		
Industrial	Self-consumption and Direct power purchase & sale model "PCs can strengthen the PPA terms to more bankable terms enabling low-cost long-term financing for industrial consumers."		

Legal Considerations

There is currently no specific legal framework for installation of storage systems for solar projects in Vietnam. Under Decision No. 13, the Prime Minister instructed EVN to "*study on investments in power storage solutions for the power systems in order to ensure the power system's stable operation when absorbing renewable energy sources*". Under the current regulations, there is no higher FiT, or any incentives offered to encourage the use of power storage system. The use of such systems is subject to commercial and technical considerations.

In order to effectively implement the proposed deployment scheme, the Government will need to amend the current regulations to provide technical requirements and/or offer incentives for the use of this technology.

- For Short Term (Large scale rooftop deployment): Decision No. 13 of the Prime Minister is silent on the use of power storage system/technology for rooftop solar projects. If the Government wishes to offer a higher FiT for projects using power storage system, the current FiT policy under Decision No. 13 may need to be amended or replaced.
- For Medium Term (Integrated power system deployment): The Government may need to provide additional guidance on storage systems (as instructed under Decision No. 13 as cited above). The current regulations on types of ancillary services for the power system operation under Circular No. 45/2018/TT-BCT may need to be revised.
- For Long Term (Deployment at consumer end): The relevant state authorities (e.g. the MOIT) may issue legal documents to provide certain technical standards or provide guidance for consumers to install and use power storage systems.

In terms of licensing formalities for the relevant project in each Phase, if the project owner decides to install power storage system when the project has already come into operation or when the project has obtained certain permits or licenses, the installation of power storage system may trigger licensing requirements. Among others,

- the high cost of power storage system may significantly increase the project's construction expenses and investment capital, leading to required amendments to the relevant project licenses (e.g. Investment Policy Decision/Investment Registration Certificate; project's construction estimates);
- the new construction or the installation of power storage system causing material alteration to an existing construction works may require the project/premise owner to formulate or amend the relevant construction design and such designs must be appraised by the competent authorities before commencement of the construction or installation works.

Appendix A. - Appendices

A.1. Tariff structure

EVN's Retail Tariffs

(Attached together with Decision No. 468)

Table 2: EVN's Retail Tariff

No.	Groups of customers	Electricity price (VND/kWh)
1	**Retail electricity prices for production**	
1.1	**Voltage of 110 kV or higher**	
	a) Normal hours	1,536
	b) Off-peak hours	970
	c) Peak hours	2,759
1.2	**Voltage from 22 kV to less than 110 kV**	
	a) Normal hours	1,555
	b) Off-peak hours	1,007
	c) Peak hours	2,871
1.3	**Voltage from 6 kV to less than 22 kV**	
	a) Normal hours	1,611
	b) Off-peak hours	1,044
	c) Peak hours	2,964
1.4	**Voltage of less than 6 kV**	
	a) Normal hours	1,685
	b) Off-peak hours	1,100
	c) Peak hours	3,076
2	**Retail electricity prices for public sector**	
2.1	**Hospitals, nursery schools, kindergartens, schools**	
2.1.1	Voltage of 6 kV or higher	1,659
2.1.2	Voltage of less than 6 kV	1,771
2.2	**Public lighting; public sector entities**	
2.2.1	Voltage of 6 kV or higher	1,827
2.2.2	Voltage of less than 6 kV	1,902
3	**Retail electricity prices for business**	
3.1	**Voltage of 22 kV or higher**	
	a) Normal hours	2,442
	b) Off-peak hours	1,361
	c) Peak hours	4,251

No.	Groups of customers	Electricity price (VND/kWh)
3.2	**Voltage from 6 kV to less than 22 kV**	
	a) Normal hours	2,629
	b) Off-peak hours	1,547
	c) Peak hours	4,400
3.3	**Voltage of less than 6 kV**	
	a) Normal hours	2,666
	b) Off-peak hours	1,622
	c) Peak hours	4,587
4	**Retail electricity prices for domestic use**	
4.1	**Retail electricity prices for domestic use**	
	Level 1: 0 – 50 kWh	1,678
	Level 2: 51 – 100 kWh	1,734
	Level 3: 101 – 200 kWh	2,014
	Level 4: 201 – 300 kWh	2,536
	Level 5: 301 – 400 kWh	2,834
	Level 6: 401 kWh or higher	2,927
4.2	**Retail electricity prices for prepayment meters**	2,461
5	**Wholesale electricity price in rural areas**	
5.1	**Wholesale electricity prices for domestic use**	
	Level 1: 0 – 50 kWh	1,403
	Level 2: 51 – 100 kWh	1,459
	Level 3: 101 – 200 kWh	1,590
	Level 4: 201 – 300 kWh	1,971
	Level 5: 301 – 400 kWh	2,231
	Level 6: 401 kWh or higher	2,323
5.2	**Wholesale electricity prices for other purposes**	1,473
6	**Wholesale electricity prices for collective living quarters, residential areas**	
6.1	**Districts**	
6.1,1	**Wholesale electricity prices for domestic use**	
6.1,1,1	Substation invested in by the seller	
	Level 1: 0 – 50 kWh	1,568
	Level 2: 51 – 100 kWh	1,624
	Level 3: 101 – 200 kWh	1,839
	Level 4: 201 – 300 kWh	2,327
	Level 5: 301 – 400 kWh	2,625

No.	Groups of customers	Electricity price (VND/kWh)
	Level 6: 401 kWh or higher	2,713
6.1,1,2	Substation invested in by the buyer	
	Level 1: 0 – 50 kWh	1,545
	Level 2: 51 – 100 kWh	1,601
	Level 3: 101 – 200 kWh	1,786
	Level 4: 201 – 300 kWh	2,257
	Level 5: 301 – 400 kWh	2,538
	Level 6: 401 kWh or higher	2,652
6.1,2	**Wholesale electricity prices for other purposes**	1,485
6.2	**Communes**	
6.2,1	**Wholesale electricity prices for domestic use**	
6.2,1,1	Substation invested in by electricity seller	
	Level 1: 0 – 50 kWh	1,514
	Level 2: 51 – 100 kWh	1,570
	Level 3: 101 – 200 kWh	1,747
	Level 4: 201 – 300 kWh	2,210
	Level 5: 301 – 400 kWh	2,486
	Level 6: 401 kWh or higher	2,569
6.2,1,2	Substation invested in by the buyer	
	Level 1: 0 – 50 kWh	1,491
	Level 2: 51 – 100 kWh	1,547
	Level 3: 101 – 200 kWh	1,708
	Level 4: 201 – 300 kWh	2,119
	Level 5: 301 – 400 kWh	2,399
	Level 6: 401 kWh or higher	2,480
6.2,2	**Wholesale electricity prices for other purposes**	1,485
7	**Wholesale electricity prices for commercial – service – domestic complexes**	
7.1	**Wholesale electricity prices for domestic use**	
	Level 1: 0 – 50 kWh	1,646
	Level 2: 51 – 100 kWh	1,701
	Level 3: 101 – 200 kWh	1,976
	Level 4: 201 – 300 kWh	2,487
	Level 5: 301 – 400 kWh	2,780
	Level 6: 401 kWh or higher	2,871
7.2	**Wholesale electricity prices for other purposes**	

No.	Groups of customers	Electricity price (VND/kWh)
	a) Normal hours	2,528
	b) Off-peak hours	1,538
	c) Peak hours	4,349
8	**Wholesale electricity prices for industrial zones**	
8.1	**Wholesale electricity prices at 110 kV bus bar of 110kV/35-22-10-6kV substation**	
8.1.1	Total installed capacity of transformers of substation is greater than 100 MVA	
	a) Normal hours	1,480
	b) Off-peak hours	945
	c) Peak hours	2,702
8.1.2	Total installed capacity of transformers of substation is from 50 MVA to 100 MVA	
	a) Normal hours	1,474
	b) Off-peak hours	917
	c) Peak hours	2,689
8.1.3	Total installed capacity of transformers of substation is less than 50 MVA	
	a) Normal hours	1,466
	b) Off-peak hours	914
	c) Peak hours	2,673
8.2	**Wholesale electricity prices at medium-voltage bus bar of 110kV/35-22-10-6kV substation**	
8.2.1	Voltage from 22 kV to less than 110 kV	
	a) Normal hours	1,526
	b) Off-peak hours	989
	c) Peak hours	2,817
8.2.2	Voltage from 6 kV to less than 22 kV	
	a) Normal hours	1,581
	b) Off-peak hours	1,024
	c) Peak hours	2,908
9	**Wholesale electricity prices for markets**	**2,383**

Time-of-use (peak, normal and off-peak hours) classifications are detailed as follows:[17]

+ *Normal hours*

From Monday to Saturday:

- From 4.00 a.m. to 9.30 a.m. (5 hours and 30 minutes);
- From 11.30 a.m. to 5.00 p.m. (5 hours and 30 minutes);
- From 8.00 p.m. to 10.00 p.m. (2 hours).

[17] Circular No. 16/2014, Article 5.1.

Sunday:
-From 4.00 a.m. to 10.00 p.m. (18 hours).

+ ***Peak hour***

From Monday to Saturday:
- From 9.30 a.m. to 11.30 a.m. (2 hours);
- From 5.00 p.m. to 8 p.m. (3 hours).

Sunday: No peak hours.

+ ***Off-peak hours:***

All days: from 10 p.m. to 4 a.m. of the following day (6 hours).

The power purchasers subject to this three-rate / time-of-use pricing include:[18]

- Customers using electricity for production, business, services, using electricity supplied via dedicated transformers of 25 kVA or above or having average electricity consumption of 2,000 kWh/month for three consecutive months;
- Retailers of electricity in industrial zones;
- Electricity purchasers buying electricity in order to retail electricity for non-household consumption purposes in commerce – service – residential building complex.

[18] Circular No. 16/2014, Article 5.2.

A.2. Assumptions considered for rooftop commercial analysis for business models

Description	Units	Values	Remarks
Ownership of Rooftop solar system	Type	Consumer	
Mode of Investment	Type	Upfront and Debt	
PLF	%	13%	
Grid availability	%	100%	Considering SAIFI of 6 for Danang
PPA Tenure	Years	18	
FiT for rooftop solar	VND per kWh	1943	Future escalation at 1.4%
Project Cost	VND Mn/kWp	15.75 to 17.55	As per stakeholder consultations, installation cost for rooftop systems are as below: • 3 kW system (70 mn VND) • 5 kW system (105 mn VND) • 10 kW system (198 mn VND) These installation costs also cover approval process and permits from installation to grid connection
Equity %	%	30%	
Type of Loan		Domestic	
Debt %	%	70%	
Tenor	years	14	
Interest Rate	%	10%	

A.3. Stakeholder discussion summary

Rooftop developer

Stakeholder	Rooftop solar developer

About the stakeholder	• Started developing rooftop solar since 2017. GEC, a sister company of stakeholder, focuses on solar farm market.
	• As on June 2019, installed 40 MWp of rooftop solar in Central and South Vietnam
	• Various service offerings
	  o Mostly focused on corporate customers (commercial & industrial).
	  o Plan to expand to residential segment, combining with financing solution offerings.
	• Various service offerings
	  o Sale and distribution of PV equipment (PV modules, inverters)
	  o RTS design, installation and O&M
	  o Financing solution for RTS investment (partnering with banks to support customer to invest in RTS system)
	• Support in obtaining approvals

Key discussion points	• Business models adopted for implementation of rooftop solar
	  o CAPEX model
	  o Bank leasing
	  o ESCO leasing: customers lease the RTS system in 15-25 years. After this period, the system is transferred to customers.
	• Consumer category that has the highest market interest for rooftop PV:
	  o C&I consumer show highest interest in rooftop PV installations due to cost savings and availability of large rooftop area.
	  o Residential consumers have also started to show interest as they get paid from EVN
	• Barriers for rooftop development for each consumer category:
	  o Residential consumers:
	    • Requires financial support from EVN.
	    • There are lots of newcomers offering low price with cheap quality products/services, affecting overall RTS developers' reputation
	    • Vietnamese common opposition against China products and most PV equipment are made in China.
	  o Commercial consumers: there are several obstacles in convincing corporate customers to deploy RTS system
	    • Commercial consumers aim for lowest pricing to fulfill their cost-saving goal. Therefore, it is difficult to have a competitive but profitable pricing.
	    • Commercial buildings do not have sufficient rooftop space to install RTS system (capacity limit of 1MWp)
	    • Investment in RTS requires high upfront cost. Therefore, financing availability is very important. However, limited collateral options restrict the corporates' accessibility to project financing.
	    • TTC Energy must show how effective the project is, e.g. guarantee of short-term payback period (~5-6 years)
	    • Complex procedures to obtain approval from the corporate customers' BOD
	• Challenges faced in grid integration
	  o EVN has standards for grid connection of RTS system. EVN approval procedures are complex and lengthy. Developer must inform EVN in advance about the RTS installation. The entire approval process and meter change takes about 2-3 weeks. EVN HCM is supportive in the approval processes. However, the procedures are not as clear and supportive in countryside areas.
	  o Some other notable challenges are delay in work from EVN, undocumented fees, etc. The law of Vietnam only allows for 1 PV system on 1 rooftop
	• Warranties and guarantees offered – on modules, inverters, performance

Stakeholder	Rooftop solar developer
	○ Warranty period for RTS systems is 10-12 year for PV panels, 5 years for inverter and 5 year for frame structure. ○ O&M carried out every 3 months for the whole system lifetime (20-25 years). ○ Developer also commits/guarantees generation output for 25 years with 0.11% productivity deduction every year. • Financing options available for consumers ○ Banks that offer rooftop financing solutions for residential consumers include Saco bank, Capital Bank, HD Bank, Vietcombank. The terms and conditions of such loans are tenure - 5 years, Interest rate: 1st year - 9%, 2nd year onwards - 9%+margin. Banks refuse to take the RTS system as collateral for the loan. Providing collateral options is a challenge ○ Financial incentives available for rooftop are available. Consumers prefer receiving cash support in RTS development similar to incentives for installing solar water heater, where consumers receive VND 1 Mn/kWp as financial support

Stakeholder	Rooftop solar developer
About the stakeholder	• Two major business lines: ○ Solar panel manufacturing ○ Solar rooftop contractor/developer/installer
Key discussion points	• Market for rooftop solar in HCMC: ○ HCMC is a current hotspot which attracts fierce competition. Moreover, with high population, there is going to be very high demand for solar rooftop ○ Compared to Hanoi and Danang, HCMC/South Vietnam has higher solar irradiation. Moreover, Hanoi has lots of dust, which can reduce overall efficiency of rooftop system • Typical capital costs for rooftop system ○ 3 kW system – 70 Mn VND ○ 5 kW system – 105 Mn VND ○ 10 kW system – 198 Mn VND • Typical O&M costs ○ 500,000 VND/year; ○ Typical maintenance activities include panel cleaning, invertor replacement, wire/cable fixing • Typical consumer categories ○ Govt. organization, commercial and industrial (< 1 MW) – customers with capacity > 1 MW require permit/approval, which is a complicated process. As a result, the Developer is focusing on project with capacity below 1 MW ▪ There should be more focus on solar rooftop installation for government offices/schools/ public facilities. These facilities have big rooftop which is ideal to install solar rooftop. Also, installing solar rooftop in such facilities will in help promoting rooftop solar ○ Small business (<25 kW) ○ Household (3/5/10 kW) • Preference for business models to Developers ○ Current prevalent business model implemented by Developer is EPC mode. However, Developer is evaluating “leasing model” for industrial consumers. ▪ Consumers are deterred to invest in such project because of high upfront costs. Developer may provide the capital to develop the project then lease it back to industrial consumers. ▪ Current interest rate of 10% is too high, these consumers need more attractive rate to start adopting solar rooftop ▪ However, leasing has lots of risk since it’s a new business model (no legal framework) such as default risk (in case of default, developers cannot do anything to recoup their investment), Legal risk regarding ownership of the system (no current legal policy) and Leasing continuation risk (Short-term tenants or customers who want to sell factories will not continue to lease the system, while new owners may not be interested in continuing the lease agreement)

Stakeholder	Rooftop solar developer

	• Financing options available for consumers?
	  ○ For household consumers, the Developer is currently offering 12-month installment package with no interest rate (i.e. Developer bears the interest rate). Developer suggests coordination with banks so that the banks can invest and bear the interest of 12-month installment instead of Developer.
	• View on FiTs and scaling of rooftop solar
	  ○ Net metering scheme is more suitable for household and gross metering is more suitable for industrial consumers
	    ▪ FiT for rooftop solar is lower than existing electricity price payable by household. Through net metering, cheaper solar energy offsets some of the expensive imported energy from the grid. Thus, household effectively receives higher value for their solar energy
	    ▪ For industrial consumers, FiT for rooftop solar is higher than non-peak electricity price industrial consumers paid to EVN. Thus, gross metering is more appropriate

Commercial consumer

Stakeholder	Commercial consumer (Shopping mall)
About the rooftop system installed	• 258 kWp (without storage) rooftop system installed in October 2018 • Generation: 1,000 – 1,300 kWh/day on average; meets about 20-35% of total energy demand • Peak Generation Hour: 9 AM – 3 PM • Total rooftop space utilization: ~ 100% of the rooftop area. Site's rooftop is almost shade-free. • The energy produced is used for a cinema in the building before being used by other parts of the building. The overall demand for the site is very high as it includes large tenants such as cinema, hospital. Thus, this site rarely exports energy back to the grid (exported ~ 16 kWh till date) • System life is estimated to be 20 years • Implementation model –CAPEX/ Consumer owned model • Process of selection – Bidding process where bidding criteria include total Capex, advertised system performance and reputation of developer

Key discussion points	• About Operation & Maintenance of rooftop solar
	  ○ EPC contractor was selected as O&M provider because Developer installed the system as well as supplied PV panels for the site and hence is familiar with the system. Current O&M contract with is for 2 years and is expected to be renewed during the full lifetime of the system
	  ○ Maintenance is scheduled once per month and includes cleaning panels, performing routine maintenance of cables and inverters. Warranty period for equipment is 2 years

Residential consumer

Stakeholder	Residential consumer
About the rooftop system installed	• Capacity: 3 kW installed under CAPEX model • Peak production per day: 16-17 kWh; meets about 1/3rd of the household's electricity demand. • Number of panels: 12 panels • Rooftop area used: 26 sqm (~¼ of the total roof area at the house). User intended to use remaining rooftop area for other purposes • Installation process took about 2 weeks (does not include approval time). • System life: 20 years • Models of implementation: CAPEX model
Key discussion points	• Developer's role: ○ Installation of rooftop solar system and handed over the asset to the site

Stakeholder	Residential consumer
	o Developer offered 2-year warranty for the system. This includes periodic maintenance activities (cleaning, fixing). Developer also provides guaranteed energy output for 5-year term. Developer also provided a phone monitoring system for its users to monitor generation output real-time. • Related to polices/regulations: o Consumer is aware of general tariffs for solar rooftop. Due to lack of official guidelines/ policies for technical specifications of solar panel, there is an influx of sub-par/low quality panels flooding the market • Pricing of rooftop system o Capex of installing rooftop: VND 80 Mn/kWp. o O&M cost is included in the lump sum fee • Implementation model o Most household consumers in Vietnam use Capex model due to its simplicity. Moreover, most big developers in the market only offers this model for the household consumer category.

EVN

Stakeholder	EVN
Key discussion points	• Rooftop solar (RTS) deployment in VN o Currently, 200 MW rooftop solar (RTS) is installed in Vietnam o EVN aims to cover all EVN building rooftops with solar PV in September 2019; EVN targets RTS increase of 500 MWp/year o RTS deployment is an urgent matter, so consultant needs to consider a suitable timeframe of RTS deployment to align with MOIT policies o Consumer target for pilot deployment: households will be priority, industrial, commercial, EVN buildings, etc. o EVN is developing a website for household/developer to assess the installation capability. • Comments on regulations and policies o Net metering drove the solar market in 1 year and had many issues. Therefore, net metering is no longer applicable. As a result, EVN recommends to only use gross metering in the policy and business model propositions. In addition, gross metering will help to eliminate cross subsidy. o Decision 11 will be changed, including for RTS, and will be applied nationwide soon. So, this study can't change the new decision but may be applied in next cycle. This study should utilize the new decision to support RTS deployment. • RTS financing o Households don't have good financing from banks or applicable incentives, business models from policies. o On-bill financing is a benefit of utility -> if government specifies this in the regulations, it will help EVN secure payment from consumers/developers. • Business models o Considering the high investment cost to install batteries, energy storage option may not be currently viable. Furthermore, EVN is facing power shortage issues, so generation output will be used up and, thus, storage batteries are not necessary in short term. o Regulations on RTS application may not be changed immediately. Therefore, EVN recommends splitting the RTS adoption in phases. Business models and potential irradiation should be focused early. Storage and smart inverter are not current issues and may be targeted for 2020. Solar auction may be a long-term discussion in 2021.

Thank You!