CLEAN ENERGY BUSINESS MODEL MANUAL

November 2018

C40 CITIES
CLIMATE LEADERSHIP GROUP

C40 Cities

C40 Cities connects more than 90 of the world's greatest cities, representing 650+ million people and one quarter of the global economy. Created and led by cities, C40 is focused on tackling climate change and driving urban action that reduces greenhouse gas emissions and climate risks, while increasing the health, wellbeing and economic opportunities of urban citizens.

Around three quarters of global greenhouse gas emissions come from cities, and the C40/ Arup Deadline2020 report shows that building energy use accounts for over half of total city emissions on average and 29% of building emissions are associated with the supply of electricity. Building-scale clean energy deployment in cities may deliver up to two-fifths of total emissions savings from the energy sector. This highlights the significant opportunity for buildings to be equipped with renewable and low carbon generation technologies such as photovoltaic panels, solar thermal and heat pumps. As it is stated in the recent report "Focused Acceleration" launched by McKinsey and C40, cities cannot achieve a 1.5°C trajectory without decarbonizing the grid. While cities cannot do this alone as utilities and generators need also to play a central role, cities have an essential role to play by leading by example. Setting clear decarbonization goals, promoting decentralised energy generation, aggregating demand for renewables, promoting energy efficiency, and shifting more urban energy consumption to electricity (e.g. transport and heat) are key actions that cities can take. This manual is aimed to provide guidance on business models and financial mechanisms that can assist cities in achieving these goals.

The BE2020 programme is working alongside the existing C40 city networks between 2017 and 2020 to help cities overcome barriers to the implementation of policies and programmes to deliver low and zero carbon buildings at scale. The BE2020 programme is made possible by funding from the Children's Investment Fund Foundation and the ClimateWorks Foundation. This manual is one of the resources produced as part of the BE2020 programme.

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EXECUTIVE SUMMARY

Decarbonisation of energy, primarily electricity – known as decarbonising the grid – is essential for cities to achieve their 1.5°C trajectory; without decarbonisation of the grid, C40 cities will miss their targets. Cities have an essential role to play in increasing clean energy deployment by setting decarbonisation goals, aggregating demand for renewables, electrifying urban energy consumption, and improving demand-side management. This manual focuses on business models and financial mechanisms that can assist cities in achieving these goals. However, there are many financial, information, social and regulatory barriers that can be overcome through the use of innovative business models and financial instruments.

This manual explores business models and financial instruments and presents their administrative and financial structure, suitability for various regulatory contexts and market conditions, advantages, and disadvantages, and provides examples and case studies from C40 cities.

Some of the common advantages of the business models:

- They enable access to clean energy sources that are not limited to the immediate locality of the consumer
- They promote community involvement
- They create demand for new clean energy projects

There are many requirements for the effective implementation of business models that need to be addressed such as enabling and supporting regulations, competitive electricity markets and market deregulation, issues around customer protection and competition rules, and sufficient resources, previous experience and knowledge for proper design and successful implementation.

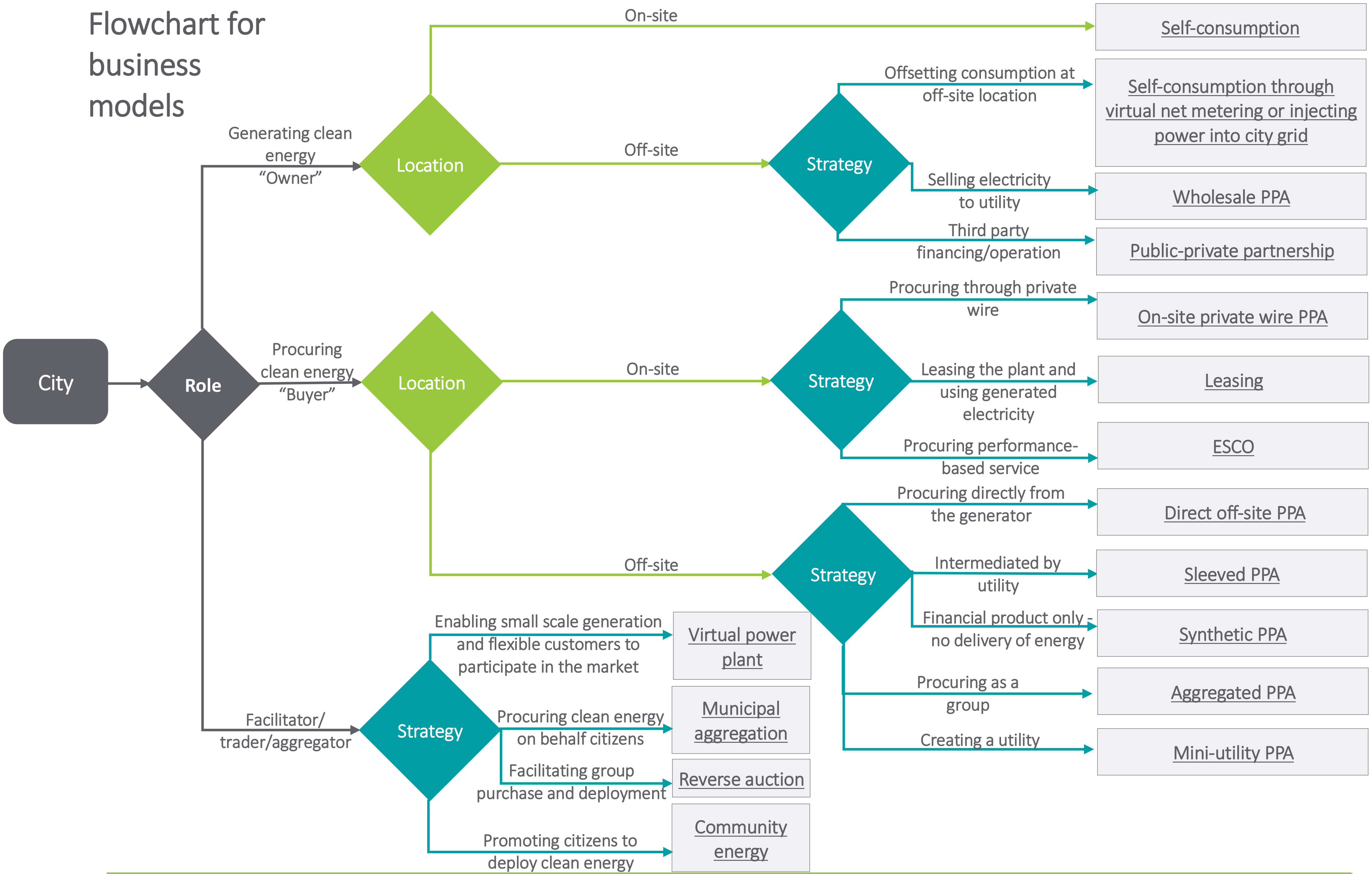
Similarly, financial instruments also bring many advantages to clean energy deployment:

- They remove barriers to entry
- They create a revenue stream and financing basis for business models
- They have the design flexibility to be adjusted to support different technologies or actors

Similar to business models, financial instruments require regulatory and legislation support/change, time and resource for administration process and proper design for successful and effective implementation.

The aim of this manual is to be an informative guidebook on different types of business models and financial instruments that supports cities and their communities with their clean energy projects and policies. The flowchart below can be used to navigate through the document and explore business models according to the role and strategy of the city and the location of the clean energy plant. Furthermore, overview of the features of business models and financial instruments are provided in the following tables.

Flowchart for business models



Overview of business models

	Supports local generation	*Independent from local resources*	*Easy implementation/ transaction / contractual structure*	*Low up-front investment*	*Suitable for regulated & deregulated markets*	*Public/ community involvement*	*Creates additionality*
Self-consumption	✓		✓		✓	✓	✓
On-site private wire PPA	✓			✓			✓
Direct off-site PPA		✓		✓			✓
Synthetic PPA		✓		✓	✓		✓
Sleeved PPA		✓		✓			✓
Aggregated PPA		✓		✓			✓
Wholesale PPA		✓	✓		✓		✓
Mini-utility PPA		✓					✓
PPP		✓			✓		✓
ESCO	✓			✓	✓		✓
Leasing	✓			✓	✓		✓
Community energy	✓	✓				✓	✓
VPP	✓					✓	
Reverse auction	✓				✓	✓	✓
Municipal aggregation		✓		✓		✓	

Overview of financial instruments

	Removes capital cost barrier	*Easy implementation/ transaction structure*	*Provides on-going additional revenue to consumer*	*Return on capital for financier*	*Public/ community involvement*	*Low capital/public funding required*	*No regulatory/ legislation complexity*
Crowdfunding	✓	✓		✓	✓	✓	✓
Feed-in scheme			✓		✓		
Renewable energy certificate			✓			✓	
Net metering			✓		✓	✓	
On-tax bill financing	✓			✓	✓		
On-energy bill financing	✓			✓	✓		
Tax incentives	✓	✓			✓	✓	✓
Investment grants	✓	✓			✓		✓
Green bond	✓			✓		✓	✓
Pay as you go	✓			✓	✓		✓

1 INTRODUCTION

Following the Paris Agreement in 2015, C40 have been looking at how cities can work together to go beyond the ambition set out in the agreement and limit the temperature rise to 1.5°C. The Deadline 2020[1] Report demonstrates that the energy emissions in C40 cities are primarily associated with the supply and use of energy for buildings and outlines a pathway that requires a radical and comprehensive transformation to both reduce building energy demand and clean up the energy supply. It is therefore key that cities prioritise low carbon new buildings, retrofits of existing buildings and the use of cleaner energy sources. C40 cities have significant opportunity to lead the transformative actions to achieve this.

"Focused Acceleration: A strategic approach to climate action in cities to 2030", the report published in 2017 by C40 with McKinsey Center for Business and Environment[2], analyses the biggest opportunities for cities to accelerate the reduction of their carbon emissions. After assessing more than 450 emissions reduction actions identified in Deadline 2020, the report lists the 12 priority opportunities across four action areas that have the greatest potential in cities to curb emissions and put cities on a 1.5°C temperature rise pathway through to 2030.

While cities may believe they have little influence over the grid mix, in fact, they often represent a major portion of any local electric utility's customers, potentially giving them significant leverage to shape the emissions profile of the electricity consumed within their metropolitan area. However, cities cannot do it alone as utilities and regulators must play a central role in ensuring that the overall mix of renewables is appropriately balanced at a system level and that critical components such as energy storage are in place to ensure grid reliability. Nevertheless, cities have an essential role to play in encouraging the clean energy deployment through setting decarbonisation goals, aggregating demand for renewables, electrifying urban energy consumption, and improving demand side management.[2] Cities are typically also large energy users and can stimulate the market via direct investment or renewable energy purchasing. Similarly, target setting by cities to set a clean energy pathway and identifying business models to achieve this is very crucial.

This manual focuses on business models and financial mechanisms that can be used to support clean energy uptake for decarbonising the grid. There are many opportunities and barriers associated with clean energy deployment. Some of these barriers can be overcome through the use of innovative business models.

The first key action identified in the Focused Acceleration report is decarbonizing the grid, as cities cannot achieve a 1.5°C trajectory without a massive expansion of renewable electricity generation.

1.1 Objectives and structure of this manual

The aim of this manual is to be an informative guidebook on different types of business models and financial instruments that supports cities and their communities with their clean energy projects and policies. This manual is intended to act as a guide for cities to facilitate more renewable energy in their communities and/or cities by looking at ways to procure renewable energy to meet their energy demand. The scope of this manual is limited to business models and financial instruments for power generation and purchase. The manual does not focus on business models for district heating and cooling or thermal decarbonisation.

The information included in this manual aims to provide cities with information on each business model and enable them to look into which business models would fit best to their clean energy project and use this manual as a starting point for business model selection and development. Case studies are included to provide examples to demonstrate how other C40 cities have applied different business models and financial instruments.

As every city is unique and has different regulatory and market conditions, the scope of this manual is limited to providing general and common information on business models, therefore is not designed to address specific challenges or provide information for unique conditions.

This manual consists of:

Chapter 1 - Introduction presents current barriers to clean energy deployment and how business models and financial instruments can help to remove these barriers and accelerate clean energy deployment.

Chapter 2 - Business Models explores various business models and presents their administrative and financial structure as well as assesses their advantages, disadvantages and suitability to various regulatory and market conditions. Case studies on business models that are implemented by various cities are also presented within this chapter.

Chapter 3 - Financial instruments explores various financial instruments and presents their implementation as well as advantages and disadvantages. Several case studies on financial instruments that have been implemented by cities are also presented.

1.2 Opportunities and barriers to clean energy deployment

In addition to the essential role of clean energy deployment in combating climate change and enabling the 1.5°C trajectory, there are many opportunities and drivers for it:

- Renewable energy is the fastest growing type of electricity generation[2] and has increasing maturity and competitiveness
- The costs of renewable energy technologies are rapidly decreasing[2] and this can help decrease risks associated to price volatility and price uncertainty of fossil fuels
- It can provide a solution to the growing energy security problem and decrease the exposure to supply risks as it provides significant potential for decentralisation and the fuel is freely available and constantly renewed
- Clean energy technologies already deliver important CO_2 emission reductions and can improve air quality
- It offers opportunity to empower and increase participation of community and small/medium scale businesses
- It encourages economic development, particularly associated with rural and agricultural sectors, or with innovation and high-tech manufacturing
- Renewables when deployed in a geographically diversified manner can lead to a smaller impact on the overall system in the event of a localised event such as a natural disaster
- Off-grid renewable technologies provide a sustainable and cost-effective alternative to the diesel generators that would be typically deployed in rural and off-grid areas.
- Renewable technologies can also help to displace other unsustainable energy sources used in off-grid and rural areas such as kerosene lamps and traditional biomass[3]
- Decentralised clean energy deployment can help delaying and avoiding network infrastructure upgrades which will decrease the overall costs and network charges for the citizens
- Decentralised clean energy generation can help decrease the energy losses due to transmission of electricity for long distances from remote centralised plants.

In order to accelerate and penetrate clean energy deployment market, social, information, regulatory and technical barriers need to be removed. These barriers are listed below:

Market and social barriers

- **Price distortion:** Since the market price for energy does not include externalities such as the costs of natural resource depletion, health and environmental impacts from pollution, extraction of resources, and climate change, consumers do not receive the accurate market price for energy.
- **The 'hassle factor':** The benefits of clean energy may be outweighed by the transaction costs and efforts required for administrative, operational tasks and installation.
- **Split incentives:** This refers to situations where the investor who pays the upfront costs for clean energy technology is not the same person who receives its benefits, e.g. lower energy costs. For example, split incentives occur in rental properties when there is little incentive for the building owners to invest as they will not obtain the benefits, only tenants will. [4]

Information failures

- **Limited capacity and awareness:** There is a general lack of public awareness on the benefits of clean energy as well as a lack of adequate information describing financing options available to customers who are interested in investing in clean energy. [4]

Regulatory barriers

- **Complicated building permitting processes:** Permits for the installation of clean energy technologies may be difficult to obtain or involve a long and slow process. [4]
- **Regulation and policy uncertainty:** Possible retroactive regulatory changes can discourage new clean energy projects as they may disrupt the revenue stream. Insufficient transparency and clarity regarding policies and regulations can also create a barrier to investment.
- **Use of the public grid:** In many countries, power cannot be transferred and sold via the public grid by non-utility third-party entities.

Financial barriers

- **Low investment returns:** Long payback periods can discourage investment in clean energy technologies.
- **High upfront costs:** Most clean energy technologies have a higher upfront capital cost than conventional technologies.
- **Difficult access to capital:** Low income households and small businesses often lack capital and have difficulties getting access to financing for clean energy technologies.
- **High risk:** Clean energy projects are often considered risky investments because of high technology or regulatory risk. [4]
- **Taxes and charges:** High taxes and charges on the self-consumed or exported electricity can act as a significant barrier to investment.[5]

Technical and infrastructure barriers

- **Network connection:** In areas where network capacity is constrained and/or improvement is required, connection costs and long processes can create a barrier for new clean energy installations.[6]
- **Risk of curtailment:** High level of congestion in the grid and lack of flexibility may lead to clean energy systems being curtailed. This will create financial uncertainty and impact the financial viability of the project especially if the level of curtailment and compensation is uncertain.
- **Low expertise:** Lack of technological expertise in the local area might lead to low levels of clean energy deployment.
- **Intermittency:** Available renewable energy sources are dependent on meteorological and climatic conditions, which leads to availability challenges. Renewable energy sources also cannot be stored in primary form over a long period of time in large quantities, with the exception of large hydropower and biomass. [3]

1.3 How business models can help

As listed above, there are various barriers to clean energy deployment, which can be overcome with regulatory changes and community involvement as well as innovative business models and financial instruments. Some examples are:

- **Financial barriers (e.g. lack of capital) and technical barriers (e.g. lack of resource, and site issues) to clean energy deployment can be overcome with the help of business models and financial instruments:** Community energy business models allow citizens who are unable or unwilling to deploy clean energy on their properties (due to reasons such as low income, lack of capital, lack of space, insufficient renewable energy source, not owning the property, etc.) to buy a portion of or buy power from a shared clean energy project. Crowdfunding is one of the financing instruments that can be used to remove lack of capital barrier where community members can each pay a small amount to raise the funds for a community clean energy project. (See Financial instruments chapter for details on crowdfunding).

- **Business models can help increase public acceptance and involvement of residents in the local and national clean energy agenda:** The City of Copenhagen launched a cooperative through its own utility to invest in a 40 MW wind farm two kilometres off its coast. The cooperative attracted more than eight thousand investors in the local community, which helped overcome resistance to a large wind farm.[2] (See Community energy business model section for more details on community energy).

- **Innovative business models can stimulate the deployment of new clean energy projects:** The City of Melbourne developed a group energy procurement project and joined forces with other city governments, cultural and educational institutions, and businesses in the area to help development of a new large renewable energy plant through committing to purchase 110 GWh of electricity over ten years.[2] (See Aggregated PPA section for more details.)

The aim of this manual is to be an informative guidebook on different types of business models and financial instruments that supports cities and their communities to overcome the barriers and accelerate their clean energy projects and policies. This manual is aimed as a guide for cities to facilitate more renewable energy in their communities and/or cities looking at ways to procure renewable energy to meet their own city load. In the next chapters, innovative and commonly used business models and financial instruments for power generation and purchase will be explored.

The terminology and regulatory descriptions used in this manual are generic and therefore they may have different definitions in different contexts. As every city is unique and has different regulatory and market conditions, the scope of this manual is limited to providing general and common information on business models, therefore it is not designed to address specific challenges or provide information for unique situations.

2 BUSINESS MODELS

For the scope of this manual, a business model is defined as a procurement and financing strategy to invest in clean energy technologies which leads to increased clean energy deployment in cities. As explained in the previous chapter, successful business models can help financing and implementation of clean energy projects as well as help eliminate barriers for clean energy deployment. The most appropriate business model for a project will depend on local conditions, the financial and regulatory environment and the financial support mechanisms in place. Therefore, each business model needs to be adapted to the local conditions and risk profiles of the selected project.

Business models in this manual are defined depending on the roles of and relationship between primary stakeholders (financier, owner, operator, the consumer and the third-party supplier e.g. utility), the connectivity of the project (i.e. on-site and off-site) as well as financial structure.

In this chapter, we present the following information on each of these business models:

- Administrative and financial structure
- Regulatory context and market conditions
- Examples for city applications
- Advantages and disadvantages

The business models that are included in this manual are:

- Self-consumption
- Power Purchase Agreement (PPA)
    - On-site private wire PPA
    - Direct off-site PPA
    - Sleeved PPA
    - Synthetic (Virtual) PPA
    - Aggregated PPA
    - Wholesale PPA
    - Mini-utility PPA
- Public-Private Partnership (PPP)
- Energy Services Company (ESCO)
- Leasing model
- Community energy
- Virtual power plant (VPP)
- Municipal aggregation
- Reverse Auction

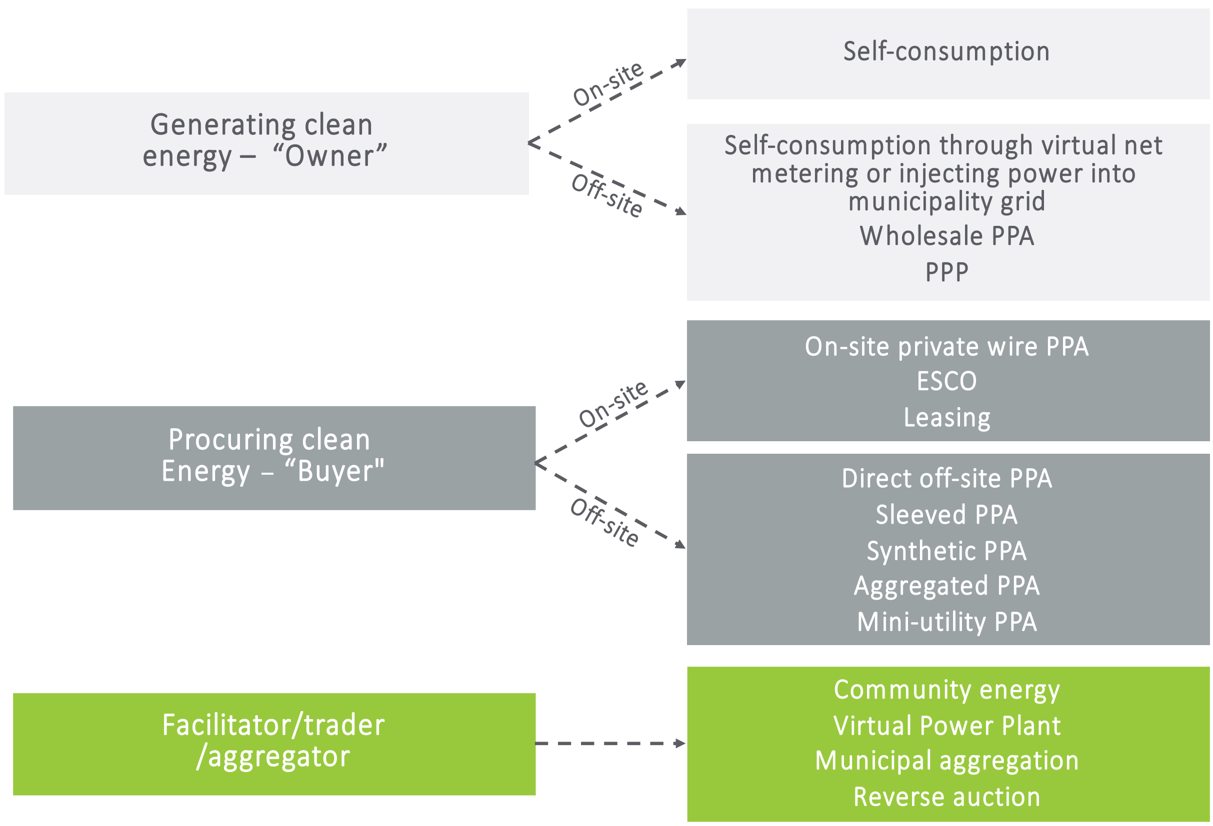
Selecting a business model for a clean energy project is highly dependent on the local regulations and market structure, the financial conditions, and available resources. The city's role will influence the choice business model, therefore we have categorised the above business models depending on the role of the city[7]:

- Generating clean energy – "Owner": This category involves the city owning and operating its own clean energy plant. This can be divided into two categories depending on the location and connection of the plant.

- Procuring clean energy – "Buyer": In this role, cities buy clean energy from third-party developers/generators. This is again divided into two categories depending on the location and connectivity of the plant.

- Facilitator/trader/aggregator: Under this role, the city can aggregate and trade electricity, forming a bridge between clean energy generators and customers to facilitate and promote clean energy deployment by prosumers, community members, businesses, etc.

Categorisation of business models is shown in the figure below. A more detailed categorisation is presented in the flowchart earlier in this document. Further details are provided for each business model in this chapter. Some general information on power purchase agreements are provided in the box below. Different variations of PPAs are explained later on in the chapter.



Power Purchase Agreement (PPA)

In this business model, a customer can negotiate a direct power purchase agreement (PPA) with renewable energy generators. A PPA sets a period of time and an agreed rate for price or discount per kWh of purchased power which might be fixed, linked to inflation or indexed. Through this model, the customer does not have to own the installation but can simply purchase the energy from the clean energy generator.

PPA models help to secure financing for clean energy projects, overcome barriers such as price uncertainty and enable cost savings for customers and higher revenue for generators as the agreed price is generally higher than wholesale price but lower than the retail price.

There are several barriers to the PPA business model. These include restrictions on purchasing power from any entity that is not a centralised and vertically integrated utility, and indirect limitations such as electricity market structures that make PPAs difficult to implement e.g. fees and charges.[8] The basic regulatory conditions that are required to set up a PPA business model are presented below.

There are many different forms of PPA – the following are included in this manual:

- On-site private wire
- Direct off-site
- Sleeved
- Synthetic (Virtual)
- Aggregated
- Wholesale
- Mini-utility

Freedom to choose electricity supplier	Power consumers should be free to choose their electricity supplier and to have more than one power supply contracts at the same time.
Long term PPAs allowed	Competition authorities must allow long-term PPAs. Signing a long term PPA might contradict with competition rules as the customer will not have any retail option for a long term.
Third party sales permitted	Non-utility parties such as generators selling power directly to customers should be permitted.

Key issues to consider while structuring and entering into a PPA include:

Energy modelling to determine load and generation profiles, and green/black import/exports as inputs into the business model: Overall usage and load profile as well as the future projections need to be understood in order to determine the optional energy procurement strategy. The load needs to be overlaid with the output profile from the clean energy plant in order to estimate the differences. There needs to be arrangements in place for managing the shape and volume differences, this can be achieved via firming arrangements with the retailer, financial hedging products, grouping of buyers with other consumers with different load profiles, etc. Similarly, in times of low demand, there may be surplus of generation which can be sold back to the grid at market prices. [9]

Contract structures between generator, customer, energy retailer e.g. direct PPA, bundled PPA and retail contract (sleeved PPA): Customers and generators can enter into a direct PPA where they are the counterparties. All contractual payments, terms and conditions with respect to the procurement of clean energy would be specified directly in this agreement. Direct arrangement may either be decoupled from the energy retailer that is managing physical supply and settlement, or the retailer can get involved to pass through the generation value, provide balancing services, and manage the risks associated with renewable energy intermittency. The intermediated option is a bundled PPA and retail contract where the retailer enters into a PPA with a specific clean energy generator on behalf of the consumer. The consumer would then enter into a separate retail agreement with the intermediate retailer which specifies the generation source, the price and terms on which clean energy generation is procured. [10]

Pricing: The pricing structure should be specified in a PPA, including whether there will be a fixed or other payment structure for energy, and whether Renewable energy certificates (RECs) are separately priced. Pricing structure includes:

- Components of fixed and floating prices for the PPA
- Pricing in the event of a market failure
- Inflation factor or escalation clause

Energy or REC pricing can be fixed at a set price for the term, or the PPA can include a predetermined price escalation over the course of the PPA term. While fixed prices provide simplicity and certainty against fluctuation and potential increase in market prices, there is a risk of lack of opportunity for the consumer if market prices go down. Most investors in clean energy projects generally prefer PPAs that contain simple and specific prices for energy and RECs as this facilitates the project to get financing through debt or equity and their costs are generally fixed. [11]

Inclusion of Renewable energy certificates (RECs) e.g. electricity only, electricity and RECs (bundled), or RECs only PPAs: A consumer can choose to buy RECs and electricity separately or together which is referred to as bundled. Buying RECs only may offer a simple contract structure and the opportunity to purchase RECs at a better price. A bundled contract can provide a more comprehensive hedge against future budget volatility and cost increases. It also provides a stronger tangibility as there is a clear relationship between the customer's electricity purchase and a specific power plant. Through retiring the purchased RECs, the consumer can make GHG emissions savings and renewable energy

claims associated with the project. The disadvantage is that it involves a more complex contracting structure, higher set-up costs, and require more time and legal resources. The electricity only model may be cheaper than buying electricity with RECs as in some cases the price of RECs from the project may be more expensive than the RECs that can be bought elsewhere due to type of technology and plant, market conditions, etc. Although electricity only model can provide a strong connection with a specific power plant, the procured energy will not be renewable for carbon accounting and reporting purposes and the consumer cannot claim the associated GHG emission savings. [9] Bundled purchases provide a clearer connection to decarbonisation of the energy supply and GHG emission reductions. See Financial instruments chapter for more information on RECs.

Physical or virtual approach: Physical approach is the transfer of generation value through allocation of market revenue from physical generation; and virtual approach is the use of financial hedging products to transfer value extracted from financial flows with respect to physical electricity procurement. An example for a physical PPA is the Sleeved PPA where the utility plays an intermediary role and passes through the power as well as the market revenue related to the physical power generation. Virtual PPAs are generally financial hedges implemented via Contract for Difference (CfD). A CfD involves financial flows between parties based on the difference between the negotiated PPA strike price and actual market price over a period of time. [10] For more information on CfD, see Synthetic (Virtual) PPA business model section.

PPAs with new or existing clean energy plants: A consumer may prefer to procure clean energy from a new facility which is built specifically to satisfy their requirements or to procure from a clean energy plant which is already financed and built. Existing generation which is not facing a financing barrier will likely be more flexible and able to contract for shorter terms. These shorter term contracts would however reflect market prices and be higher cost than long term agreements with a new clean energy plant generation. Also entering into a PPA with a new clean energy plant can be related to additionality and accelerating clean energy deployment as it provides a financial certainty to a new clean energy plant which otherwise might not have been built. Some risks of entering into a PPA with a new clean energy plant that needs to be considered are risk of late start and deal falling. [10]

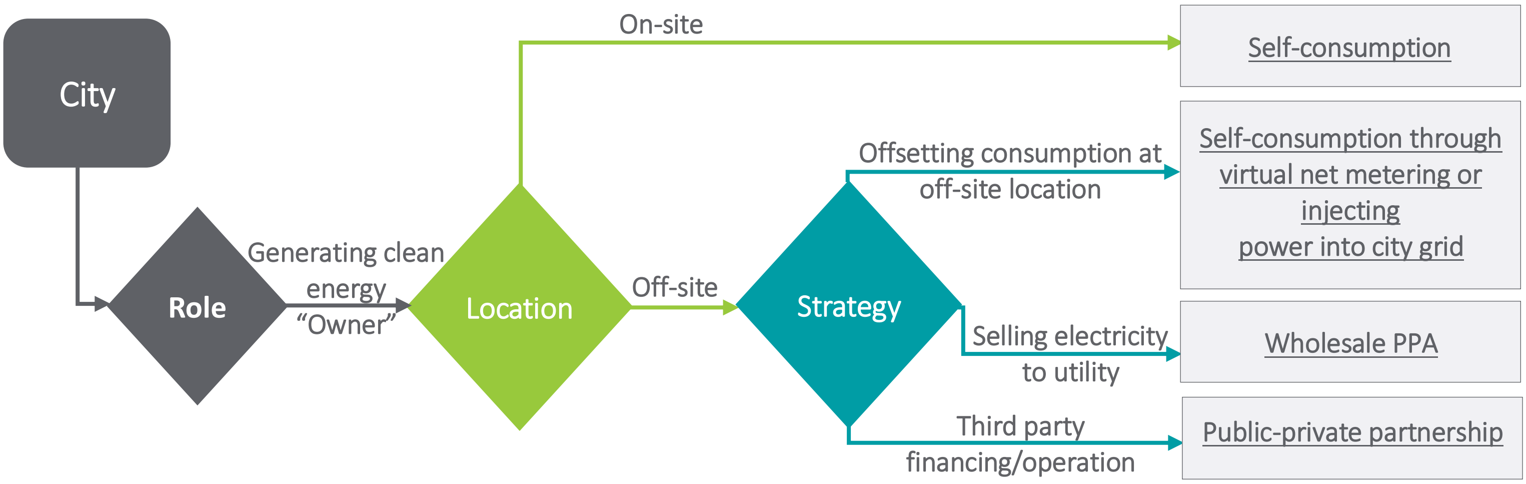
Risks: Some of the risks associated with PPAs include wholesale price uncertainty (e.g. wholesale prices going down), counterparty risk (e.g. the project is not completed on time, and counterparty goes into insolvency), power consumption risk (e.g. in the case of under supply, the consumer is subject to merchant risk as consumer needs to buy electricity at the market prices), exposure to regulatory change (e.g. changes in law such as tax), currency risk[8], risk of financial exposure (on the underlying commodity and due to price basis risk and long-term financial obligation), etc. There are likely to be other risks that require consideration and arrangements for each case when structuring and negotiating PPAs.[12]

Any organisation looking at entering into a PPA will need sophisticated understanding of the key issues listed above, energy profile and legal contracting. Energy procurement and contracting is a specialist and complex area, so consultants will likely be needed for developing such projects such as energy market advisors, procurement facilitators, brokers, or advisor, probity advisors, and legal advisors. For further information and tips, see [9].

2.1 Generating clean energy – "Owner"

Business models in this category involve the city to own and operate its own clean energy plant. This can be divided into two subcategories depending on the location and connection of the plant: on-site and off-site. On-site generation involves building and operation of embedded clean energy plant in a city-owned facility. Energy generated from the on-site clean energy plant is mainly for supplying some power to the facility for own use. An example is rooftop solar PV on city owned buildings. Off-site generation involves building and operating stand-alone city-owned clean energy plant where the generated energy is directly fed into the grid. Stand-alone city-owned clean energy plants refer to projects that are installed on lands with the explicit purpose of generating energy, such as solar PV and wind farms.

Depending on the strategy that a city takes, there are various business models for generating and owning clean energy as shown in the flowchart below.

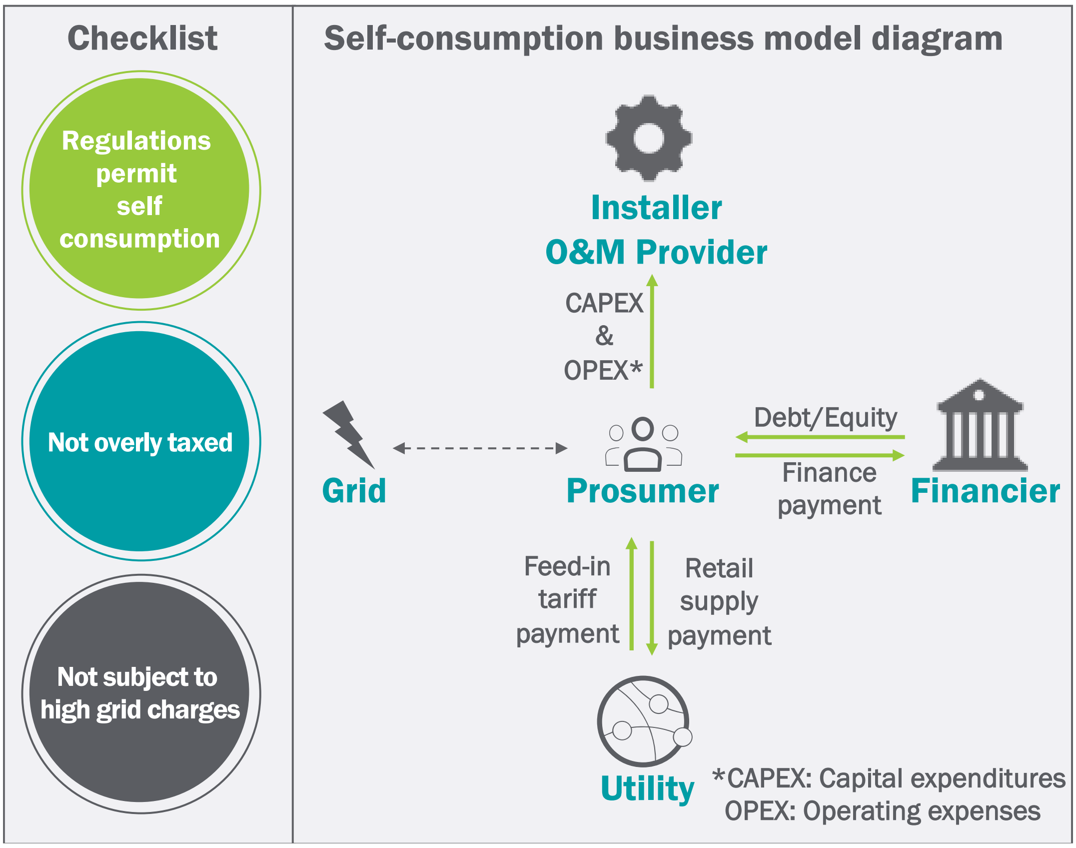


2.1.1 Self-consumption model

In the self-consumption business model, the generator and consumer are the same entity (prosumer) and the installation is financed by the prosumer. The prosumer self-consumes the energy generated by their clean energy plant. The prosumer contracts an installer to carry out the installation of the plant and can also contract the installer or a maintenance provider for ongoing operation and maintenance works. The income is generated through avoided electricity costs as well as net-metering, net billing and feed-in schemes (if available) that enable payments from the utility or the government for generation and/or export of energy. (See Financial instruments chapter for more details on feed-in schemes, net metering and net billing.)

An example would be a city financing a solar PV installation on their own building and using the generated electricity on-site.

Another variant of self-consumption business model is where the clean energy plant is located off-site instead of being embedded on-site. For the city to be able to "self-consume" the electricity generated and fed into the grid at an off-site location, **a virtual net metering** mechanism can be used. In summary, this mechanism allows the city to offset the electricity consumption of a public building at a different location against the electricity generated at an off-site plant. (See Financial instruments chapter for more details.) Or, the city can buy back the energy from its own clean energy plant through a power purchase agreement (PPA) e.g. **West Sussex County Council** purchases power from its own Tangmere and Westhampnett solar farms. [13]



The self-consumption model can take several forms depending on the number of consumers:

- **Single power consumer self-consumption:** This is the most popular variant of the self-consumption business model. In this case, there is only one power consumer and that consumer is the owner of the installation. The diagram is presented above.
- **Multi power consumer self-consumption:** This is a variant of the self-consumption business model where there is more than one power consumer such as self-consumers located in the same multi-occupancy building, commercial building, site or closed distribution system. This model can be set in several forms:
  - The occupants of the building/site own a stand-alone segment of the installation which is connected to each occupant through a direct wire. This model mostly applies to solar PV and works best with new buildings as it can be incorporated into the design of the building.[5] Through this model, every occupant will have the ability to choose their own utility. Its disadvantage is that the investment costs are higher as it might require the installation of direct wire to each occupant.
  - The installation is owned by all or some of the occupants and feeds power into the main supply of the building/site. This model requires the occupants to be equipped with a smart meter for accurate billing purposes. Using estimations instead of smart meters might lead to unfair allocation of costs and benefits.[5] In the multi power consumer self-consumption business model, split incentives can occur due to the large number of tenants in multi-occupancy buildings. Split incentives arise when those responsible for paying energy bills (the tenant or the occupant) are not the same entity as those making the capital investment (the owner or the landlord). This may hinder the project as the landlord will have no incentive to invest if the benefit goes to the tenant. This barrier can be eliminated by using the leasing model (This is explained later on) or by financial instruments such as on-tax bill financing or on-energy bill financing (See Financial instruments chapter for more details.)

Advantages	Disadvantages
Direct effect on creating a new clean energy capacity	High up-front capital investment
Reduced electricity costs after initial capital investment and ongoing operation and maintenance costs	The city is responsible for contracting or supplying the operation and maintenance services
Protects the city from volatile electricity and fuel prices	Risk of city's building energy demand not being met due to limited available space and insufficient load matching
Suitable for both regulated and deregulated markets	Limited generation potential dependent on local renewable energy resources
Opportunity to lead by example	Long-term commitment requirement

DURBAN: ENERGY OFFICE SOLAR (EOS) PROJECT

The City of Durban has the target of supplying 40% Durban's electricity consumption from renewable energy by 2030.

As part of this strategy, the City of Durban has started the EOS project which aims to promote the use of embedded solar PV generation in Durban through installing solar PV on city-owned buildings and establishing examples for private sector and other municipalities. So far, 5 installations has been completed in uShaka Marine World, Metro Police HQ, Water and Sanitation Headquarters, People's Park Cafe, and Moses Mabhida Stadium Arch buildings. The total capacity of the system is 300 kWp with 426.3 MWh annual generation. They bring an estimated annual reduction in carbon emissions of 439.5tCO_2e.

The next phase of the project is a rollout of rooftop solar PV systems to a larger number of municipal buildings.[14]

SANTIAGO: THE SOLAR PUBLIC ROOFS PROGRAMME

The goal of the Metropolitan Region of Santiago is to increase distributed clean energy generation and energy efficiency, as part of the Regional Strategy of Resilience and the Regional Plan to Decontaminate and Prevent the Air Pollution.

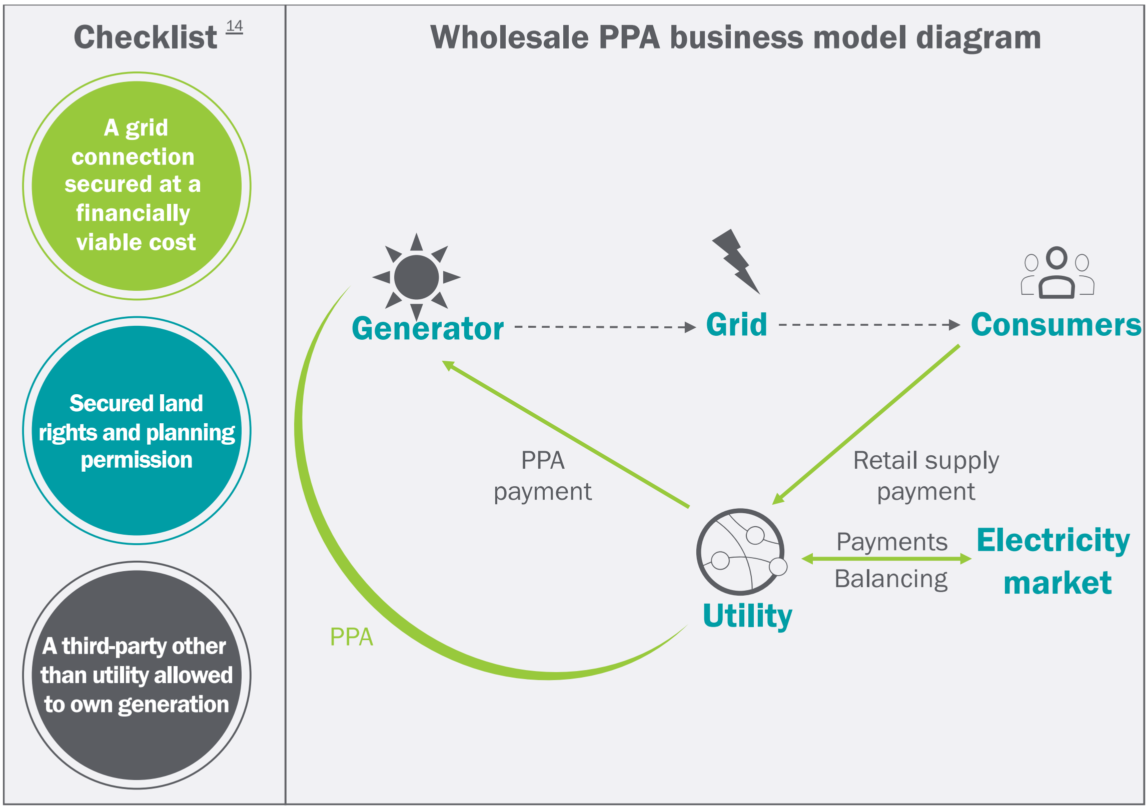
The Renewable Energies and Energy Efficiency Programme for Public Buildings at Santiago, is a regional initiative that includes two programmes of the Chilean Ministry of Energy, with the objective of reducing GHG emissions, energy consumption and energy costs in public buildings. One of the programmes is The Solar Public Roofs Programme which consists of 18 PV projects in public schools, hospitals, and some emblematic buildings in Santiago. The generated solar energy is used for self-consumption in these buildings and the surplus energy is injected to the grid. Total installed capacity under this programme is 1075 kWp with an expected generation of 1.47 GWh/year, which means a reduction of 605.8 tCO2eq/year. The Solar Public Roofs Programme had an investment of over USD 1,000,000 provided by the Chilean Ministry of Energy.

2.1.2 Wholesale PPA

The wholesale (or utility) PPA is used for selling power on the wholesale market where the generator establishes a PPA contract with a grid operator such as a licensed supplier or balancing party. The grid operator then sells the electricity on the wholesale market and to its customers. [5]

This business model is suitable for cities in a regulated retail market where utilities have monopoly over supply but not generation, and for cities who do not have any control over their power purchase but are allowed to own a clean energy installation.

A city can finance and build their own clean energy project in an off-site location that will be feeding electricity into the grid. The city enters into a Wholesale PPA with the utility to sell the electricity. (See Johannesburg municipal landfill gas to electricity case study in PPP business model section).



Advantages	Disadvantages
Well suited to different project sizes due to the flexibility of the model [15]	Not cost advantageous as some of the profits will go to the utility
No off-taker risks for the city as the agreement is with the utility thus less risky than other PPA models	Worse deal than other PPA models in terms of prices for the generator/city
Simple model with low legal costs	

2.1.3 Public-Private Partnership (PPP)

A PPP involves a contract between a public-sector authority and a private party for a clean energy project. In PPPs, a public partner's role can include contributing to the financing, providing sites, monitoring performance of the private partner and enforcing its obligations, among others. The private partner's role includes providing financing, undertaking installation, technical operation and maintenance services and upon completion of the project providing public services such as electricity.

PPPs have several main features:

- They are long term contracts
- Parties share risk and responsibility
- Private partners bring their expertise and knowledge
- They supplement limited public sector funding by bringing in private sector capital
- Private partners may operate the plant without any time limitations or for a pre-defined period under a long-term concession contract and transfer the ownership and operation of the plant back to the public partner after this period.

The PPP business model generally involves the creation of a Special Purpose Vehicle (SPV) which will develop, build, maintain and operate the clean energy plant for a designated period. The SPV enters into a contract with the public partner and with the subcontractors to build the plant and then provides operation and maintenance services.[16]

A city can apply this model through tendering for a private partner who would finance, design, build, own and operate a clean energy plant. See case study below for Johannesburg's municipal landfill gas to electricity project with a private partner.

Advantages	Disadvantages
Enables access to additional capital	High transaction costs due to complexity
Accommodates the interests of both public and private partners	Market risk in the event the product prices fall [17]
Fast delivery of the project, high efficiency, risk sharing and improved quality of services can be achieved through engaging core capabilities of both parties	Risk of insolvency of the private partner Financial exposure risk as PPPs bring an ongoing financial obligation to the city as part of a long-term agreement

JOHANNESBURG : MUNICIPAL LANDFILL GAS TO ELECTRICITY

In order to solve the excess methane emissions issue at some of their landfill sites, the City of Johannesburg initiated the landfill gas to electricity project. The City's Environment, Infrastructure and Service Department and Ener-G Systems has formed a Build-Own-Operate-Transfer (BOOT) PPP where Ener-G, the private partner, has been awarded a 20 year contract for five sites (Robinson Deep, Marie Louise, Linbro Park, Ennerdale, Goud Koppies) with 18.6 MW capacity. The operation is run under a profit sharing agreement with the city. After 20 years, plants will be transferred to the city.

The City were unable to purchase electricity through City Power (the municipal utility) from these sites due to the requirement to procure services at best value for money as the price proposed by Ener-G was higher than the average electricity price provided by Eskom (South African public utility). Ener-G submitted bids to the Renewable Energy Independent Power Producers Procurement (REIPPPP) instead. The project was selected and in August 2015, a Wholesale PPA was signed with Eskom.

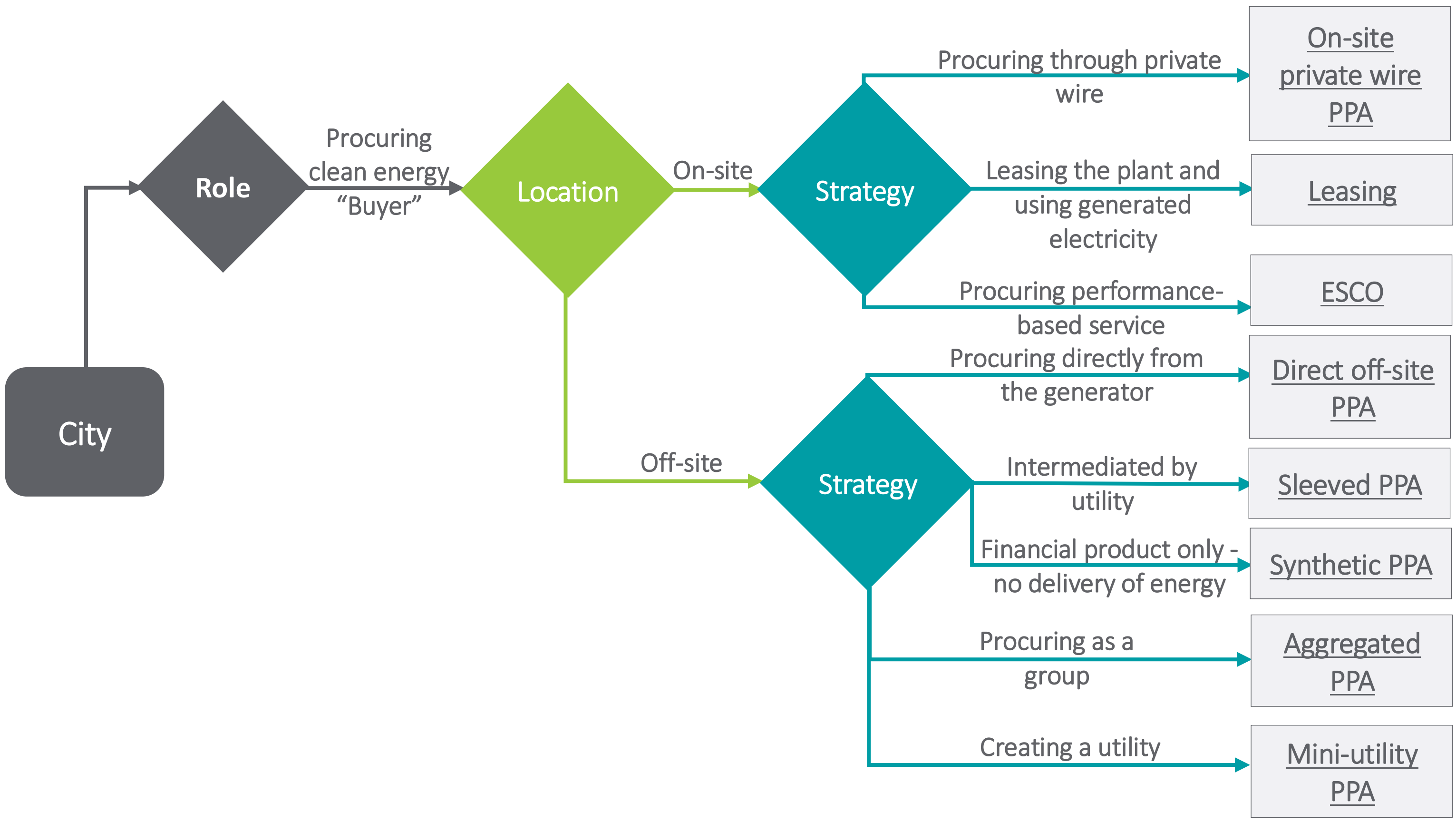
Three of the five plants will be connected to the Eskom grid and two to the City Power grid. As per the REIPPPP processes, no wheeling arrangements were needed for these two sites. Eskom and City Power have amended their delivery supply agreement to accommodate this additional point of supply on the network so that the metering points become an Eskom point of supply delivering electricity directly to City Power.[18]

2.2 Procuring clean energy – “Buyer”

This category positions cities as a procurer of electricity, rather than clean energy plant builder and operator. In this role, cities buy clean energy from third-party developers/generators. This is divided into two subcategories depending on the location and connectivity of the plant: on-site and off-site. On-site subcategory involves the city purchasing power from an embedded clean energy plant at a city-owned facility. The clean energy plant is owned by a third-party rather than the city.

Off-site subcategory involves the city purchasing power from a clean energy plant that is located at a different point at the network. The off-site clean energy plant is owned and operated by a third-party such as a non-utility, independent generator.

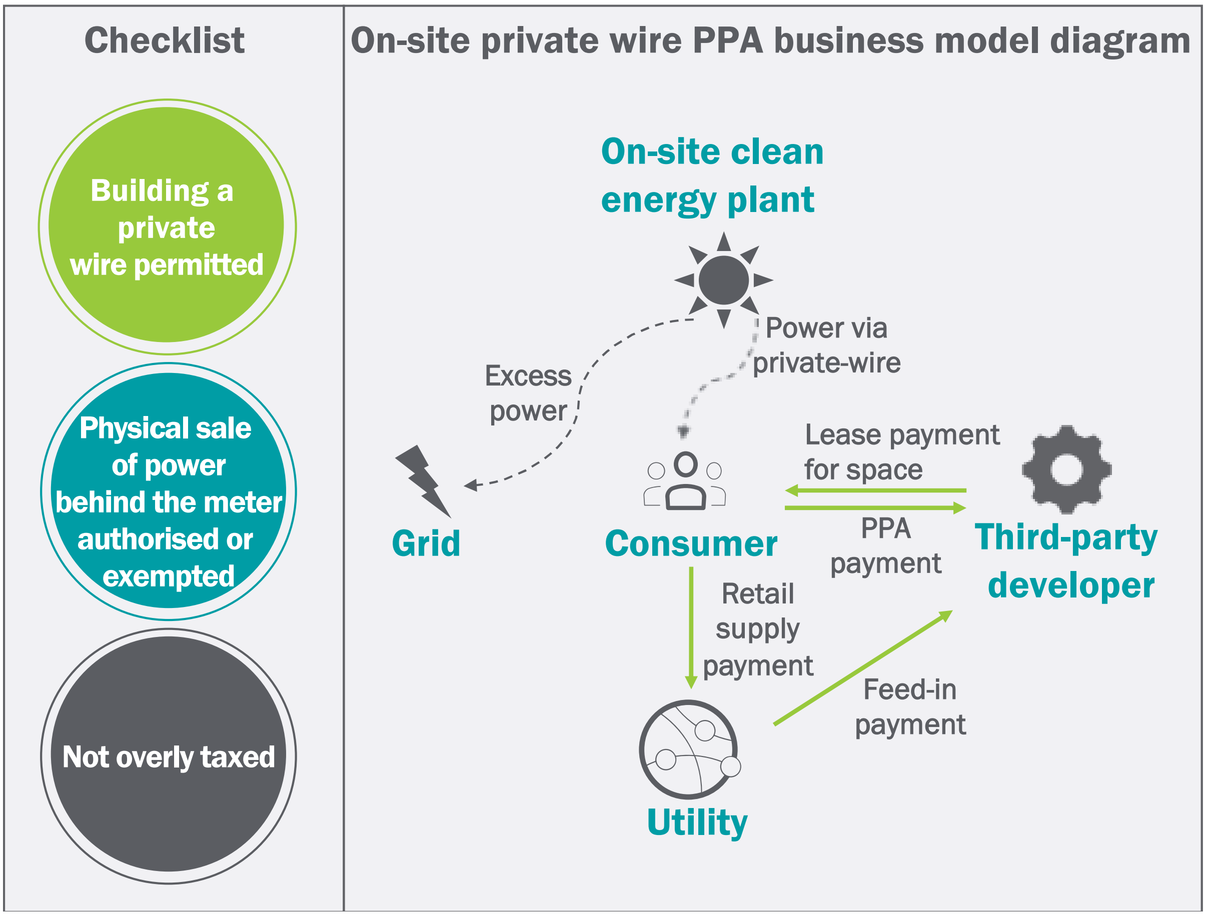
Depending on the strategy that a city takes, there are various business models for procuring clean energy as shown in the flowchart below.



2.2.1 On-site private wire PPA

On-site private wire PPA can be established when a third-party developer installs and operates a clean energy plant located on the same building or in a nearby location to the consumer. The connection between the consumer and the generator is made through a direct wire without using the public grid. The consumer buys some or all of the power produced from the generator under a PPA and the rest of the demand is provided by the utility. The generator can also sell the excess power not used by the consumer to the utility through another PPA or feed-in-scheme. The diagram is presented below. The agreed PPA price is generally lower than the retail price to provide an incentive to the customer to enter into a PPA with the generator.

An example is a third-party developer financing and installing solar PV plant on city-owned buildings and entering into a PPA with the city where the generated energy is sold to the city at a reduced rate and used on-site.



Advantages	Disadvantages
Avoids grid charges as the electricity is not transmitted via public grid	Long-term commitment requirement
No investment cost for the customer	Financial exposure for the city due to fixed price and long-term obligation for payment
Reduced electricity bills	Generation potential is dependent on local renewable sources
Locally delivered clean energy	High transaction costs due to the bespoke contracting structure [15]
Direct effect on creating a new clean energy capacity and creates a tangible connection between the clean energy generation and investment	Requirement for a large consumer energy demand that is time matched with the generation

WASHINGTON D.C.: PPA FOR MUNICIPAL ON-SITE SOLAR PV

District of Columbia has the target to increase the use of renewable energy to make up 50% of the District's energy supply by 2032.

In early 2015, the District of Columbia Department of General Services (DGS) sought to develop a municipal portfolio of onsite solar energy projects on sites including schools, hospitals, recreation centres, police training facilities, and one carport.

To achieve this, DGS has entered into a 20-year onsite PPA with Sol Systems and its investor WGL Energy to purchase power generated from the onsite solar PV systems that are installed, owned and operated by Sol Systems and WGL Energy.

Project was completed in July 2017 and consists of 10.9 MW of solar PV generation capacity installed across 35 projects. Solar PV systems collectively produce about 13,800 MWh annually.[19]

2.2.2 Energy Services Company (ESCO)

ESCOs deliver energy services such as heating and lighting and/or other energy efficiency improvements to a customer's premises or facility and accepts a level of financial risk through providing performance standards e.g. pre-determined energy savings. As ESCOs generally provide energy services and energy savings rather than actually selling energy, their main focus is on reducing consumer demand which results in lower energy use and CO_2 emissions. ESCOs often design, develop, finance, and manage the project on a performance-based contract.

The city can appoint an ESCO to carry out energy retrofitting on their building stock such as insulation, improving the indoor climate and integrating renewable energy sources such as solar PVs, heat pumps, etc.

An example is **Halsnæs municipality** who entered into an ESCO agreement with YIT for energy renovation and renewable energy measures in city-owned buildings with the target of reducing energy consumption by 30%. [20]

Checklist

- A license or a private network to supply electricity
- Long term contracts with ESCO allowed by competition authorities
- Regulatory challenges around consumer protection removed

Advantages	Disadvantages
Encourages energy demand reduction	High transaction costs of tendering and contract management
Suitable for off-grid electrification projects because it relieves low-income rural households from financing through debt and helps ensure that equipment is properly maintained [3]	Not easy to apply due to regulatory barriers that prevents cities from long-term contracts, retention of energy cost savings to pay ESCOs, procure to select most value, etc.
No upfront investments for the customer	Long-term commitment requirement
Suitable for regulated and deregulated markets and also unregulated services such as heat	Difficult to reliably measure non-technical influences such as changed business practice, weather, etc.

2.2.3 Leasing model

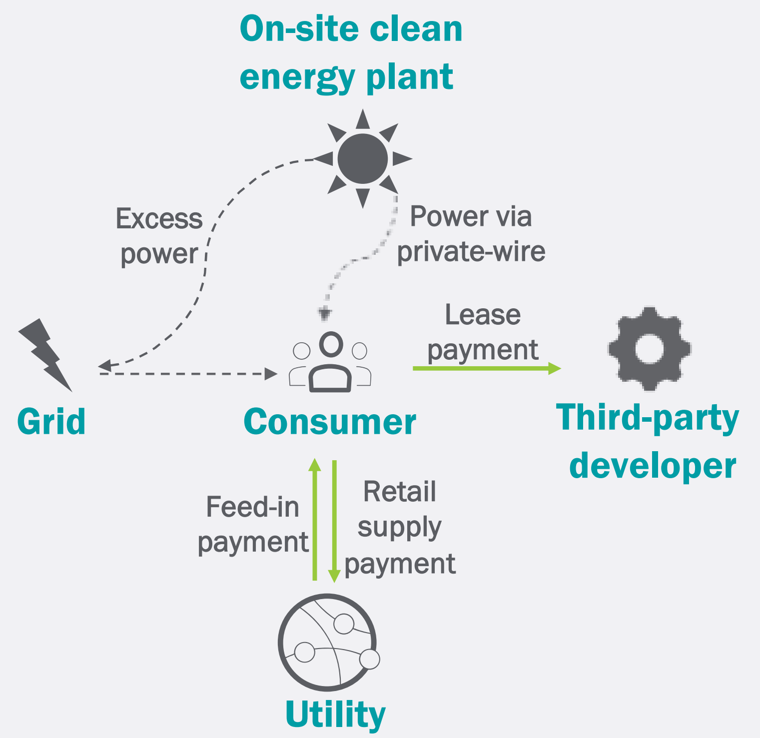
Leasing model is where the investor/owner of the clean energy installation leases the system to the occupant or owner of the site. In the leasing model, the customer operates the system and either self-consumes the energy or exports it back to the grid via an export price or net metering mechanism. The investor receives a monthly rent payment from the customer. This model may be especially useful in markets where PPAs are not allowed (due to restrictions on third-party power sale) since in this model the whole system is leased rather than the power being sold to the consumer.

There are several ways of setting up a leasing business model:

- A utility, developer or investor finances and arranges the installation and leases the clean energy system to the site/building owner e.g. city.
- A utility or similar third-party lease the system to the occupant (e.g. a tenant) but signs a contract with the landlord for permission to use the space such as the roof for solar PV.
- The landlord leases the system to the tenant. [5]

In this model, a third-party developer invests in and installs clean energy systems on city-owned buildings and leases the system to the city e.g. Kansas City leasing solar panels for its approximately 60 city-owned buildings from a third-party under a 20 year operating lease & solar service agreement at a fixed cost. [21] Cities can also use this model to enable installations of clean energy technologies on third-party buildings or sites. An example would be a city investing and owning the clean energy technology on a site that is owned by a third-party and leasing the system to the occupant. (See Stuttgart case study below.)

Advantages	Disadvantages
Eliminates the need for upfront investment for the customer	Risk of overpay if generation estimates are inaccurate
Solves the split incentive problem as the investor can get a return from their investment through leasing even without being the occupant	High operations and maintenance risks for the customer unless the third-party developer provides these services or guarantees
The leasing party can monitor the system in real-time and solve problems promptly with a maintenance agreement in place	In the case of city leasing clean energy equipment to its residents, there is high off-taker risk as the revenue is dependent on reliability of the lessee
Enables installations on sites not owned by the investor such as city-owned buildings	Not suitable for all clean energy technologies as it should be possible to remove the technology from the building/site [4]
Suitable for market introduction of new and innovative technologies [4]	

Checklist	Leasing business model diagram
Regulatory challenges around consumer protection removed Third party ownership of the system allowed Clean energy system can be removed at the end of lease term	

STUTTGART: LEASING PHOTOVOLTAIC SYSTEM

Stadtwerke Stuttgart, a municipal utility, is offering households the option to buy or lease solar PV panels from them. Consulting, installation and servicing are provided as one package. There is also the option for integration of power storage or charging box for electric vehicles.

With the lease model, households have no investment costs and the municipal utility takes over any repairs for the entire contract period. In addition, the household is rewarded with a bonus every five years through a reduction of the monthly lease payment.

The solar power that the panels produce is consumed by the households and surplus electricity is fed into the electricity grid. The households also receive a feed-in tariff for this, which the grid operator will pay for 20 years from the date of commissioning. After the lease period, the households can take over the photovoltaic system; or the utility dismantles the system. [22]

2.2.4 Direct off-site PPA

A direct off-site PPA business model involves a customer establishing a PPA with an off-site clean energy generator directly. Generators can sell the energy via a PPA to customers located anywhere in their electricity service territory or in the country if regulations allow.

> An example would be a city entering into a PPA with an off-site clean energy generator to buy clean energy for one of the city's facilities. This model can help cities to reach their clean energy targets without having to own a clean energy plant.

This model creates a balancing risk as the customer and the generator enters into a PPA directly. Balancing risk relates to the continuous supply of electricity to the customer. The customer has a number of ways to mitigate this risk. **Therefore, there can be different versions of direct off-site PPA business model depending on the approach that the customer takes with regards to handling the balancing risk.** Some different versions of direct off-site PPA and ways to mitigate the balancing risk is provided below:

- The customer can purchase balancing power on its own by setting up an entity that can undertake trading and balancing services e.g. Mini-utility PPA
- A third-party provider can provide balancing services
- The customer can sell the purchased energy from the generator in the wholesale market and receive the revenue as well as the RECs without using the power e.g. Massachusetts Institute of Technology (MIT), Boston Medical Center and Post Office Square joint solar power purchase agreement with Summit Farms
- The customer and the utility can enter into a retail agreement in which the utility can top up the power supply from the clean energy generator with other electricity sources to meet the power demand of the customer [8] e.g. Sleeved PPA

As explained above, direct off-site PPA can take many forms depending on the type of PPA (physical or virtual), the customer type (single or multiple), or if intermediary parties are involved, and how the balancing risk is handled, etc. In this manual, 4 different types are included, these are presented in the diagram below and explained in the next sections.

Direct off-site PPA
The customer and generator are direct counterparties in the PPA

Sleeved PPA*	Synthetic/Virtual PPA	Aggregated PPA	Mini-utility PPA
The utility/retailer plays an intermediary role for balancing and sleeving purposes. *Variant 1 - Direct	Direct PPA between customer and generator is only for financial purposes, there is no transfer of power	The customer is a consortium of multiple buyers rather than a single consumer. It can be in the form of Synthetic PPA, Sleeved PPA, etc.	The customer enters into direct PPAs with generators and creates an entity for carrying out its own trading and balancing services

Advantages	Disadvantages
Enables access to locations with higher renewable energy resources as the project is not limited to customer's site	Not suitable for regulated markets and markets where direct energy sales are not permitted
Better PPA deals for generators as the accompanying costs of third-party intermediary can be avoided. Also enables a tariff that meets the needs and values of the consumer [23]	There can be location-specific transaction structuring and permitting issues that need to be addressed to satisfy regulations [11]
Allows individuals to select their energy supplier and to get involved in the clean energy policy	Balancing risk. Going 100% renewable with this business model can be difficult when there is no top up or balancing provision

Checklist

- Deregulated electricity market
- Competitive retail energy sales to customers permitted
- Non-utility system owners utilizing the grid permitted

[23]

WASHINGTON D.C. - SOUTH CHESTNUT WIND FARM PPA

The District of Columbia has the target to increase the use of renewable energy to make up 50% of the District's energy supply by 2032.

As part of this strategy, Washington D.C. established a 20-year Power Purchase Agreement in 2015 with Iberdrola Renewables, LLC that will directly supply 35 percent of the District government's electricity demand with wind power. Under the PPA, the Department of General Services (DGS), which manages the District's portfolio of government buildings, will purchase the entire output of Iberdrola's South Chestnut 46 MW wind farm in southwestern Pennsylvania, along with the associated Renewable Energy Certificates to be retired.

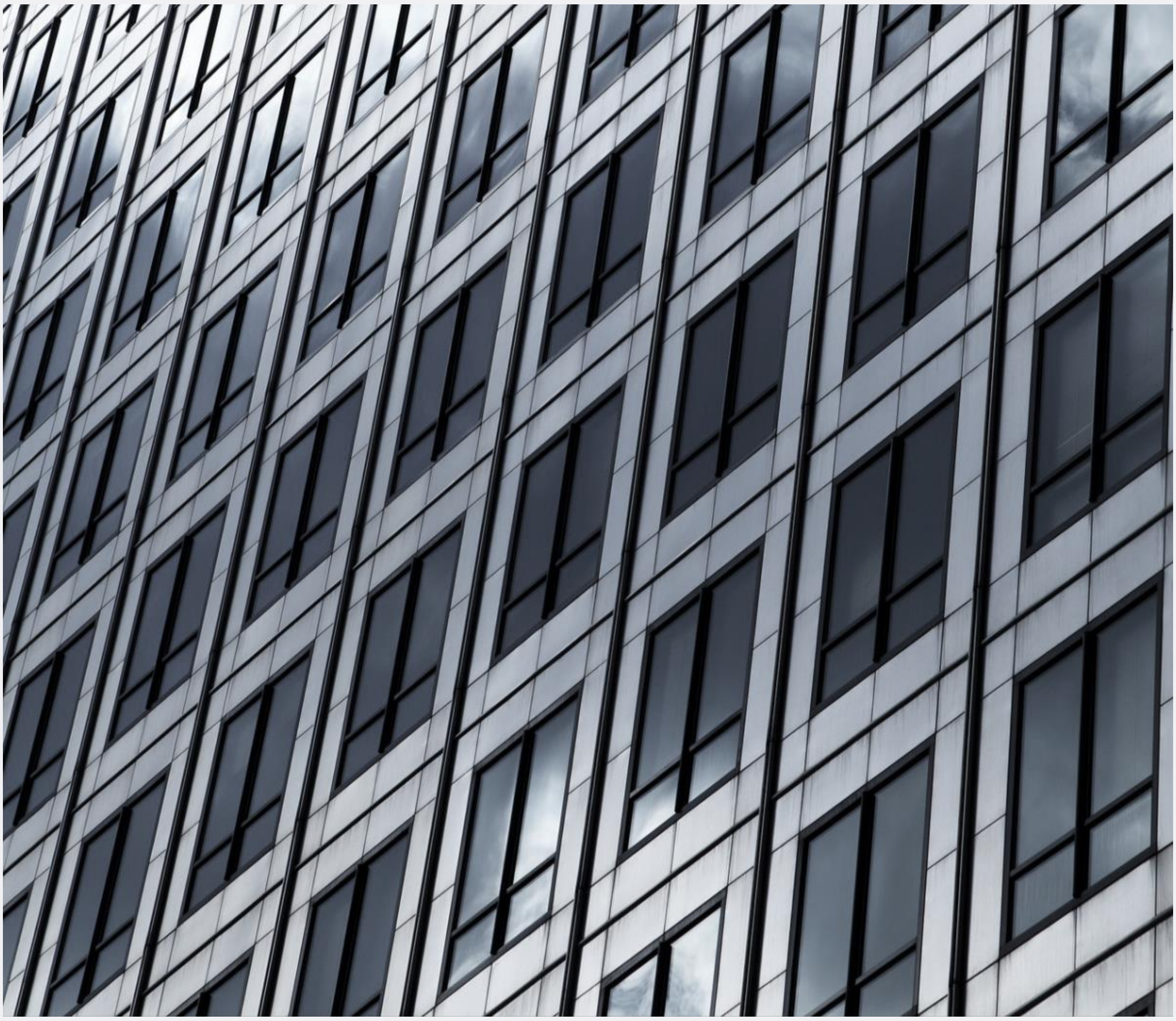
This will supply the District of Columbia with approximately 125,000 MWh of clean electricity every year.[24] Additionally, this is the first long-term wind PPA entered into by a city without a municipal utility.[25]

Peer-to-peer model (P2P)

In this model, power can be directly traded between generators and individual households or businesses and it enables consumers to buy directly from generators. An electricity supplier is usually required to enable this relationship by transferring power across the public grid and for balancing functions when the consumer's selected generators are insufficient to meet consumer's demand. [6]

For P2P model, a software platform is needed to connect individual customers and generators where the generators set the price for their power and customers select clean energy generator(s) for their energy supply directly. [23] This platform can either be run by licensed supplier or by a blockchain technology or third-party intermediary if the regulations allow power to be sold over the public network without a license.[26] (See Virtual power plant section for more details on blockchain technology.)

> A city can apply this model through getting involved in the facilitation of the model and establishment of the P2P trading platform.

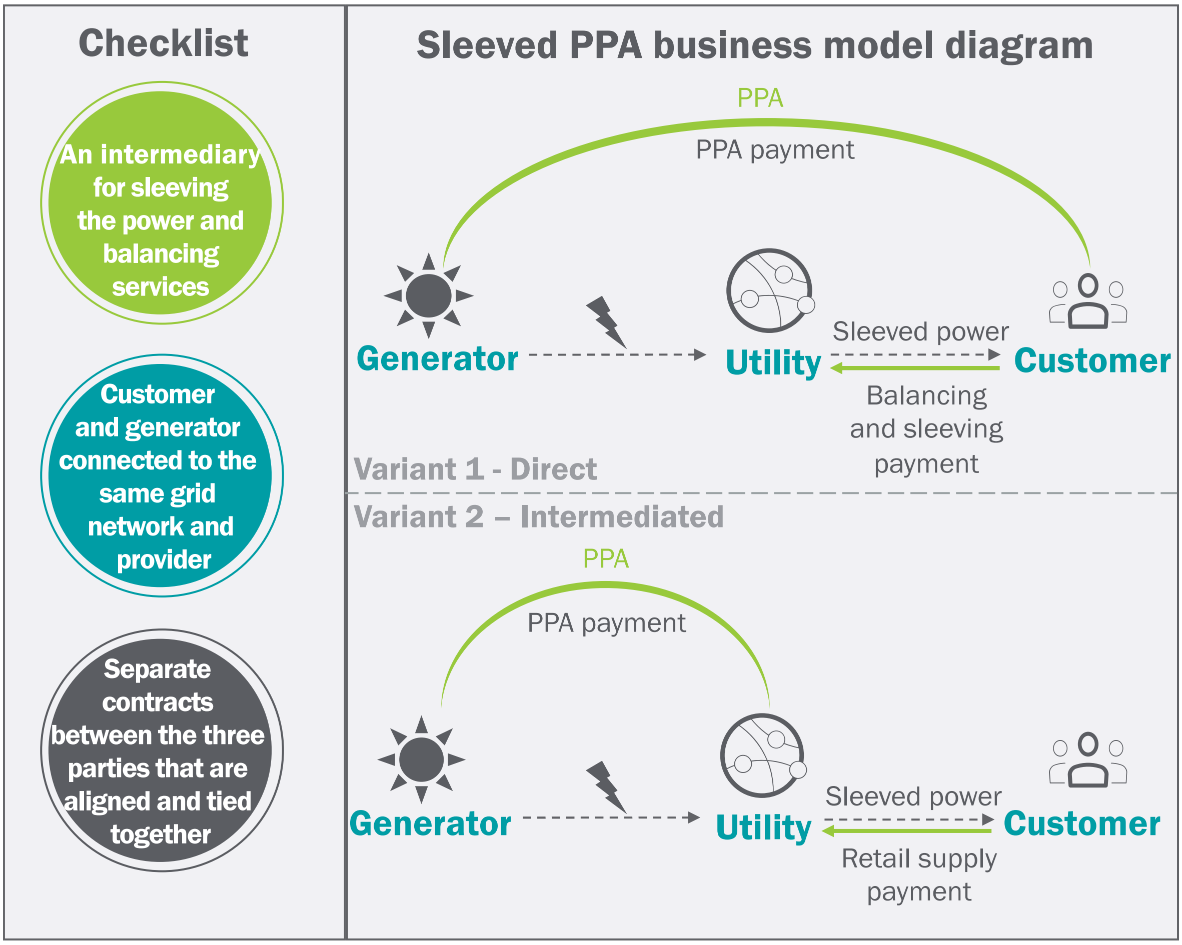


2.2.5 Sleeved PPA

Sleeving means a utility physically delivering power on behalf of the customer. In the sleeved PPA model, the generator sells the power to the customer under a PPA and a third party-supplier/utility is appointed by the customer to sleeve the power from the generator to the customer. There are two variations of this business model depending on if the customer and generator enters into a PPA directly or through the utility. In the variant 1, the customer and generator enter into a PPA directly, and the third-party supplier is involved to match the supply and demand and for balancing services (See figure below for Variant 1). Variant 1 is a type of Direct off-site PPA as explained in the previous section.

A city can use this business model to procure clean energy directly from a clean energy generator that is not located in their immediate locality.

Second variant is where the generator and customer cannot enter into a direct PPA. In this intermediated model, the generator and customer rely on the utility to enter into a PPA with the generator and provide a separate retail agreement to the customer to pass the power through the network and renewable energy certificates (Variant 2). This business model is suitable for markets where direct energy sales are not permitted, and requires the use of an intermediary, usually a utility. [11] The diagrams for the two variants of Sleeved PPA business model are presented below.



Advantages	Disadvantages
No high-up front cost for the customer	Obligation to purchase a minimum level of generation irrespective of customer's demand
Having the third-party supplier is useful for providing balancing services and helps the customer and the generator to reduce their exposure to uncertain and volatile prices	As the project has an expensive structure to implement, it needs to be large enough to sustain the high transaction costs [15]
Having a direct PPA with the generator allows the customer not to be tied to a single retail contract for a long period and provides flexibility of changing suppliers during PPA duration (valid for Variant 1)	Not cost advantageous as the power is sleeved through the third-party supplier which incurs costs for its sleeving and balancing services [5]

HOUSTON - SOLAIREHOLMAN SOLAR FARM PPA

The City of Houston has been holding the top spot on the U.S. Environmental Protection Agency's (EPA's) Top 30 Local Government list of the largest green power users from the Green Power Partnership. The City uses over 89% percent of its total energy needs from green power.

The City of Houston had an existing PPA with Hecate (now SolaireHolman) for buying 30 MW solar power. In February 2017, the City has decided to increase the purchase volume to 50 MW.

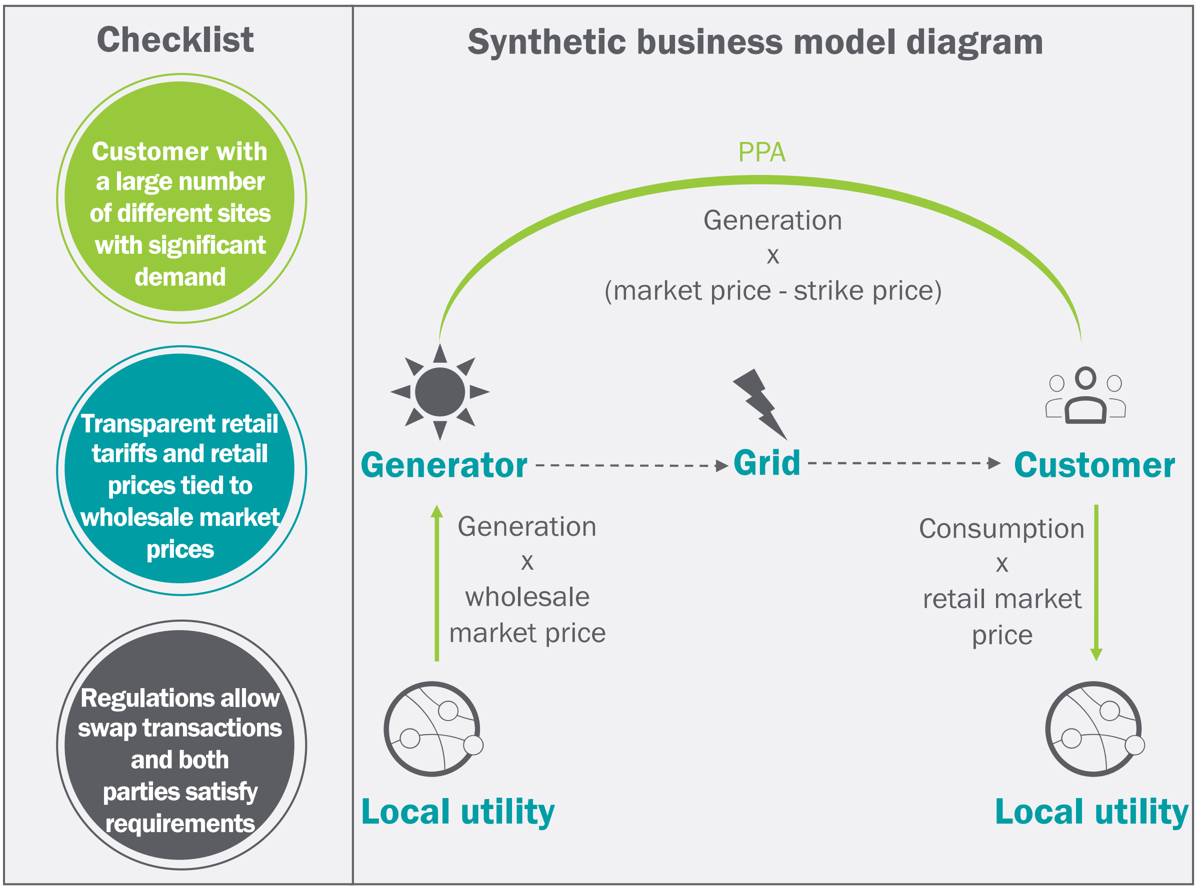
As part of this expansion, the city has entered into a PPA with ENGIE under which SolaireHolman solar farm located in Alpine, Texas will supply the City's electricity provider, Reliant Energy Retail Services LLC with up to 50 MW of solar power at a set guaranteed price for 20 years which then will be transferred to City of Houston through the electricity provider. [27]

2.2.6 Synthetic (Virtual) PPA

The Synthetic PPA business model enables a clean energy generator to sell power 'virtually' without physical exchange of power to multiple assets of the customer. The synthetic PPA replaces the sleeved PPA model with a similar financial structure without the sleeving fee and services. [8] Synthetic PPAs are essentially hedges for volatile power prices. As a Synthetic PPA is only a financial contract, this type of PPA could also be used in regulated markets where direct retail sales are not permitted. [11]

Synthetic PPAs generally take the form of contract-for-difference (CfD) where the contract between the generator and customer sets a fixed strike price. When the market price at which the generator sells electricity is lower than the agreed strike price, the generator receives a payment for the difference from the customer. When the market price is higher than the strike price, the generator pays to the customer for the difference. The diagram for this business model is shown below. Where applicable, the contract may involve the physical transfer of renewable energy certificates if they are part of the contract.

A city can use this model to virtually purchase clean energy from an off-site generator and meet its clean energy targets.



Advantages	Disadvantages
Price and financial certainty for both customer and generator	Does not support local generation
The customer is not required to define where the electricity is used and can aggregate demand for a single purchase transaction of a large volume of power. This is useful if customers have multiple sites and want to retain the flexibility to change their facilities	In some instances, synthetic PPAs can act as a hedge to protect cities against increases in energy prices; however, this hedge is only effective if energy prices for a city's facilities are highly correlated with the revenue it receives from its synthetic PPA
Customers can contract with generators located in the other markets. It also enables the generator to sell to a supplier different to the customer's supplier. This is useful in markets where the grid and the market are highly fragmented [15]	Due to increasingly uncertain wholesale prices, locking in a fixed price might not be optimal. If wholesale market prices are consistently below the PPA price, the customer will lose money on the transaction [28]
No sleeving fee as the third-party supplier is not involved	If the customer and generator are located in different markets, potential differences in prices in these markets can lead to an imperfect hedge and financial exposure to the city due to price basis risk [8]
High levels of revenue can be generated during periods of high market prices	

CANBERRA: RENEWABLE ENERGY REVERSE AUCTIONS

Canberra has a target of 40% reduction in GHG emission on 1990 levels, 100% renewable electricity by 2020 and zero net emissions by 2050. Australian Capital Territory (ACT) held 4 reverse auctions between 2012 and 2016. 640 MW of renewable energy is contracted which secures the 100% renewable energy target. In the reverse auctions, RfPs were released and the auction bids were evaluated based on the price, risk, community engagement and local investment benefits. The winners are awarded a feed-in tariff (FiT) price on a 'Contract for Difference' basis. The FiT is paid on a monthly basis by the ACT's electricity distributor, ActewAGL Distribution. ActewAGL Distribution pays the generator the difference between the FiT price for each MWh of renewable electricity generated and the value of that MWh in the wholesale electricity market. If the market price is higher than the FiT price, the distributor will be paid the difference—and the savings are passed on to ACT consumers. FiT prices are fixed for 20 years and not indexed to inflation, so that as wholesale price of electricity increases over time, FiT payments go down and savings go up. All the renewable energy certificates associated with the generation are transferred to ACT. [29]

2.2.7 Aggregated PPA

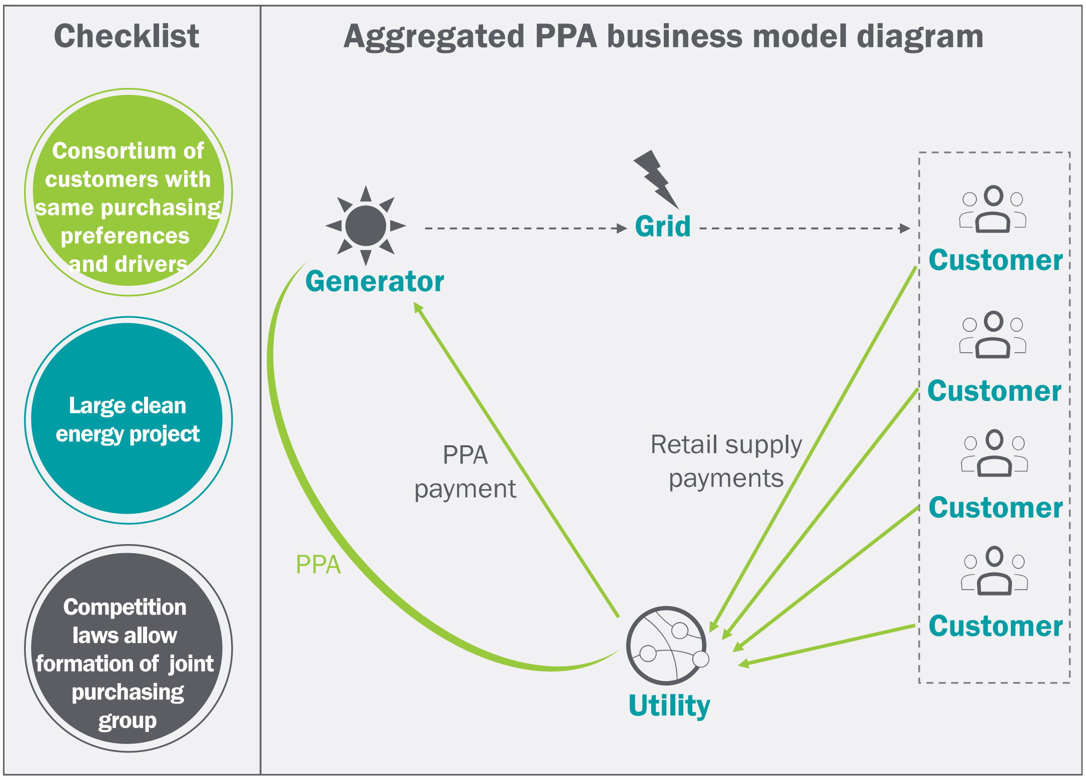
In this business model, customers with lower energy demand and/or less experience of entering into PPAs can set up multiple buyer structures with other customers to purchase power from a clean energy generator directly.

This business model can be set up in several forms. Diagram presented below illustrates only one of them.

- **Multiple PPAs for a single clean energy project:** Each customer has a separate direct off-site PPA with the generator. This structure can only be used in deregulated markets where direct retail sales between generator and consumer is allowed unless a virtual approach is taken through a Synthetic (Virtual) PPA.
- **Development of a customer group into a single PPA:** A single PPA can be established between the generator and the customer group. The PPA can be set up directly between parties e.g. Synthetic PPA or through an intermediated deal with a retailer who enters into a single PPA with the generator on behalf of the customer group. (See the diagram below.) In some cases, this becomes a tri-partite deal where the generator, the retailer and customers are all counterparties.[8]

A city can initiate and get involved in the formation of a consortium of buyers who will have a large aggregated energy demand which can help financing of a large clean energy project.

The City of Boston, along with a consortium of 20 cities is currently exploring options for joint virtual contracts with large-scale renewable energy projects. Consortium issued a Request for Information to obtain feedback from renewable energy project developers to inform a future joint purchase of RECs as part of a virtual PPA with a CfD or similar structure. [30]



Advantages	Disadvantages
Cost-effective model as multiple customers share the cost (consultants, legal and market agent costs, etc.)	Long and complicated process especially if parties do not have previous experience with PPAs
Multiple buyers with aggregated demand can increase their bargaining position and enable better economics from scale [8]	Time and resource-intensive process due to the complexity of multiple stakeholders' management and demands [9]
Enables customers to access the benefits of the PPA while sharing the risks	Significant transaction costs due to legal, consultant and procurement costs
Enables sharing of the work and expertise between members of the group	Stakeholders need to have similar load profiles and drivers such as risk mitigation, price stability, environmental goals for an efficient project development process
Helps financing of large clean energy projects through aggregation of demands of multiple customers	Mismatch between participants' existing energy contract expiry dates is a challenge

MELBOURNE RENEWABLE ENERGY PROJECT

The City of Melbourne has a longstanding commitment to creating a carbon neutral municipality. This commitment includes a target of sourcing 25% of the municipality's electricity from renewable sources by 2018.

As part of this strategy, the City of Melbourne has initiated the Melbourne Renewable Energy Project (MREP) which includes the formation of a city-led group of local governments, cultural institutions, universities and corporations to stimulate demand for renewable energy. The group's aggregated demand will enable financing and construction of a new 80 MW wind farm at an offsite location. It will be owned and operated by Melbourne-based clean energy company Pacific Hydro, and the power will be supplied by its retail arm, Tango Energy.

The MREP deal is underpinned by an agreement for each customer to purchase large scale Generation Certificates (certificates created by renewable energy generators) from Pacific Hydro, alongside retail electricity from Tango. This arrangement allows customers to purchase "green" electricity at a lower cost whilst directly supporting a new renewable energy project. The contract term is for 10 years. The pricing structure includes a fixed price for LGCs, a fixed price for a proportion of energy, and a variable price reset every 2 years for remaining portion. [10]

2.2.8 Mini-utility PPA

In this business model, the customer contracts directly with the generator (without the intermediary supplier), who does not provide balancing or sleeving services. Therefore, the customer is responsible for balancing, transmission and associated risks. To achieve this, the customer establishes an entity with energy trading function: a trading Special Purpose Vehicle (SPV) (See the box below for more details on SPV). The generator sells the power to the SPV and the SPV then contracts to sell the power on to the customer.

An example would be a city to set up its own utility to buy power from a clean energy generator directly for its facilities. This model could be extended to provide power to private households and business i.e. premises and facilities that are not city-owned.

Checklist

- Large projects and large consumers with high demand
- Facilitated process for getting a supply license for delivering power to single customer entity
- City permitted to buy and sell power

Advantages	Disadvantages
Removes the need for a third-party for supplier/balancing function and reduces the overall costs	High up-front costs (often about EUR 1 million) of obtaining a supply license
Allows the SPV to pass more value onto the generator and customer, as the SPV will have interests that are aligned with both interests	The high cost of maintaining an SPV due to the requirement for outsourced balancing and administrative services to meet its contractual obligations [15]
The municipal mini-utility model can incentivise local generation through better PPAs, achieve fairer tariffs, and re-localise the energy value to the local area [23]	The customer is responsible for managing the balancing, transmission and other risks of the physical power [31]
	Risk of the SPV going bankrupt if it misjudges its balancing strategy

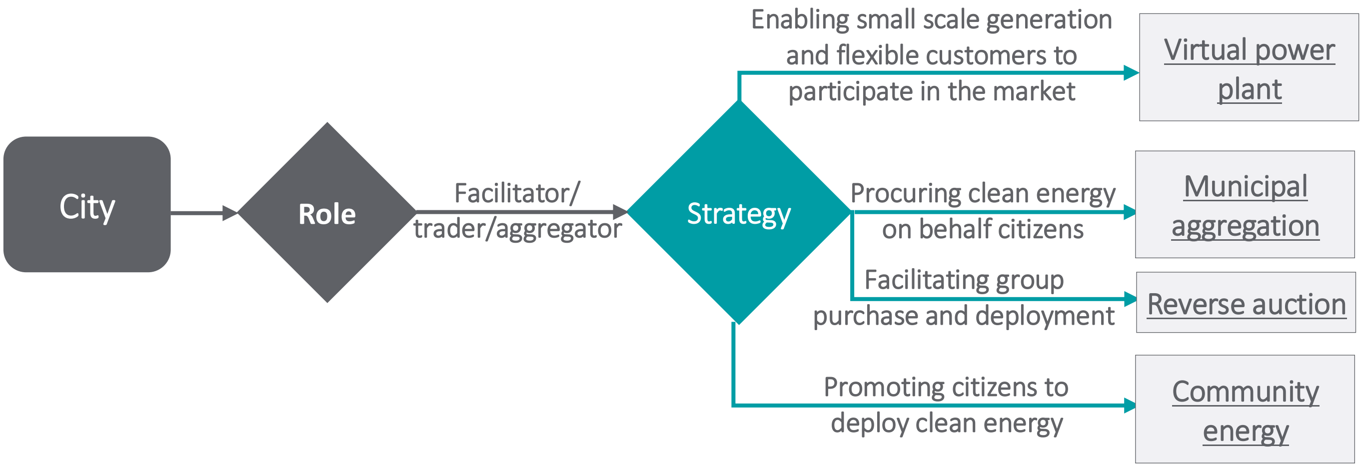
Special Purpose Vehicle (SPV)

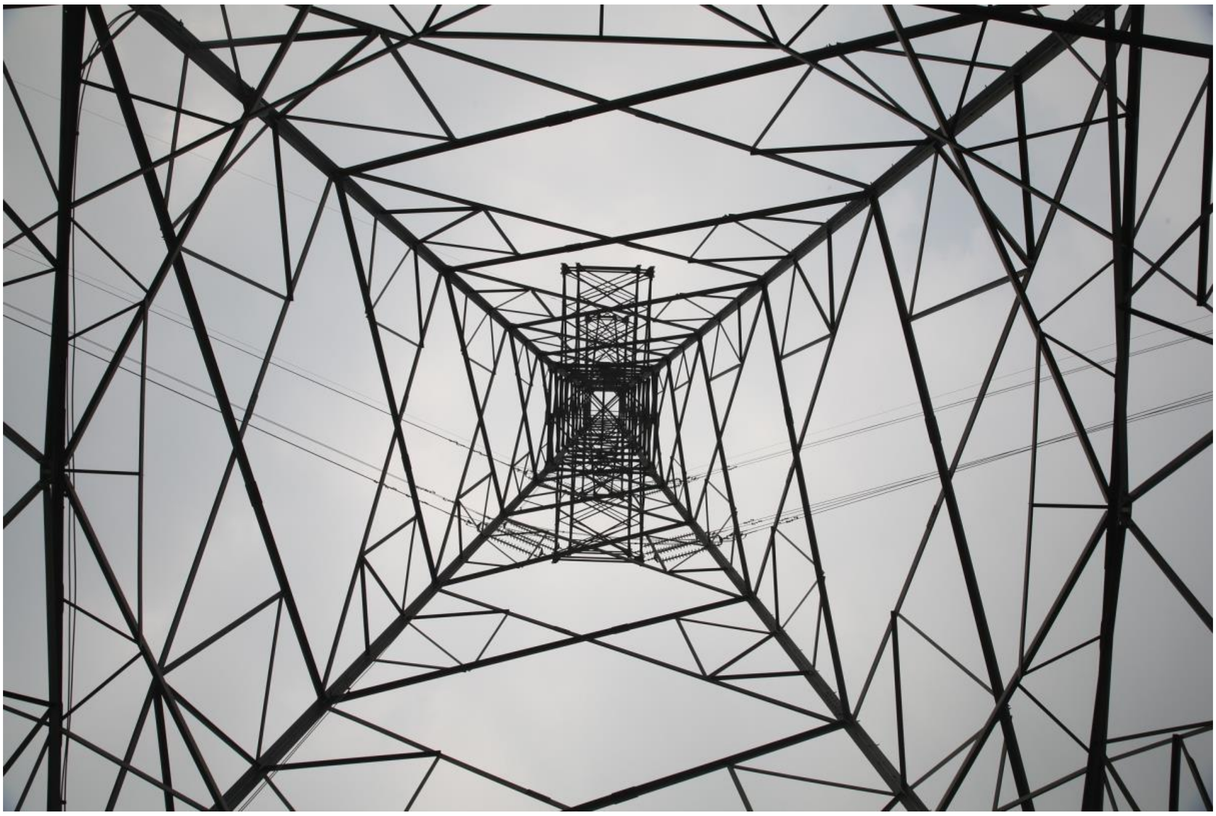
An SPV is usually a subsidiary company containing certain assets and liabilities, created for a specific objective and project. As the project's own legal entity, SPV is responsible for entering into PPA (if applicable) and for other financial responsibilities. It can be structured as a partnership between multiple companies or can be created as an arm's-length entity of the investor/owner of the clean energy project e.g. city. In addition to owning the assets and being responsible for financial liabilities, an SPV of a project is responsible for entering into an EPC for installation, and operational and maintenance services. The SPV can be a limited partnership, trust, corporation, limited liability corporation or other legal entity. [5]

An example of a limited partnership is SPARX Public-Private Green Energy Fund Investment Limited Partnership. This fund was created as a PPP with Tokyo Metropolitan Government (TMG) where TMG has provided 1.5 billion JPY to the fund. This fund has completed various clean energy projects with a total capacity of 1200 MW.

2.3 Facilitator/ trader/aggregator

Besides generating and procuring clean energy, a third set of business models strategically locates cities as bridging agents. This role can take three different forms, namely aggregating, trading and facilitating clean energy. This business model can provide a platform for cities to engage its residents and promote procurement of clean energy. Depending on the strategy the city takes, there are various business models that a city can choose. These are explained further in this section.





2.3.1 Community energy model

Community clean energy projects focus on community ownership, community leadership, and community benefits. A community energy business model is generally established through shared ownership or joint ventures, where benefits are shared by the community, crowd-funded projects and community ownership models such as co-operatives, social enterprises, community charities, development trusts and community interest companies. [6]

Community energy projects have several main features:

- Citizens and communities own, or participate in the production of clean energy, and/or
- Most of the community energy project's profit is given back to the community through revenue distribution or other benefits such as programmes targeting vulnerable and fuel-poor households, providing energy advice to community members, and/or
- The clean energy installation provides power to the community members.

Depending on the regulations and structure of the model there are several ways of financing a community energy project:

- Avoided electricity cost through self-consumption or PPA if the community energy project is located on-site
- PPA if the community energy project will be selling power to a third-party or utility
- (Virtual) net metering on participants' bills if regulations allow (See Financial instruments chapter for more details on net metering.)

There are several forms of community energy models:

Utility sponsored model: The utility owns or operates a project that is open to voluntary community participation. This model has the advantage of making use of the existing legal, financial and program management infrastructure of utilities.

City owned or sponsored model: This model involves ownership of the clean energy installation by a city. The power produced is sold to a third party (a utility) or consumed on-site to offset energy usage at public facilities such as schools, community buildings, etc. Its advantages are exemption from lease or property tax payments if located on a city-owned site, and access to low-cost financing with municipal bonds. [17] When the project generates sufficient additional revenue, there could be indirect benefits in the form of community-benefits such as programmes targeting vulnerable and fuel-poor households, providing energy advice to community members, etc.

Through the community energy model, a clean energy system can be installed on a city-owned facility. The city can create a community SPV and lease the site for the clean energy installation to the SPV and enter into a PPA with the SPV to purchase the generated energy. The revenues received from the project can benefit the community through various kinds of programmes, etc. The community SPV can also offer shares to the community members to invest in the project and the community members can receive return on their investments.

Cooperative: It is a community organisation owned and managed by its members. The cooperative is responsible for carrying out and overseeing all administrative and operational tasks such as the installation,

maintenance, and financial management, etc.[16] Cooperatives can be profit-driven companies but allow members to own shares in clean energy projects, share the profits of the projects through dividends and often get their electricity supply at a fair price from the community clean energy installation instead of a larger utility.

The city can help with and support the formation of a cooperative for a community clean energy project.

Advantages	Disadvantages
Enables community members that cannot or choose not to install a clean energy at their properties to access clean energy	The success of the model is highly dependent on regulation and support schemes, availability of financing and finance mechanisms, and local skills
Minimises adverse social and environmental impacts of the project	Challenging and time-consuming stakeholder coordination
Increases social acceptance through community involvement in the local clean energy policy	Reliant on volunteers and requires passionate local community members to develop a successful project
Increases local energy security as well as economic resilience and generation of local jobs	High risk as volunteer managers can lack commitment and appropriate management skills [16]

VIENNA: CITIZEN POWER PLANTS

Wien Energie, the energy company part of Wiener Stadtwerke owned by the City of Vienna, has been encouraging citizen participation in its efforts to expand the use of photovoltaics since 2012, and for wind energy since 2015. There are several models available for citizen participation:

Sale-and-lease-back model: Citizens can acquire a share in a power plant (e.g. photovoltaic panels) and become a co-owner. Wien Energie then leases this share or panel back from the citizens and citizens receive an annual payment in return for their investment.

Voucher model: Wien Energie equips partner buildings with photovoltaic plants. Customers of the partners can buy voucher packages to support the installation and, in return, citizens receive a percentage as remuneration and shopping vouchers every year for 25 years. At the end of the term, citizens are given back the rest of the purchase price.

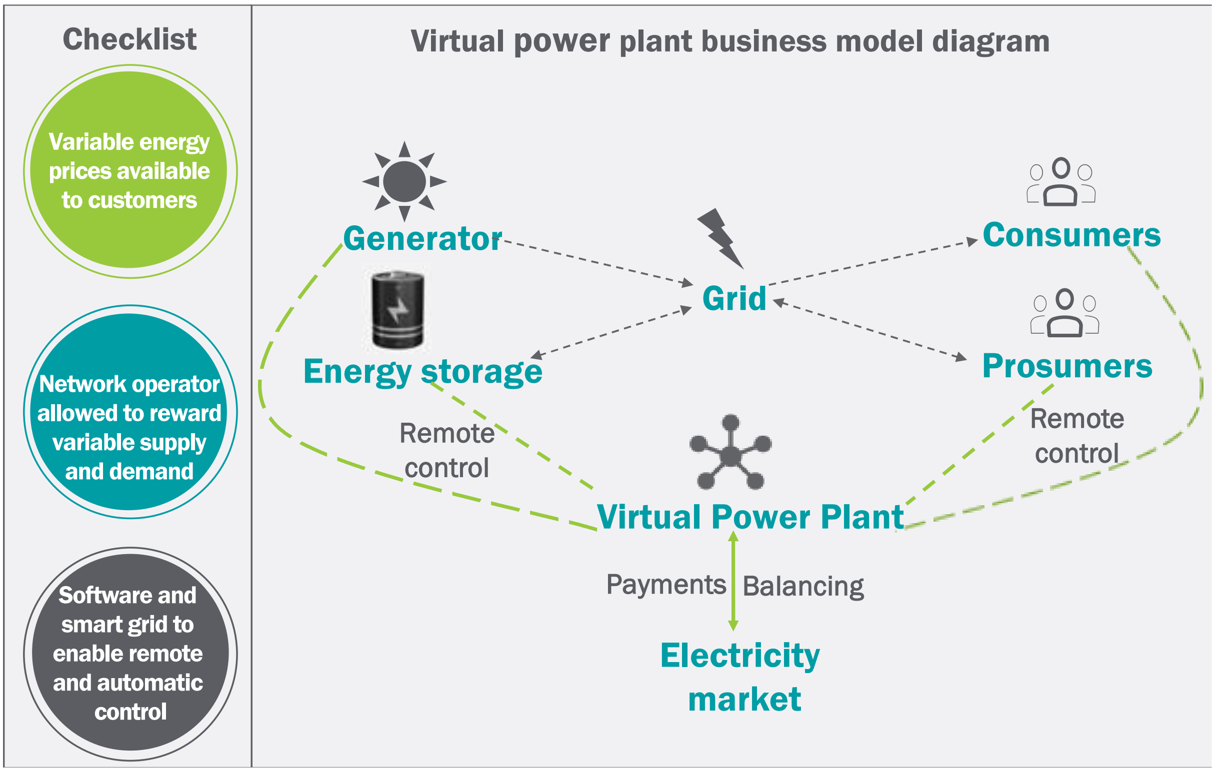
In all the models, the minimum duration of agreement is 5 years with an option to terminate the contract subject to a charge. And at the end of the contract term, the rest of the full amount invested is returned to citizens.[32]

2.3.2 Virtual power plant (VPP)

A virtual power plant (VPP) is a software platform that remotely controls a network of medium and small-scale generator units such as solar, micro combined heat and power plant (CHP), wind, biogas, small hydro, storage systems connected to flexible consumers that have the capacity to increase or decrease their demand.[5] All units are remotely controlled and dispatched through the VPP's central control room while remaining independent in their ownership and administration.

A city can apply this business model through getting involved in the creation and facilitation of a VPP. Individual households and businesses can become part of VPP as flexible consumers and provide smart response to VPP; and prosumers, decentralised energy generators, and storage systems can participate in VPP through providing variable power resource.

The objective is to smartly control generation and consumption of the connected units, trade the generated and consumed power in a profitable way and take advantage of high prices so that participating consumers pay lower energy bills through re-numeration and reduced electricity costs and participating generators make more profit through accessing higher prices. For example, during periods of peak load, VPP can discharge connected electric vehicles, batteries, and decrease the consumption of the flexible consumers in order to relieve the load on the grid and take advantage of high prices. Through controlling generation and consumption levels in VPP's network, VPP sells the electricity or ancillary services on the electricity and balancing markets, or the aggregated power is regionally dispatched to match supply and demand in the region.[33]



Advantages	Disadvantages
Enables a more flexible energy system and peak load shaving	High imbalance risk as it might be difficult to predict power demand [26]
Decreases additional investments required in the grid and production infrastructure	There is limited access to the aggregation market for small and domestic customers
Provides a source of revenue for those with flexible load or generation	Very dependent on the prices and declining prices can affect profitability [33]
Feed-in tariff or similar financial incentives are generally available for a limited period e.g. 20 years. Most technologies last for over 35 years. VPP can provide revenue during the remainder of equipment's lifetime [5]	Requires design of complex algorithms and software to generate the most value out of small changes in market price [5]
Supports technology uptake (e.g. batteries) [26]	Difficult to gain reasonable profits

YOKOHAMA: VIRTUAL POWER PLANT PROJECT

City of Yokohama, TEPCO Energy Partner, Inc. and Toshiba Corporation have partnered to create the Virtual Power Plant building Project. The project includes installing storage batteries in elementary and junior high schools that are designated local disaster shelters and running remote operation tests to control electricity usage at times of peak demand. Coordinating usage in ordinary times and acting as an emergency power source during emergencies will help to deal with peak electricity demand and increase resilience to disaster. TEPCO EP will use storage battery group control systems developed by Toshiba to adjust power supply (demand response) during normal hours, while City of Yokohama will use them to provide power in the event of a disaster or other emergency. This project will help with reducing use of old and inefficient thermal power plants currently used during peak loads through charging batteries during periods of low demand and supplying power during peaks using remote energy management systems. [34]

Blockchain technology

Blockchain is a distributed ledger or database technology that chronologically records and links secure decentralised transactions. Blockchain can reduce transactions costs through standardisation via smart contracts and the automatic execution of orders. This allows smaller lot sizes and bypassing intermediaries. This enables P2P models of power production and distribution where prosumers buy and sell energy directly with a high degree of autonomy. An example is UK's first ever P2P physical trade of energy on the blockchain at a community housing estate in **Hackney, London** which has solar panels installed on the blocks of flats within the community. The platform is able to calculate the energy demand profile of homes, determine the solar energy supply in each storage battery and in turn allocate green power to participating 40 flats based on their needs.[35]

Blockchain can also be used for VPPs. VPPs aggregate distributed generation and prosumers and can optimise power flows. A central actor could deploy blockchain that automatically integrates local information and optimises local grids which are then aggregated to provide stable power capacity at low cost. Blockchain can also make the organisation and management of VPPs more efficient.[36]

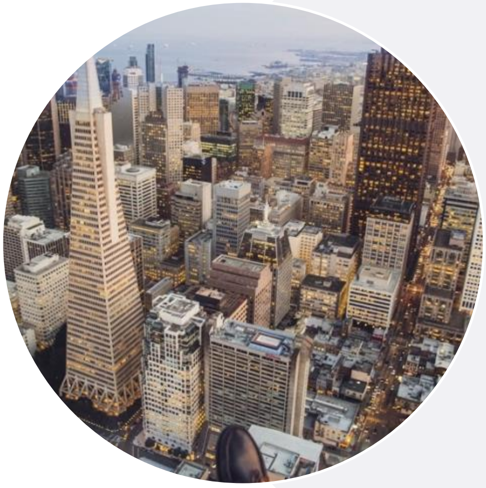
2.3.3 Municipal aggregation

In this model, a municipality, city or a group of municipalities can form an entity to procure electricity in bulk to meet the aggregated energy demand of interested residents and businesses. Typically, certain classes of electricity customers in the community are automatically enrolled to the scheme, but they can opt out. By aggregating energy demand, cities can negotiate competitive rates with suppliers and developers. Most of the electricity can be sourced through long term PPAs with independent clean energy generators. The local private utility is generally not involved in the energy production, but it is still responsible for transmission and distribution of the power, as well as for billing, collections and other customer services. [37]

A city with a municipal utility can use this business model. Through aggregating the energy demand of the residents and local businesses, the city can procure clean energy directly from generators and at more competitive rates to enable their residents to access clean energy and meet city-wide clean energy targets.

Advantages	Disadvantages
The city is not responsible for operation and maintenance of the clean energy projects	Renewable energy may be sourced from older clean energy projects, so this model might not have a direct effect on the creation of new clean energy projects
Enables cities to choose the source of their electricity and achieve higher renewable energy shares citywide	There may be fees involved when residents want to opt out or exit the scheme,
Lower prices for residents and businesses due to group buying, thus increases the demand for clean energy citywide	High complexity for the city due to handling of multiple contracts with different generators
Large environmental impact at the community level	Possible significant start-up costs
Facilitates the community engagement as the model provides a simple process to the residents for buying renewable energy through their city's utility	Possible resistance from incumbent electricity supplier [38]

Checklist



SAN FRANCISCO: CLEANPOWERSF

The City of San Francisco has the goal to meet 100% of city's electricity demand from renewable energy sources.

As part of this goal, the City launched San Francisco's Community Choice Aggregation program, CleanPowerSF, in May 2016. It is a program permitted by law in several states that allows cities and counties like San Francisco to buy electricity on behalf of their residents and businesses. Through aggregating the demand, CleanPowerSF aims to create demand and source cleaner energy as well as support local economy. While San Francisco is responsible for owning and purchasing energy to meet demand in CleanPowerSF programme, their investor-owned utility partner, PG&E, continues to deliver the power, maintain the network, respond to outages and provide billing services. Residents and businesses are automatically enrolled to the programme, but there is the option to opt-out.

There are two tariffs in CleanPowerSF that enrolled customers can select from: Green and SuperGreen. Green tariff provides at least 40% renewable energy from sources in California and SuperGreen provides 100% renewable energy from sources in California with a small premium over Green tariff rates.[39]

2.3.4 Reverse auction

In a reverse auction, the roles of seller and buyer are reversed where sellers bid in the auction in contrast to usual auctions.

The reverse auction model can be used for purchasing clean energy equipment as well as purchasing power produced from a clean energy system. The two cases are explained below:

- **Reverse auction for purchasing power from a clean energy project:** In this model, the city calls for tenders for clean energy projects with specified technology types and capacity as part of an auction process. Project developers who participate in the auction submit a bid with a price per unit of electricity. The city evaluates projects according to price amongst other criteria. The possibility to include additional evaluation criteria is one of the advantages of this model, as these criteria could include the share in local manufacturing, community engagement, local economic development benefits, etc. After the evaluation of the projects based on the lowest price or other evaluation criteria, a PPA is signed with the preferred bidder. The PPA provides the selected renewable generator(s) with a fixed price for a specified period and a guaranteed purchase for all generation, which can be used as a basis for financing the project.[40]

The reverse auction model is suitable for deregulated markets and can also be used in regulated markets as the type of PPA can be selected depending on the regulations. In regulated markets, the selected PPA can be in the form of a contract for difference which is a form of synthetic PPA model.

An example would be a city releasing a request for proposal for an off-site clean energy power purchase agreement containing a long-term commitment to purchase clean energy from the large-scale clean energy plant who is the preferred bidder of the auction. (See Canberra Renewable energy reverse auctions case study in Synthetic PPA section.)

- **Reverse auction for purchasing clean energy equipment:** In this model, the city requests to buy a clean energy product and many sellers bid to provide that product. The bidder that can provide the clean energy product at the lowest price wins the auction. The city generally engages with an external company who sets up a platform where customers e.g. residents and businesses that are enrolled in the scheme are connected with the winning installer(s) and get quotes for installations. If the quote is accepted by the customer, the customer contracts the installer directly for the installation. An example of this is **Solar Together London** group buying scheme. As the city is generally only involved in setting up and managing the scheme and is not involved in power purchase or ownership of the installation, this model can be applied in all type of energy markets.

A city can use this business model to select solar PV installer(s) who will provide solar PV installation to residents at competitive rates. This can help accelerate the solar PV uptake by households and businesses in cities.

Checklist

Standardized product and of known quality

Multiple sellers of the same product

A range of prices the product can be produced and sold at [38]

PORTLAND: SOLARIZE

The City of Portland's Climate Action Plan establishes a goal to reduce carbon emissions 40 percent by 2030 and 80 percent by 2050. More recently, Portland City Council established a goal to be 100 percent renewable in all sectors of the economy by 2050.

The first Solarize campaign started as a community-led movement to help Portlanders overcome the financial and logistical barriers to installing solar power at their properties. Solarize Portland helped residents make an informed purchase and negotiated volume discounts on the price of installing rooftop solar energy systems. Solarize began in one Southeast Portland neighbourhood and quickly spread to other parts of the city with support from the City of Portland, U.S. Department of Energy, Solar Oregon and Energy Trust of Oregon. These organizations provided seed funding, technical assistance in contractor selection, programme design, project management and coordination, financial incentives, outreach support and educational materials. Three years of Solarize Portland campaigns resulted in over 600 solar installations and 1.7 MW of additional solar PV capacity at resident's properties in Portland. Solarize has been replicated over 170 times in 18 different U.S. states and abroad.[41]

	Advantages	Disadvantages
Reverse auction for purchasing equipment	Helps overcoming complexities for the customer in relation to purchasing clean energy equipment	Not suitable for customers who cannot afford the capital cost and/or does not have the available space or sufficient renewable energy resource
	Motivates customers to act quicker and accelerate the clean energy deployment as the price offer is generally time-limited	High demand and enrolment from participants may lead to long contractor response time if the contractor is not prepared for the volume of applicants
	Price bargaining due to the collective pool of customers	If the uptake is low, this might decrease confidence in the clean energy technology and cause reputational risk for the city
	Reduced installation costs through bulk buying	Installer quality is essential for the success of the model
Reverse auction for purchasing power	Creates demand for new large-scale clean energy projects	Not suitable for situations where reasonable competition cannot be expected
	Helps cities achieve their renewable energy goals cost-effectively through competitive bidding	Complex and competitive models can prevent non-expert participation in the auction and might put larger and experienced companies in a powerful position. This can act as a barrier to new entrants, smaller developers and community projects [23]
	Flexibility in design brings the possibility of achieving various economic, environmental and community-related benefits	Risk of underbidding as the developers might bid too low to win and not be able to realise the project, this would create a risk for the city who is the buyer [40]
	Ability to control clean energy capacity installed. It is also useful for budget control issues, especially if a ceiling price is used [40]	Irregular auctions may lead to discontinuous clean energy deployment, which may prevent investment in local manufacturing facilities and the development of a robust supply chain, thus create a barrier to city's future projects

3 FINANCIAL INSTRUMENTS

Financial instruments are used to finance clean energy projects in both the private and public sector. They are very important because the cost of a clean energy investment primarily comprises the upfront cost, one of the most important barriers to clean energy deployment. In addition to overcoming this, financial instruments can help circumvent other obstacles such as lack of long-term or project financing from the private sector or underdeveloped financial markets where it is difficult to obtain financing at reasonable costs. Therefore, publicly funded financial instruments should target the elimination of barriers or risks that are hindering private investment as well as to deliver the greatest amount of private funding using the smallest amount of public funds.[42] Therefore, it is important to select the correct type and level of financial instrument in order to tackle these barriers effectively.

The common financing mechanisms that have been used widely in various sectors are:

Self-funding: This is the one of the simplest financing mechanisms, where the system owner, usually also the power consumer, uses their own cash to pay for the installation outright. This financing mechanism is heavily dependent on support schemes and also available to only investors who have large amounts of cash readily available. [5]

Debt: Debt financing is where the owner/investor borrows part of the money needed to pay for the clean energy installation. Debt financing comes in several forms: loan, senior debt, subordinated debt (mezzanine finance).

Equity: In equity financing, the investor has a share which gives the investor the ownership of some or all of the assets and earnings of the project but only after all other debt obligations are met.

In this chapter, we have explained several innovative financial instruments that cities can use to accelerate clean energy deployment:

- Crowdfunding
- Feed-in scheme
- Renewable energy certificates (RECs)
- Net metering
- On-tax bill financing
- On-energy bill financing
- Tax incentives
- Investment grants
- Green bond
- Pay as you go (PAYG)

The table below represents how much control or influence a city can exert on each of these financial instruments. These may differ for each city depending on the regulatory context and powers of the city.

Crowd funding	Feed-in scheme	RECs	Net metering	On-tax bill financing	On-energy bill financing	Tax incentives	Investment grants	Green bond	PAYG
High	Medium	Low	Low	Medium	Medium	Medium	High	High	High

3.1 Crowdfunding

Crowdfunding is a financing instrument that allows many investors or community members to each put in small amounts of money in order to raise funds for a clean energy project. Crowdfunding is often combined with loans or equity financing mechanisms.

A city can have a role in bringing together the community and clean energy project developers, while promoting crowdfunding as a tool to finance these projects jointly.

Crowdfunding platforms provide financing in the form of loans, equity or grants. In equity crowdfunding, the investors become co-owners or shareholders of the clean energy project. This brings many smaller private and non-professional investors together where the crowdfunding platform acts as an intermediary for them. Cooperatives can be formed through equity crowdfunding, where the investors jointly own and run the project and share out the proceeds of the project.

The other type of crowdfunding is peer-to-peer lending which is a form of debt crowdfunding, often done via online platforms. [5] The crowdfunding platform enables investors and individuals to invest in clean energy projects directly.

Some examples of platforms and projects are **Abundance, The Solar Schools Project in the UK, Mosaic**, etc.

Advantages	Disadvantages
Increases involvement in and acceptance of clean energy projects of the local community	The success of financing is dependent on the community's support and involvement
Eliminates barrier to entry through allowing investors to invest small amounts	The platform might have high financial transaction fees
Crowdfunding platforms might have different due diligence processes compared to banks. It can thus provide finance to a broader range of projects such as innovative and small-scale projects which might struggle to get other forms of financing	As the investment is not secured, crowdfunding includes higher risk and therefore it is more expensive than traditional loan or equity funding

3.2 Feed-in schemes

A feed-in scheme is a financing instrument where the clean energy generator receives a direct payment per unit of energy produced i.e. feed-in tariff.

The scheme can also offer feed-in premiums which are added on top of the wholesale market price that the generator sells their production at. Caps and floors can be also introduced to prevent excessive profits or limit risks for generators for cases where the electricity market price is too high or too low.

Feed-in schemes guarantee a predictable and long-term revenue stream, which can serve as a stable financing basis for a business model.[4] Level of feed-in schemes generally vary depending on the size of the installation, technology and fuel used and the payment is generally based on production or export levels.

A city can introduce feed-in tariffs to incentivise its residents and businesses to generate clean energy on their buildings and promote clean energy deployment at the private sector. The city can also use the feed-in scheme to purchase the energy generated from an individual's or business' clean energy systems to help the city reach its clean energy goals.

An example is **Value of Solar** rate provided by Austin Energy to its customers for their on-site solar energy production in Austin.

Advantages	Disadvantages
Assures the generator of a stable and predictable and long-term source of income from a reliable counterpart (government or network operator) which can significantly increase the bankability, reduce the financial risk of the project and facilitates clean energy deployment	Dependent on cost estimates so under-estimation might cause the tariff levels being insufficient to make a successful business case. Overestimation may result in unusually high profits for investors which may decrease the cost-effectiveness of the scheme and hinder the continuation of the scheme
Transparent and relatively simple	Administrative costs may be significant
Because of the ability to differentiate, cities can use feed-in tariffs to support specific technologies or markets with the aim of technology learning or market creation	The uptake of available feed-in schemes may be hindered by the fact that individual property owners may favour shorter payback times than what feed-in schemes provide (typically 8-20 years) [4]
Flexibility in designing the tariffs to meet the demands of different technologies and actors	It may require significant use of public funds or put an increased burden on the energy consumers [4]

3.3 Renewable energy certificate (REC)

Renewable energy obligation or quota system is a scheme that is introduced generally at a national level requiring producers to generate a specified proportion of energy from renewable sources, suppliers to supply a given proportion from renewable sources, or consumers to consume a given proportion from renewable sources.

These requirements are fulfilled through certificates e.g. renewable energy certificates (RECs). Each certificate represents the certified generation of one unit of renewable energy (typically one megawatt-hour). REC represents a quantification of the non-energy attributes of power generated using renewable resources, unbundled from the value of the electricity. REC can be used for both regulatory compliance purposes and voluntary consumption. Certificates provide a tool for trading and meeting renewable energy or quota obligations among suppliers and/or generators, and for voluntary clean energy purchases. Though the sale of RECs, additional cash flow and funding for the installation of new clean energy projects can be achieved.[17] RECs can facilitate cities to claim clean energy purchases and achieve their city-wide clean energy targets. Bundled purchases of renewable energy with the associated RECs enable cities to claim towards GHG emission reduction as well as decarbonise their energy supply targets.

Advantages	Disadvantages
Enables the marketing of locally-produced renewable energy nationally	Uncertainty in revenues caused by volatile REC prices
Enables consumers who are not able to purchase clean energy from their utility to access clean energy markets [17]	The regulations may not allow unbundling of RECs from electricity sales or may restrict customer ownership of RECs
Promotes investment in local renewable energy projects as investors seek to capture two streams of revenue: e.g. power sales and the sale of RECs	A small generator may be unable to own or sell RECs due to factors such as regulations, unclear REC ownership conditions, marketing challenges and high transaction costs for selling small volumes of RECs [17]
Bundled renewable energy and RECs purchases can enable development of new clean energy generation	Policy implementation can be costly depending on the design of verification and trading approaches [4]
Compatible with electricity procurement practices and PPAs [40]	The effectiveness of RECs is highly dependent on the subnational and national binding targets and effective compliance and enforcement mechanisms
No project-level risks involved	Unbundled and cheap RECs may lead to decrease in support for local projects

3.4 Net metering

Net metering can be used under a self-consumption business model. **Through net metering, prosumers can net off the generation from their consumption over a large timeframe. Therefore, the generation and consumption does not have to take place simultaneously or in matching amounts. This mechanism allows the prosumer to net off the generation from their meter even though they are not consuming power when it is being generated.** As the power is netted of from the meter, this excess energy is valued at retail price as the consumer does not have to pay for their consumption for the netted amount. This allows the prosumer to achieve higher benefits from their investment compared to just exporting the excess power to the grid with an export tariff rate which is generally lower than retail price e.g. wholesale price. This second approach is called **net-billing**. With net billing, the consumers can reduce their energy bills through receiving credits for the monetary value of exported energy.

There are several variations of net metering such as **aggregate net metering** and **virtual net metering**. These variations can be used with other different business models such as PPA, community energy, etc. They allow a customer to receive bill credits for some or all of the generation from an off-site clean energy project. Virtual net metering allows clean energy generator to have many consumers of energy, and similarly consumers may have many generators to choose from.[43] Aggregate net metering enables cities to net off the energy produced on an off-site clean energy project from the meters of their multiple sites such as city-owned buildings. These net metering variations can also be used for the local residents to receive net metering credits from a shared community energy project.

Advantages	Disadvantages
Provides compensation for excess electricity which improves the business case for the project	Ineffective for addressing the high-up front capital cost barrier
Virtual net metering eliminates the off-taker risk as in the event of a customer default, the system owner can sign a contract with a new customer in the electricity service territory	Unsuitable for promoting optimal design of the clean energy system as the load matching and optimal sizing is not important due to being able to net off the consumption any time
Virtual net metering increases site selection flexibility and allows for larger and more centralised clean energy projects	Creates a system cost recovery risk and imbalance between retail tariff and value of electricity
Through aggregated net metering, the financial and technical barriers to entry for community energy projects can be eliminated. Also, it enables reduced costs via economies of scale [43]	Places a pressure on the grids that are inflexible and centralised [5]
	Requires regulatory and legislation changes

3.5 On-tax bill financing

On-tax bill financing is a mechanism used by local governments to provide low-interest loans for homeowners to invest in clean energy, which they gradually pay back through slightly higher property taxes. An example of this model is the property-assessed clean energy (**PACE**) financing model used in the United States. There are many PACE programmes such as **City of Dallas PACE**. (For further information and examples, visit http://pacenation.us/)

As the loan is secured by the property itself as opposed to the owner, repayment obligation can be transferred to the new property owner. This financing instrument come at a reduced rate, as local governments can obtain debt at a lower cost than individuals can. [37] The on-tax bill financing programmes are generally financed through municipal green bonds.

Advantages	Disadvantages
Overcomes the barrier of high-up front costs and improves access to capital	Challenging for the city due to the requirement for a change in the legislation to establish the scheme
Helpful to overcome the barrier for homeowners who want to sell their house if the loan can be transferred together with the property to the new homeowner	Re-selling of the properties might be an issue when mortgage lenders are involved as taxes are senior loans and they need to be paid before mortgage payments [43]
Energy savings will exceed property tax payments which will improve the financial situation of homeowners, provided the clean energy technologies and energy efficiency measures are properly designed and implemented	If clean energy technologies and energy efficiency measures are not designed or implemented properly and achieved energy savings are less than the additional property tax payments, this might negatively affect the financial situation of the homeowner
Little direct costs to the government for financing such measures as the government does not need to use its own funds	Requires cities to have the right expertise to establish and run an on-tax bill financing scheme
Removes the split incentive issue if the tenant who benefits from the upgrades pays the property tax or the increase in property tax can be passed on from the landlord to the tenant through higher rent payments	Setting up and administering the scheme might be too expensive for small municipalities [4] – to overcome this problem, on-tax bill financing programme can be run by private programme administrators

3.6 On-energy bill financing

This financing mechanism is suitable for individual households or businesses who would like to install clean energy technology at their building or site. **The goal of on-energy bill financing is to eliminate the upfront cost of the clean energy installation to the customer by financing it with an addition to their regular energy bill.** The loan payments are made over a long period and with a low interest rate. The repayment obligation typically remains with the property and not the homeowner or company. Therefore, any new owner needs to agree taking over the repayment obligation if they want to take possession of the property.

Cities can use various ways to facilitate on-bill financing programs through:

- mandating or strongly incentivizing utilities,
- clarifying legal issues around liabilities created through on-bill financing programmes,
- partnering with utilities in providing access to capital for the programme,
- combining the programme with subsidies to enable the installation of a wider range of clean energy technologies and energy efficiency measures. [4]

An example of this mechanism is **Clean Energy Works Portland**.

Advantages	Disadvantages
Overcomes the barrier of high-up front costs	High initial capital to fund the revolving loan
Attractive to rented households, as the repayment of the loan is linked to the energy meter and stays with the property	Utilities are generally unwilling to enter into lending business as it is outside their traditional competencies
Net energy cost savings achieved for the building owner if structured properly	Difficult and costly to implement changes to the billing system
Utilities can partner with financial institutions that lend money to private individuals and small businesses to bring in their expertise in evaluating and managing customer credit. This may make on-bill financing more attractive to utilities	High complexity as it requires the coordination of multiple stakeholders e.g. participating financial institutions, government and utility
Removes the investment barrier as the occupant can move without any difficulty and transfer the loan to the next occupant	Possibility of termination of energy service to the customer as a result of non-payment [43]
Transparent and simple – it is easy for the customers to see potential cost savings by comparing current and previous bills [4]	Requires approval of the regulator for the new tariff structure [4]

3.7 Tax incentives

Tax incentives and benefits are one of the common instruments used by governments to promote the introduction of new clean energy technology. They can be applied to a wide variety of taxes but are usually maintained for a period until the market for the energy product is deemed to be established.

Instead of tax incentives for clean energy, energy taxes on fossil fuels can also be implemented. Similar taxes include emission-related taxes, such as on CO_2 emissions. An example to this is **British Columbia's carbon tax**. These taxes are meant to correct a market failure through incorporating the external costs of fossil energy sources in the heat and electricity sectors. Such taxes make it easier for clean energy to compete in the marketplace.

Tax incentives can also take the form of a tax credit which reduces the recipient's tax obligations. Thus, an investment tax credit allows investments in clean energy to be fully or partially deducted from tax obligations or income.

Another common form of tax incentive is to subsidise the cost of clean energy technology by reducing the associated sales tax or import duty for equipment purchase.[17]

Advantages	Disadvantages
Brings considerable value to investors that have large tax liabilities	Local authorities might not be able to enjoy the benefits of the tax-deductibility if they are not paying taxes
Effective for supporting the introduction of a new clean energy technology	Needs to be time-limited as it might cause loss of tax-revenue or if the tax incentive is set too high[17]
Less time consuming with a lower administrative burden although they may bring complexity to the process of financing a transaction as in the case of investment and production tax credits in the US. However, they are used in almost all projects showing that the benefits outweigh the costs	Uncertain impact on government's revenue, as it is difficult to know how many developers will be applying for tax incentives

3.8 Investment grants

The investment grants/rebates are generally in the form of cash and used to encourage deployment of clean energy technologies and eliminate the investment cost barrier through reducing the upfront cost to the customer. They are used by states, municipalities, cities, utilities, and other non-governmental organisations to encourage the use of certain renewable energy technologies. Rebates and grants are generally available for a limited time and/or from a limited budget.[43] While grants may require the city to evaluate each proposed project/installation, rebate programmes generally have a set of eligibility requirements, and all eligible projects qualify for the rebate. Therefore, rebate programmes can be easier to administer than grant programmes.

Advantages	Disadvantages
No interference with short-term market signals as they are not based on generator's actual production level	Setting the level of grant/rebate is crucial, as an overly generous payment can lead to overinvestment and too small incentive may not attract sufficient investment
Direct and easily implemented financing incentive	No return on capital that could be used as funding for further projects [42]
Lowers the effective price of the installation and makes the supported technology more competitive[3]	Not effective for motivating efficient system design and component selection e.g. high-efficiency panels/turbines. This risk can be mitigated by including minimum performance requirements
No need for ongoing administration	May require significant funds and lead to relatively high cost to taxpayers

SAN FRANCISCO: GOSOLARSF

GoSolarSF incentive is a form of investment grant and the programme aims to encourage solar PV installations at residential and commercial properties through offering one-time incentive payments. The incentive is available to all San Francisco residents that are enrolled in or signed up for CleanPowerSF or customers of Hetch Hetchy Power (A water system owned and operated by San Francisco Public Utilities Commission). There are also additional incentives targeted to residents in low income neighbourhoods and low-income households for whom the funding may cover up to 100% of the cost of the solar PV installation. In addition to households, incentive payments are also available for businesses and residents in multi-unit buildings using virtual net metering. There are also supplemental incentives for contracting with a local installer.[44]

3.9 Green bond

Green bonds are similar to regular bonds, except for the fact that their proceeds are used to finance exclusively green projects which are tracked to ensure green compliance. As many cities have limited access to capital markets[37], green bonds can help municipal governments to raise funds to invest in clean energy projects. Like other type of bonds, investors – buyers of green bonds – receive a financial return on their investments.

Advantages	Disadvantages
Useful to aggregate and diversify risks, as projects can be pooled across a range of technologies and geographical locations	Inappropriate for small companies as bonds need to be of sufficient size to be cost effective, and investors generally have minimum size requirements and issuers require expertise and capability to enter the green bond market
Raising debt via a green bond may be cheaper than other financing mechanisms	Investors may be unwilling to pay the premium for a green bond
The potential to bring new investors to the financing pool	Insufficient level of assurance, certification and impact reporting may damage the credibility of green bonds [45]

MEXICO CITY: GREEN BOND

Mexico City has issued the first municipal green bond in Latin America in December 2016 to raise funds towards its projects for its Climate action programme such as mobility, energy efficiency projects, water infrastructure and management projects.

The green bond issued by the city was worth MXN 1bn and it was oversubscribed at 2.5 times. Some of the advantages were the City's solid finances and AAA international credit rating, coordination between different local agencies, and close coordination with Mexican Stock Exchange through the Ministry of Finance, HSBC and the certifier Sustainalytics. [46]

JOHANNESBURG: GREEN BOND

The City of Johannesburg has issued the first municipal Green Bond in South Africa in June 2014 to raise funds towards implementation of its climate change mitigation strategy including projects such as biogas to energy, solar water-heating and dual fuel and biogas buses projects.

The green bond issued by the city was worth USD 140 million and it was oversubscribed by 150%. The city's sound financial situation and investment-grade credit rating helped to attract investors and receive a positive response.[47]

3.10 Pay as you go (PAYG)

In pay-as-you-go (PAYG) financing mechanism the clean energy equipment or system supplier removes the up-front capital barrier through providing the clean energy system to the customer for an initial small (or no fee) and the customer pays to use the energy through a top up system. This system generally requires a mobile phone. Customers can buy pre-paid top-up cards from their local distributor or through their mobile phone and use SMS communications to remotely unlock the clean energy system for a specific period. Depending on the conditions of the agreement, the ownership of the system is transferred to the customer and the system is unlocked indefinitely after certain amount of payments. There is no loan requirement however if the customer stops buying top ups and using the system, the system may be eventually removed and redeployed by the provider.[48]

Advantages	Disadvantages
Helps rural electrification in off-grid areas	High technology and product risk
Enables the low-income households to access clean energy systems and removes the high up-front cost barrier	Requires a financially viable and large customer base
Flexible model as it can accommodate different levels of payments and usage level preferred by consumers	The system supplier must provide a significant portion of the finance and requires a substantial equity and working capital

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