Business models for generation, aggregation, storage, and distribution

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1. Introduction

This document assesses business models for the electricity, heating, cooling and fuel sectors in the context of the Kera district. City planning must prepare for the needs of future generations and proactively seek new forms of engaging stakeholders. However, the traditional methods of learning by doing, and trial and error are insufficient, as we need to rapidly step up the decarbonisation of our communities. City planning impacts municipal energy infrastructure and related emissions for decades to come, enabling some alternatives, while possibly leading to lock-in towards potentially unfavourable technologies. Municipalities must prepare for the changes ahead and produce an enabling environment for different stakeholders to participate in the decision-making and transformation towards low-carbon communities, while encouraging these new stakeholders to provide new business models, aiming towards a more sustainable urban environment, to the public and private sector.

Historically, the power sector has been dominated by vertically integrated companies, often state controlled utilities, with explicit or de facto sovereignty over power generation and distribution. Sometimes power utilities could even deliver energy services like lighting and indoor temperature control in the customers premises. The consumer had very little choice regarding their preferred supplier, selecting primary energy source or controlling energy expenses. New innovations in distributed renewable energy generation have increased the options available to consumers, opening the door to prosumer models and 'active consumers'. These new innovations both compete and co-operate with the traditional energy supply system in creating solutions that are both cost-effective and sustainable. This development will continue as the adoption of new technologies accelerates, and the municipalities need to work towards finding solutions that maximize carbon-neutrality while meeting the need to respond to the individualistic needs of citizens and local companies.

To facilitate value-adding specialisation in generation, distribution, grid stability and demand side management, a transparent, reliable, and equitable framework is required to provide an enabling environment for stakeholder participation. The difference between electricity and most other commodities lies in the instantaneous nature of electrical energy: it must be consumed at precisely the same time as it is produced. The power system does not store any energy without added storage capabilities. Generator fuels, rotational inertia in generators, hydropower reservoirs and batteries embedded in the systems allow for time-shift between supply and demand.

The Nordic model for power markets, Nord Pool, is based on the Norwegian mechanism of using hydropower reservoir water levels to establish a spot price for electricity. When reservoir water levels were high, power was cheap and vice versa. The modern Nord Pool day ahead market requires producers and consumers to submit bids, specifying the price at which they are willing to buy or sell electricity. The basic unit is megawatt hours in one hour intervals. Nord Pool then calculates the spot price and trade volume so that demand and supply meet each hour, and generation units are dispatched in so-called merit order. If the optimal trading volume requires more cross-border power transmission capacity than is technically available, prices are regionally adjusted. [1]

While Nord Pool ensures that demand and supply meet every hour, national transmission system operators (TSO) must ensure that supply and demand meet every second. Traditionally this was achieved with reserve generation units, such as gas power plants.

However, it is cheaper to pay consumers to adjust their consumption than to build expensive reserve power plants, so reserve markets have been established to find out which customers are willing to adjust their consumption at the cheapest rate. [2] Thus, the aggregator businesses were born to provide means for small-scale actors to join the reserve markets, and virtual power plants (VPP's) were implemented in Finland to facilitate reserve market participation for actors such as the Finnish national railway company VR Group [3] and Lidl [4].

Within the rest of this report, current and new business models will be mapped. The relevance of this report to the SPARCS actions will be explained. Lastly, the suitability of different business models to the Kera area will be explained.

2. Relevance to SPARCS

The deliverable D3.1 specifies a set of topics to be discussed to meet Action E10-1 under Intervention E10 - Solutions for Positive Energy Blocks. One of these topics is the assessment of new relevant business models for generation, aggregation, storage, and distribution.

While SPARCS Work Package 7 has overall responsibility of business models, and under WP3 for Espoo, Task 3.8 also targets business models in Espoo, this document describes relevant business models specifically for the Kera City Planning demonstration. The schedule sets milestone M21 for finalizing this report.

Action E10-1	**City Planning for Positive Energy Blocks. Exploring the possibilities to utilize the continuously updated Espoo 3D City model as a support and tool in the development and planning of the new Kera area.**
Detailed plan	• Communicate with city architects and zoning personnel to understand and document the role of the 3D city model in Kera planning. • Map technical, economic and regulatory barriers in piloting innovative PED solutions. • Identify opportunities offered by energy community legislation and new cost-efficient renewable energy generation and distribution technologies • Assess new business models for generation, aggregation, storage, and distribution. • Explore the benefits of using 3D city model in pursuing new opportunities and implementing PED solutions • Draft process to mainstream 3D city model support in PED development in Espoo.
Targeted outcome	Mainstreamed process to routinely integrate PED considerations in the early stages of city planning will reduce costs and improve the effectiveness of energy efficiency and distributed energy generation measures in new area development.
Roles and responsibilities	ESP: Main responsibility VTT: Support in identifying technologies relevant to PED development leveraging experiences from similar Lighthouse projects Siemens, Adven, PlugIt, Kone, stakeholders: Propose private sector solutions and new business models for public private partnerships in PEDs
Schedule	M18: 3D model in city architecture and zoning process documented M21: Barriers, opportunities and business models assessed M28: Assessment of 3D model feasibility in PED implementation finalized
KPIs	Qualitative assessment (Likert scale) of city planning tool Prospective On-site Energy Ratio and Annual Mismatch Ratio in Kera Prospective impact on energy expenditure for residents (€/year)
Financial scheme	This action does not require infrastructure investment. The city is actively engaged in projects to support renewable energy, circular economy and low-carbon mobility solutions, with specific budgets allocated to local pilots.

Figure 1: Excerpt from deliverable D3.1 indicating Action 10-1 breakdown.

3. Overview of current business models

An overview of current business models in power and heating sectors within Finland is given in Table 1. The table is focused on the sectors mentioned within this report, being generation, storage, distribution and aggregation. Thus, sectors such as energy efficiency optimization, construction and operation & maintenance have been marked out of the scope of this report. The table is divided into four different columns, giving the reader the following information:

- Model: The name of the business model in question.
- Sector: Whether the business model is mostly used by upstream, midstream, or downstream actors within the energy field. In this case, upstream refers to generation, midstream to transmission and distribution, and downstream to consumption.
- Added value: The value proposition offered by the business model. Can also be seen as additional information on the inner workings of the model.
- Examples: Examples of companies providing services using the listed business model.

During the literature review done for this report, a problem related to the limited research on current power and heating sector business models was identified [5], [6], [7]. This might be due to the rather centralized and publicly owned nature of the energy sector in the past years, thus leading to a lack of interest in business models of the operators. This can also be seen in Table 1, as the identified production business models heavily focus on large-scale generation upstream, while downstream business models are more focused on the procurement of generated electricity to consumers.

Another key component of the current business models is the effects of regulation on value creation, as the current system relies on heavily regulated natural monopolies especially in transmission and distribution of energy. As the distribution companies working within electricity, heating and natural gas are in a dominant market position within their designated area, their revenues are often regulated by governmental organizations to simulate competition [7], [8]. In Finland, the district heating network does not have its own regulatory authorities to supervise prices, but utility companies that maintain the system still need to abide by the Finnish Competition Act. In turn, the electricity and natural gas network operators are regulated by the Finnish Energy Authority [9].

Model	Sector	Added value	Examples
Independent power producer (IPP)	Upstream	Privately owned (non-utility) power producer. Either sells most of its produce to a dedicated customer via PPA or provides power solely to the owner. [10]	Ilmatar
Energy Utility	Upstream	Owns and operates energy production and delivers energy mainly for public use. Can be privately or publicly owned. [11]	Tampereen sähkölaitos, Vaasan sähkö, Turku energia, Helen
Local production	Upstream	Offsetting purchased electricity or heat. Sale of surplus power to the local heating or electricity grid.	Households, businesses, housing companies
Mankala	Upstream	Finnish implementation of a Special Purpose Vehicle owned by large industrial consumers. Produces power and sells pro rata to shareholders without profit. Shareholders are responsible for covering the operational costs of the Mankala company according to their share. [12]	TVO, PVO, EPV energia, Voimayhtiö SF, Kemijoki Oy
Transmission system operator	Midstream	Constructs, maintains, and develops the national transmission grid and cross-border transmission. State owned or heavily regulated. Actors within the TSO organization act separately from the DSO and retail companies to ensure fair competition. [13]	Fingrid, Svenska Kraftnät, Statnett, 50Herz
Power price hedging	Downstream/ financial	Derivatives for hedging against spot price volatility by advance pricing contracts.	Nasdaq
Distribution System Operator (DSO)	Midstream	Constructs, maintains, and develops the distribution grid within a designated area. In Finland, heavily regulated and permissioned due to natural monopoly position, thus meaning that policy heavily affects the value proposition of the company. [13], [7]	Caruna, Elenia, Helen sähköverkko
District Heating system operator and vendor	Upstream	Constructs, maintains, and develops the district heating grid. A natural monopoly due to infrastructural needs and often connected to the producer. Bills consumers according to their connected capacity and heat usage.	Vantaan Energia, Fortum

Power retail company	Downstream	Sells electricity to the end consumer. Finnish law requires an electricity contract for each usage site. However, the vendor can be chosen freely. Is not responsible for delivery of electricity or metering, as that is handled by the DSO while the retailer procures electricity according to their needs in sales and handles balances. [14]	Lumme, Oomi, Vihreä Älyenergia
Merchant power	Upstream	A privately funded power plant with no prior PPA agreement, that intends to sell power to the grid at wholesale market value. [15], [16]	Taaleri Energia, Ilmatar (depending on project, some have PPA funding)
Reserve market producer	Upstream	Payment for keeping dispatchable power reserves (by capacity) idle or dispatching reserve power (by generation) in case of disruption to supply.	In Finland consists of FCR (contain frequency within standard range), FRR (restoring frequency to standard range) and FFR (handling of low-inertia situations) markets. Producers vary. [2]
Day-ahead market provider	Up- and Downstream	Handles the determination of market price between producers and consumers of energy when procured on the market. [1]	Nord Pool
Time-dependent distribution tariffs	Mid-downstream	Lower distribution tariffs for certain times of consumption to incentivise using power in off-peak hours. Can be time-of-day specific or seasonal. [17]	Distribution companies
Balance settlement	Downstream	Settlement of balances between production and consumption [18]	eSETT (Nordic), Fingrid (Finnish), Independent operators can provide settlement consultation to market actors (e.g. Power-Deriva, Gasum)

Table 1: Current business models in Finland

4. New business models

As the energy sector develops, new solutions and services are introduced at an accelerating pace as the need for locally optimised solutions, grid balancing, dynamic pricing options and sector integration of electricity, heating, cooling and mobility progresses. In turn, these new solutions require the development of new business models that have a chance to transform the energy sector as we know it. These new business models are listed in Table 2 below. Some of the listed business models are already finding shape in other locations across the globe but are not mainstream in Finland as of yet. Table 2 is divided similarly to Table 1, giving the reader the following information:

- Model: The name of the business model in question.
- Sector: Whether the business model is mostly used by upstream, midstream, or downstream actors within the energy field. In this case, upstream refers to generation, midstream to transmission and distribution, and downstream to consumption.
- Description: More detailed description of the business model in question.
- Added value: The value proposition offered by the business model.
- Examples: Examples of companies providing services using the listed business model.

Model	Sector	Description	Added value	Examples
Energy-as-a-Service (EaaS)	Upstr. and downstr.	Energy related services, such as guidance, installation, financing and management are provided to the customer on a subscription basis by a single entity. [19]	Revenue is gained from installation margins and subscription-based contracts. Guidance drives revenue for other services.	Adven (project-dependent)
Energy Service Companies ESCO	All	Installs energy efficient equipment in customer premises to save costs [20]	Revenue is percentage of savings achieved	Assemblin, Caverion, Siemens
DSM aggregator	Downstr.	Combines a collection of flexible capacity from end users to provide value both to the end users and to the market [21], [19]	Revenue per capacity offered to Fingrid	Vibeco, Energy Pool

District Heating Demand Side Response	Downstr.	Optimizing of heat demand to balance the DH grid by altering flexible loads. [22]	Reduced use of back-up power plants in times of high demand	Fortum
VPP operator	Upstr. and downstr.	Optimizes and dispatches a fleet of distributed generation, storage and/or consumption resources. A form of aggregator business. [23], [19]	Depending on VPP project: Sold energy, provided balance to the grid, provided capacity to the reserve market.	Next Kraftwerke, Siemens, Hitachi Energy
Community Ownership	All	A group of actors, that collectively use energy resources to provide value to their community [24], [19]	Providing ecological, social, and economical value to communities via energy solutions	Lemene, Caruna Aurinkoyhteisö
Peer-to-Peer (P2P) trading	Transact.	Platform to aid prosumers and consumers in tracking and trading energy without an intermediary [19]	Not yet fully defined. Possibly License payment or fee per transaction	Power Ledger
Roof rental for photovoltaic (PV) systems	Downstr.	Installs solar panels on leased roof & façade space for grid feed-in	Revenue per m2 of roof. Resident may get share of power at low cost	STEAG Solar Energy
Pay as you go	Downstr.	Installs solar panels & battery for a recurring fee from customers. [19]	kWh produced sold to inhabitant for revenue, or monthly subscription fees	OffGridBox, Mobisol
Bidirectional heating sales	Downstream	Heating network operator buys excess heat from customers	Fixed tariffs or negotiated price for excess heat	Fortum, Helen
Carbon compensation services	Any	Clean energy interventions with proven climate benefits can be sold as compensation services	Payment per ton of carbon abated	WeCompensate

Crowdfunding	Any	Capital can be raised from the public or impact investors at favourable terms	Loans, shares	Citizenergy

Table 2: New and innovative business models in the energy sector.

5. Suitability of different business models for the functions in Kera

The upstream, midstream, and downstream sections of the traditional centralised energy system each have their own requirements for business innovation and stakeholder involvement. As the energy system evolves to a more distributed setting, new conditions arise for specific value adding services, which will be outlined here.

5.1 Generation

In a traditional electric power system, the utility would assess power demand profiles and projections for the future and build base load and peak load power plants accordingly. This only applies to areas that are covered by the electricity and heating grids. New business models within the energy sector provide new options that can bring new value to all actors, improve transparency and spur technological development.

In the most straightforward case, a power consumer simply purchases the required equipment and fuels to generate power. This is typically the case in off-grid conditions when the consumer has both the funds and the competence to run the generation activity. Independent Power Producers (IPP) have expert knowledge on their selected technology and generation prospects. Site considerations and capital expenses lead to cost estimates (Levelized cost of energy, or LCOE) which the agreed sale price needs to exceed for the IPP to make a profit. The contract may require firm delivery of certain power levels or assume that the customer can access wholesale markets to purchase any unmet demand. Depending on the preferences of the parties, the IPP may Build (B) the generation unit, Own (O) it and Operate (O) it for a predefined number of years and finally Transfer (T) it to the customer, in which case the contract is referred to as BOOT or BOT [25].

Energy Communities are expected to deploy distributed renewable energy generation through direct ownership, IPP and grid-connected models [24]. Households are encouraged to participate in energy generation, and with declining costs of solar technology it is now feasible to install PV panels on domestic rooftops and facades to offset purchased power. Per definition, Energy Communities should not seek profits [26], so any business model should serve only fair cost sharing, dynamic pricing & demand side management, social community-based benefits and sustainable energy production.

In Kera, the most prevalent restriction to on-site energy generation is roof space. As most buildings are medium or high rise, there might be shadows from nearby buildings but not trees.

The form of residency in Kera is either tenancy or ownership of a share in a housing company, which entitles the owner to reside in one apartment. As the first phase of energy community legislation has entered into force in early 2021, any power produced on the rooftop may be directly allocated to residents. As a business model, this corresponds to the owner of the building making a direct investment in PV equipment, which reduces power bills [24]. This PV equipment can then be connected to the grid to sell all extra energy to the local DSO. The costs are included in the rent or in the monthly bills of the housing company. Alternatively, the residents may install PV panels on balconies, and directly benefit from the solar yield.

The Internal Energy Market Directive also has a provision for direct lines, i.e. a specific solar PV installation that is directly connected to a consumer on the adjacent plot [24]. This could describe a situation, where for example a garage or warehouse could be fitted with solar panels, but without using the power onsite and transferring it to the neighbouring residential building instead.

For PEDs, other forms of business models are possible. An energy service company (ESCO) may build the rooftop equipment and sell the power directly to the residents at a fixed fee per kWh. Alternatively, the ESCO may decide to rent the roof space, and use it to produce power also to nearby buildings [26]. However, this is subject to cross-border power transactions, which currently are not allowed [13]. Instead, the ESCO can currently make an agreement with the local DSO to provide power to the grid. If the local residents do not have the means to produce electricity on-site, solar panels can be rented from a power retail company such as Helen. In this case, the power is produced and distributed elsewhere and produced electricity is compensated within the tenant's electricity contract with the retailer [27], [28].

Rooftop space may also be used for solar thermal panels, which would offset heating demand. In residential settings, solar heating is most useful for preparing domestic hot water [29]. Solar thermal can easily be connected to other solutions such as geoenergy to provide more value to the consumer. However, local thermal production also differs seasonally, especially with solar solutions. Thermal energy production should thus be coupled with adequate storage capability, either in the technical room of the building, or fed into the heating grid. In Kera, the heating system will be a bi-directional low-temperature (approximately 80^{o}C) heating grid operated by Fortum with an industrial-grade air-to-water heat pump as the primary source of heat [30], and a seasonal tariff structure for grid feed-in will be applied. The low-temperature design of the grid will aid in the possibilities of linking excess heat to the system.

Any municipal solid waste, biowaste or landscaping residues could be used as fuel for biogas or gasification and contribute to local energy supply. Particularly the heat supply in winter would benefit from such dispatchable options, if a boiler unit, CHP equipment or gasification plant were to be built. However, under current plans all biowaste will be collected by HSY and transported to the Ämmässuo processing site. In addition, a local plant would compete with the planned heat pump system in customers, unless a co-operating heating grid is built.

5.2 Storage

A clear business case for energy storage exists when energy price fluctuation exceeds the cost of storage. Dynamic pricing is thus a prerequisite. Even with sufficient price fluctuation, unfavourable taxation may render the storage service unfeasible. This includes situations, where the storage service provider is required to pay excise tax on energy stored but is unable to reclaim the paid tax when selling the stored energy further.

Storage of electrical energy is necessary when an IPP that has committed to delivering firm power does not have dispatchable generation units like diesel generators in use. Electrical storage and backup generators are also used in combination.

Customers may decide to invest in their own storage capacity to prevent damage from blackouts and brownouts. It is well known that the most expensive kilowatt-hours are the ones that were expected but never delivered. Costs of unreliable power access are especially significant in services such as healthcare, data centres and the process industry. In addition, local on-site storage can be constructed to make use of the reserve market by selling additional capacity. Thus, central battery storage units pose an opportunity for new business models. A large battery unit requires significant upfront investment but provides steady income in the following years, if there is sufficient variance in energy spot prices, or compensation for frequency-controlled reserves.

For heating demand, storage is often necessary to cover load peaks. Space heating is fairly flexible and may also be used for storage purposes. However, domestic hot water demand peaks in the morning and evening hours, when residents use their showers. If the capacity of the district heating heat exchanger is insufficient, a buffer tank is needed to cover this peak. Thermal batteries can be used to store produced heat. For example, Fortum has constructed a 20 000 m^3 water tank as a heat battery in the Suomenoja district of Espoo. Water tanks can be used as heat storage for daily fluctuations [31]. In addition to water, molten salt heat batteries are used as DH-based energy storage in cities such as Lappeenranta [32].

In Kera, a central seasonal heat storage unit using technologies such as Borehole Thermal Energy Storage (BTES) could be an attractive investment for institutional investors. If solar thermal collectors or refrigeration units are present, thermal energy may be collected throughout the year at appropriate prices and stored in the central storage unit. If the capacity of the unit is sufficient, this energy may be used or sold in the winter. However, a feasibility study would have to be made to determine the applicability of this business case at the chosen scale. In the neighbouring municipality of Kirkkonummi, an eco-village concept is piloted in the Masala district with Borehole Thermal Energy Storage supplied by Heliostorage [33]. This pilot will provide valuable information of the feasibility of seasonal heat storage and could be replicated in Kera if deemed feasible.

5.3 Distribution

In a traditional power system, the distribution cost is embedded in the power tariff. While this can be considered a fair cost-sharing solution, the cost of last-mile connectivity does not depend on the amount of power delivered, or other pricing factors such as distance, required amperage and grid maintenance costs. These costs will be similar for all consumers within the area of a single DSO, which cannot be altered due to regulation. Costs between DSO's will differ, but this does not affect Kera as the whole district falls under the area of Caruna Espoo OY.

The power distribution infrastructure is often regarded as a natural monopoly, as it appears unwise to invest in two parallel distribution networks, so distribution grids are allocated to local DSO's (Distribution System Operators). EU directives on Energy Communities are envisioning local solutions where consumers have control of a local microgrid. In effect, this limits the powers of grid utilities and requires careful planning and grid management to avoid service disruptions and overlapping infrastructure. With appropriate policies and private sector support such issues can be circumvented and energy community members can benefit from increased distributed renewable energy uptake and self-consumption, reduced energy costs and dependency on imported fuels, as well as enhanced local ownership and empowerment. In general, energy communities are an important component of the clean energy transition and a guarantee that public investment in climate mitigation benefits citizens and not only corporations.

In Kera, the local DSO Caruna will invest in underground cabling, and connect each building or housing association to the low-voltage distribution grid. A microgrid, fully owned by the local community is not allowed under current law. However, the utility may offer special services for customers that wish to provide self-generated solar power to the grid, while offsetting their own electricity purchases. This is subject to the approval of the utility. Luckily, Caruna has already expressed interest in providing services for local prosumers and provides their own energy community service. This service could be a steppingstone between the current distribution system and a more open model with a combination of a central utility and local microgrids.

The heating distribution system will be built by Fortum, and it is unlikely that any competing distribution service emerges. The upstream temperature levels of 80^{o}C will not allow direct feed-in of waste energy from refrigerators or air-conditioning units, and heat pumps would be necessary to prime the waste heat. However, the lower temperature of the heating grid compared to a traditional solution makes selling waste heat a more feasible solution. Solar thermal equipment, like flat-plate or vacuum tube collectors can easily reach the required temperature. However, the capacity of local rooftop solar thermal production is often not feasible for grid connection. Instead, solar thermal is usually used for the heating of on-site domestic hot water, thus offsetting the need for water heated by the DH heat exchanger.

5.4 Demand Side Management and Flexibility Aggregation

With the number of household electrical appliances increasing rapidly, automation is required to determine the cost-optimum for demand side management choices. Some appliances are critical and require continuous supply of power. Examples of such appliances are medical equipment in hospitals and servers in a data centre. Other appliances like hot water boilers and air conditioning units are more suitable for flexible operation. Even electrical lighting in homes, offices and commercial buildings can be adjusted without users even noticing any significant difference.

The need for demand side management and aggregation thereof may arise from insufficient power supply, bottlenecks in transmission and distribution capacity, or to compensate for surges in e-vehicle charging or other grid balance issues. A valid business model requires that an adequate payment is made for flexibility. Fingrid reserve markets (like FCR-N and FCR-D) [2] allocate payments through a bidding process, and the designated asset must be available to adjust the load within a certain number of seconds. Payments are made both on a continuous basis for keeping the reserve available, and for activating the reserve.

For households, both dynamic spot pricing and night tariffs incentivise flexibility. Electric heating offers the opportunity to use off-peak power for space heating. Domestic hot water is typically heated in boilers with several hours, even days of storage capacity. This alleviates the constraints of a few days of low power availability.

In Kera, the aggregation model would depend on the Fingrid demands, particularly the minimum offered capacity. As direct electric heating is not expected to play a significant role, flexible assets should be sought from electric vehicle charging, electrical drives, HVAC units, heat pumps and outdoor lighting. However, the end users expect to be compensated for any flexibility that they provide. If, for example, an e-vehicle owner agrees to use the vehicle battery for the benefit of the aggregator, a pre-defined compensation is required. This compensation could be a percentage of the revenue gained from energy sold to the market, or a flat fee.

For the heating sector, the local utility Fortum provides a smart DSM service for their consumers. This solution can optimize local consumption together with the whole heating grid, thus balancing production and flexible consumption better for peak hours. Local actors can join this AI-driven system, if the utility deems their flexibility sufficient for the service. In addition, the local utility can optimize heating on an on-site basis via a smart service called Fortum SmartLiving. These smart services can also be used for local on-site heating solutions, just with differing providers.

5.5 Financial

Renewable energy technology is characterised by high investment need but no fuel cost, a typical case of high CAPEX and low OPEX investment. Profitability is thus highly dependent on interest rates. While solar technology is technically robust, reliable and generally considered competitive in offsetting purchased electricity, high interest rates may inhibit investment.

Financial tools like leasing, loans, guarantees or crowdfunding may be used to reduce CAPEX. Targeted financing instruments, like residential mortgages or car loans, are not yet available on a large scale. Thus, every renewable energy project needs to negotiate financing arrangements separately, increasing the transaction costs.

In Kera, the local housing companies could decide to invest co-operatively, or decide to guarantee a loan for clean energy investments that is expected to increase the value of local real-estate. Public funds are available from private sector development organisations like Business Finland, or housing-sector players like ARA. Other services like parking and waste management are arranged as shared efforts, and energy services could piggy-back on these cost-sharing schemes.

The use of digital tools such as blockchain technology has been piloted as new and innovative financial business models for energy trade in the changing energy climate. These new solutions can provide means for Peer-to-Peer P2P trade directly between prosumers. However, this is currently not possible under Finnish regulation, as sold electricity must go through the local DSO if transferred across property lines, unless the system falls under the single power line exemption. Thus, the use of a blockchain system for electricity payments would most probably require the interest of the local DSO.

6. Conclusion

The Kera site only offers some opportunities for new business models, as both electricity and heat supply are still covered by utilities with existing service models. Rooftop solar energy can be utilized for self-consumption withing the same plot, but financially unattractive grid-feed-in will occur as plot sizes are small. This challenge can be tackled by investing on renewables collectively if the produced electricity is fed through the DSO to accommodate local regulation. However, this route would require paying full tax and tariff on the produced electricity. In addition, batteries may increase the self-consumption rate, while providing profits by new business models such as reserve market participation. In addition, flexible electricity consumption can be utilized via DSM services and aggregators to provide balance and reserves to the grid, while providing profits to consumers.

In heating, the planned heating grid can facilitate easier excess heating integration for local stakeholders. However, this requires a competitive business model compared to emerging on premise heating solutions, as customers can freely choose between both solutions depending on cost-effectiveness. This competitive business model is under development within the local heating utility, and will be in use as Kera development processes forward. In addition, thermal storage facilities like seasonal Borehole Thermal Energy Storage are emerging. A suitable actor with specialist expertise on storage technology and access to low-interest financing could invest in a storage service in Kera. Smart solutions can be used to optimize heat consumption, while balancing the peaks of local generation and distribution.

Locally available sustainable fuels like residential biowaste and landscaping residues could be processed locally to produce heat in the winter. This would be an alternative to the current model of centralized waste management, where the material is shipped off-site for processing. In the financial sector, co-operative financing can provide new means for local investment, while new digital tools such as blockchain can facilitate streamlined trade of local energy between locals if allowed by regulation.

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8. Abbreviations

Abbreviation	Meaning
BOOT	Build, Own, Operate, Transfer
BTES	Borehole Thermal Energy Storage
CAPEX	Capital Expenditure
CHP	Combined heat and power
DH	District Heating
DSM	Demand Side Management
DSO	Distribution System Operator
EaaS	Energy-as-a-Service
ESCO	Energy Service Company
FCR	Frequency Containment Reserve
FCR-D	Frequency Containment Reserve for Disturbances
FCR-N	Frequency Containment Reserve for Normal Operation
HVAC	Heating, ventilation and air conditioning
IPP	Independent Power Producer
LCOE	Levelized Cost of Electricity
OPEX	Operating expense
P2P	Peer-to-Peer
PED	Positive Energy District
PV	Photovoltaic
TSO	Transmission System Operator
VPP	Virtual Power Plant