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Microgrids and DER in community planning

Practices, permits, and profitability

Riku Pasonen | Ha Hoang

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Microgrids and DER in community planning
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Mikroverkot ja pientuotanto aluesuunnittelussa. Toimintatavat, lupaprosessi ja kannattavuus.
Riku Pasonen & Ha Hoang. Espoo 2014. VTT Technology 189. 49 p.

Abstract

The profitability of PV production and its possibilities for backup power were studied in this report. The idea was to study the additional value offered by PV, with investments already made, as backup in conjunction with batteries. In a typical backup power solution, backup units are only used during outages. With a PV and battery sourced backup system, production units operate the whole year round, collecting revenues and providing backup power value, on top of revenue from sales to market. These systems are similar to microgrids, which are usually defined as small-scale power systems shared by multiple buildings, with the ability to operate independently from the main distribution system for short periods. The backup power capability of fluctuating production units is, however, limited, and cannot be the only source in long outages. Small-scale production units can, however, reduce the operating costs in longer outages by reducing, for example, diesel fuel costs and generator investment costs, by reducing the size requirement for the main backup generator.

The case study was made for an area of buildings located in Närpiö. The potential and the cost-efficiency of PV panels were investigated, as well as the cost effect of using PV together with battery in backup operation. The results indicate that 22% of yearly energy could be produced with PV panels, when most of the roof is utilised for this. The profitability depends on the cost of financing and the investment cost. The system could be profitable if the interest rate was 3% or lower. In practice, financing would have to be provided by entities with low financing costs, like municipalities. PV production was best suited to the load profile of the supermarket in the case area, the load of which was concentrated in the daytime.

There are many sources of information available regarding renewable power in Finland in general, but information about combined small-scale production and backup systems is rare. This is understandable, because the power infrastructure in Finland is quite mature and outages rare.

Keywords renewable energy, microgrid, PV, urban planning, solar energy

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Tiivistelmä

Julkaisussa tarkastellaan aurinkosähkötuotannon kannattavuutta ja mahdollisuuksia varavoimakäyttöön yhdessä akkujen kanssa. Ideana oli tarkastella tilannetta, jossa on investoitu aurinkoenergiaan ja halutaan selvittää sen mahdollisuuksia akuilla tehtävään varavoimakäyttöön. Tyypillisesti varavoimalaitteita käytetään vain sähkökatkojen aikana. Aurinkosähköä ja akkuja käytettäessä varavoima tulee enemmänkin lisäominaisuudeksi verkkokäytön rinnalle. Näin lisäarvoa saadaan sähkön luotettavuuden parantumisena verkkoon myytävän sähkön arvon lisäksi. Näiden järjestelmien toiminnallisuus on verrannollinen mikroverkkoihin, jotka useimmiten kuitenkin koostuvat useamman rakennuksen kattavasta järjestelmästä ja mahdollistavat väliaikaisen käytön irrallaan jakeluverkosta. Olosuhteiden mukaan vaihteleva voimantuotantokyky kuitenkin rajoittaa kykyä turvautua pelkästään akkuihin ja pientuotantoon pitkissä sähkökatkoissa. Aurinkosähköllä ja akuilla tosin pystytään vähentämään varsinaisen varavoimakoneen käyttöä ja polttoainekustannuksia sekä generaattorin investointikustannuksia pienemmän generaattoritarpeen vuoksi.

Case-tarkastelussa tutkittiin aluetta Närpiön keskustassa. Ideana oli tutkia kustannustehokkaan varavoiman ja uusiutuvan energian mahdollisuuksia käyttämällä aurinkosähköä ja energiavarastoja. Tulokset osoittavat, että 22 % alueen vuosittaisesta energiasta olisi mahdollista tuottaa paikallisesti kattopinta-alaa käyttäen aurinkosähköllä. Järjestelmä osoittautui kannattavaksi rahoituskoron ollessa 3 % tai alle. Käytännössä tämä tarkoittaa, että rahoittajalla tulisi olla pääsy normaalia edullisemmille lainakoroille. Esimerkkinä tahoista on mm. kunnat. Aurinkovoima sopi parhaiten kauppakeskuksen kuormitusprofiiliin, jossa pääosa kulutuksesta ajoittuu päiväsaikaan.

Tietoa uusiutuvan energian käyttömahdollisuuksista on paljon saatavilla, mutta ei niinkään uusiutuvan energian varavoimakäytöistä. Tämä on ymmärrettävää, sillä Suomessa on yleisesti ottaen hyvä sähköverkko, ja sähkökatkot ovat harvinaisia.

Keywords uusiutuva energia, mikroverkko, PV, aluesuunnittelu, aurinkoenergia

Preface

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Espoo 18.9.2014

Riku Pasonen & Ha Hoang

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List of symbols

[AC]	Alternating current
[DC]	Direct current
[DER]	Distributed energy resource(s)
[DSO]	Distribution system operator
[CHP]	Combined heat and power
[LCL]	Land use and construction law
[LV]	Low voltage
[MP]	Master plan
[PV]	Photovoltaic
[RP]	Regional plan

1. Introduction

Small independent power generators near houses are an increasing component in energy systems. These types of devices can be classified as distributed energy resources (DER). In Finland, development has been slow and the focus has been more on stand-alone electric systems and heating, rather than power grid connected systems. Typical distributed power generation systems are located in rural areas, like summer cottages, and consist of photovoltaic panels with battery energy storage. The popularity of the systems comes from the way in which building a real grid connection to sparsely populated places like islands can cost much more than an adequate independent system. The most popular distributed heating source is a heat pump, which is helpful in reducing energy costs, especially in houses with electric heating.

Although the use of distributed generation is increasing in Finland, the number of units is still small compared to other Nordic countries. In many cases, the process of designing and selecting whether to acquire a specific type of generation unit or heating source has not been given enough thought to achieve the most suitable solution. In addition, the roles of different stakeholders in the process might not be clear to all parties, and same can be said about some of the opportunities DER can bring, with its new concepts.

Microgrids offer possibilities to gain more benefit from distributed energy resources and smart grid infrastructure, at a small additional cost, by focusing on coordination. The basic idea is to use distributed generation and smart grid solutions like demand response with eco-efficient housing, to increase the self-sufficiency and reliability of low voltage networks.

2. Towards microgrids with eco-efficient housing

2.1 Smart Grid and microgrids

A microgrid can be defined as a low-voltage (LV) electric network that consists of production and consumption, and that can operate as an island if needed, separate from rest of the power grid. Components of microgrids are mostly similar to smart grid concepts, but centralised power generation is missing from most concepts. DC distribution is a viable option alongside traditional alternating current distribution [1]. There has to be coordination on how different units contribute to the system and clear contracts on the roles of the different parties involved. The size of microgrid types of systems can range from individual backup power systems of houses to self-sufficient medium voltage systems consisting of multiple generators and stakeholders. The term microgrid [2] is typically used in systems with multiple buildings, but the underlying technology and size can be very similar, for example in a multi-storey building with its own backup power system utilising many sources of power.

A smart grid is a collection of technological solutions that improve communication, reliability, and flexibility, and that give new business opportunities and operational possibilities, like the previously mentioned microgrids. One of the main topics of smart grid research is integration of renewable energy sources into distribution systems. This means a fundamental change to put power sources into low-voltage networks, which results in changes in grid automation and protection. Although technological progress in smart grid research has been quite active, progress in business and service development has been slower, at least in Finland. The main reason for this is slow progress in small-scale production installations, which comes from low or non-existent financial support compared to larger renewable production. In addition, the main drivers nationally have been to achieve CO_2 reduction goals and not to increase reliability or self-sufficiency. Figure 2.1 displays microgrids in the usual smart grid context.

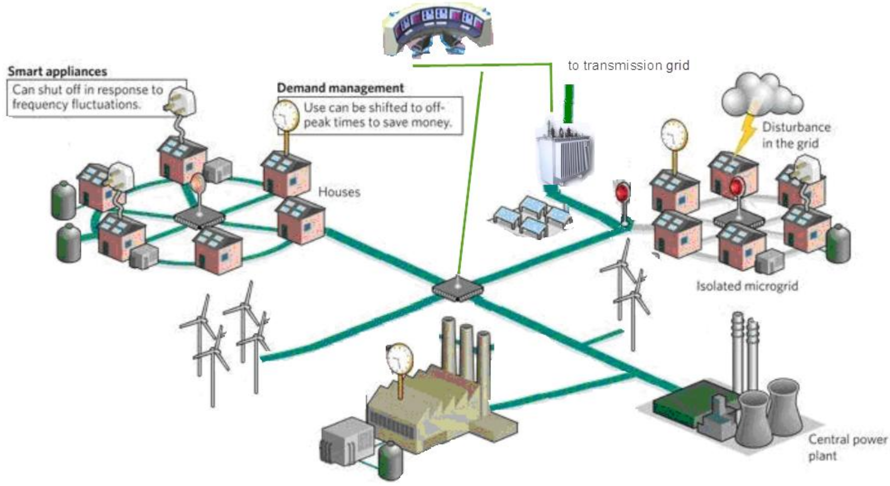

Figure 2.1. Future smart grid. Based on the figure in [3].

A microgrid is presented as a community of houses with backup power capability. Other smart grid topics in the figure are smart appliances in demand-side management; automatically controlled devices to minimise energy costs, wind power plants, and a control system for the grid.

2.1.1 Microgrid with ten houses

The Kempele “eco village” is probably the most well-known real microgrid in Finland. Ten households formed an energy co-operative together with components from the local energy developer Fortel. The community grid is separate from the distribution system, and operates as an island continuously. **Figure 2.2** displays a picture of the microgrid area in Kempele.

Figure 2.2. Kempele eco village microgrid [4].

The heart of the microgrid in Kempele is a wood gas engine with heat storage. Kempele eco village was a pilot system for the Fortel components of a wood gas engine and gasifier. Other components in the system include battery energy storage (one-day capacity), a 20 kW wind turbine, and an 80 kW diesel/rapeseed oil power generator as a backup unit. The heat is supplied to households via proprietary district heating system, and power via a low voltage three phase AC power grid. The temperature of the water in the heating system is 65°C and there are no separate heat exchangers in buildings. In other words, water from the power plant flows in radiators of the houses [5].

For administration of the system, an energy co-operative was established. We created rules for energy efficiency of household appliances and insulation requirements, and the aim was to cut the energy consumption of houses to half of the typical values.

Although the selection of materials for the buildings, and other building-specific details, are left to the house owners, plans for the houses must be first approved by the energy co-operative. This prevents one household from generating too much burden on the system [5].

The business model in the Kempele eco village is founded on the possibility to use the system as a piloting platform for Fortel components. Investments in the district heating system and electric cabling were financed by a €5000 partnership fee for the energy co-operative, and an interconnection fee of €5000 for households (a total of €10k per household). A fixed price was set for energy for the contract period, to be charged from the energy co-operative members. Fortel components agreed to operate and invest in the system, if required during the contract period [5].

The system in this example is not connected to the public power grid at any point. This is understandable, as the system is intended for use as a pilot platform for the technology provider. Generally, it might be financially more productive to use a grid connection when available, to connect the system to the public grid. This would also enable the sale of energy to markets. These types of microgrid systems are also available as products from Volter Oy, which is now the name of the sales company for the solutions used in the example. Figure 2.3 displays a microgrid system marketed by Volter Oy.

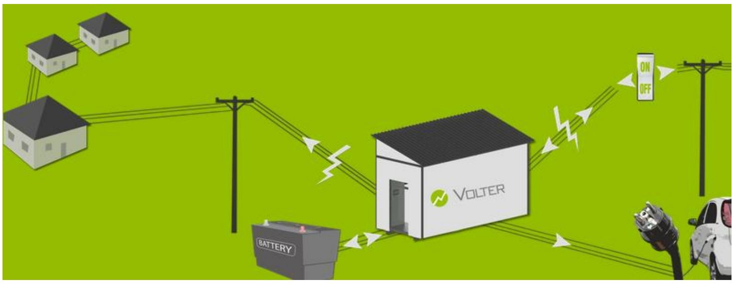

Figure 2.3. Example microgrid system marketed by Volter Oy [4].

2.1.2 Islanded microgrid in off-grid house

Off-grid power systems are common in summer cottages in Finland, but there are also some private households without a connection to the public distribution grid. Hannu Mäkinen has installed a microgrid system consisting of a wind turbine, solar panels, and a diesel generator in his house in Inari. **Figure 2.4** displays the location of Inari in northern Finland [6].

Figure 2.4. Location of Inari on the map of Finland.

A wind turbine with a nominal charging power of 720 W produced 3630 kWh of electricity in the first 12 months of operation. The battery capacity in the system is 1350 Ah in a 12 V battery. Excess energy is converted to heat in resistors of the sauna. DC voltage of 12 V is converted to a more practical 230 V of AC with a 2 kW inverter and with a smaller 150 W inverter for small devices [6].

2.1.3 Drivers for microgrids

Microgrids are not very popular in western countries, mainly due to mature power grid infrastructure. However, there can be a couple of drivers for an increase in deployment. One of them could be the further separation between market electricity price and end-user electricity price. The composition of the retail electricity price in Finland is presented in **Figure 2.5**.

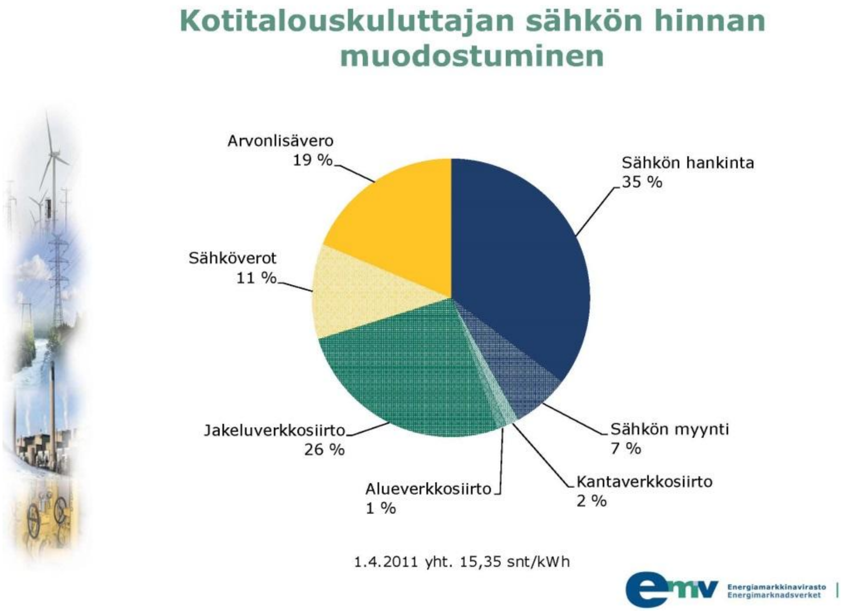

Figure 2.5. Composition of retail electricity price in Finland. The blue 35% is wholesale market price, yellow 19% is VAT, light yellow 11% is electricity tax, green 26% is transmission cost in the distribution grid, and light blue 7% is retail sales fees. The remaining 3% comes from the transmission cost from high voltage grids. [7]

Although the data is not from last year, percentages of composition are still very similar. The wholesale market price in Germany for electricity has declined during the renewable support, but the end-user electricity price has risen due to larger transmission tariffs. It can be seen in the previous figure that most of the costs come from somewhere other than the wholesale market price. Microgrids could provide a way to reduce grid usage. In addition, if capacity pricing (price for €/kW, not €/kWh) is given more weight in transmission tariffs, this could lead customers to shrink the grid capacity by using microgrid and energy storage to limit peak grid usage. Lastly, as with renewable power, financial support schemes for energy storage could increase the amount in the grid and could form microgrids with the small-scale production units.

2.2 Heating options

Heating and heat management are important things alongside self-sufficiency in electric power. Components of heating and cooling systems are also electric loads, in many cases in the form of heat pumps and ventilation systems, and therefore should be optimised together with electric system for microgrids and self-sufficient buildings.

2.2.1 Passive heating

The principle of passive solar energy is to control the energy flow from the sun into the building by manipulation of its constituents and the surrounding landscape. The idea is to utilise power from the sun with less investment costs on installation, additional equipment, and maintenance. To gain maximum performance from passive systems, they need to be integrated as a part of the building design. Therefore, when compared to active solar systems, the performance of the passive systems are more reliant on the building design at large. This includes interior and exterior components and material, as well as the dimension and location of spaces. Furthermore, the heat flow inside the building also requires attention when designing passive solar systems. This is to make sure that heat is streaming to those places where it is needed. Today, passive solar designs are commonly implemented for heating, cooling, and daylighting purposes [8] [9].The concept of passive heating is based on trapping and storing solar energy, in the form of heat within a building, for later distribution. *Collection*, *storage*, *distribution,* and *control* (see **Figure 2.6**) are steps included in such a process.

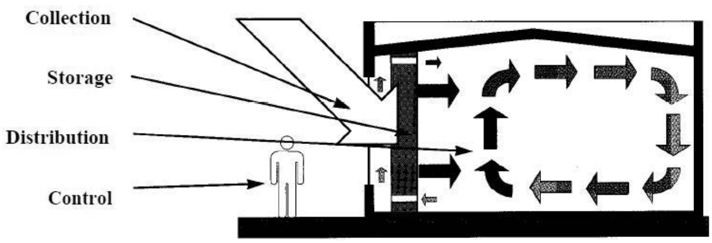

Figure 2.6. The concept of passive heating divided into the main steps: collection, storage, distribution, and control [8].

Solar radiation is usually let through a transparent material, usually a glazed window, for the direct heating of spaces or to be stored in a heat-storage. The storage, which is usually a wall or the floor of the building, is built from a material with high heat-capacity properties for accumulating a greater amount of heat for a longer period. Heat from the storage is then gradually spread to the surroundings by either natural or forced (fan) convection. Controlling passive heating systems can be done by regulating the incoming radiation from the sun by adding shading properties to the windows or air flow into spaces [8]. However, passive solar heating solutions need not include all the steps presented. In the case of direct gain, where the heat is utilised immediately, there will be less components needed, which makes the system less expensive but also less effective.

2.2.2 Active heating

Active solar heating is when solar collectors are used to effectively capture and utilise energy from the sun. Usually, the heat is transferred by a liquid in pipes to a storage or heat exchanger, where it is either stored or used for heating purposes. By using equipment and devices such as solar panels, pumps, and heat exchangers, the process of harvesting solar energy from the sun is made more effective and flexible than methods for passive heating. There are several options for solar collectors, each for different purposes and ranging in price level (see Figure 2.7). Unglazed collectors are less expensive and suitable for the heating of spaces or swimming pools. Flat plate collectors are more expensive than unglazed ones, but more suitable for the heating of spaces and domestic hot water. The most effective solar collectors are evacuated tube collectors, which can produce water temperatures above 100°C.

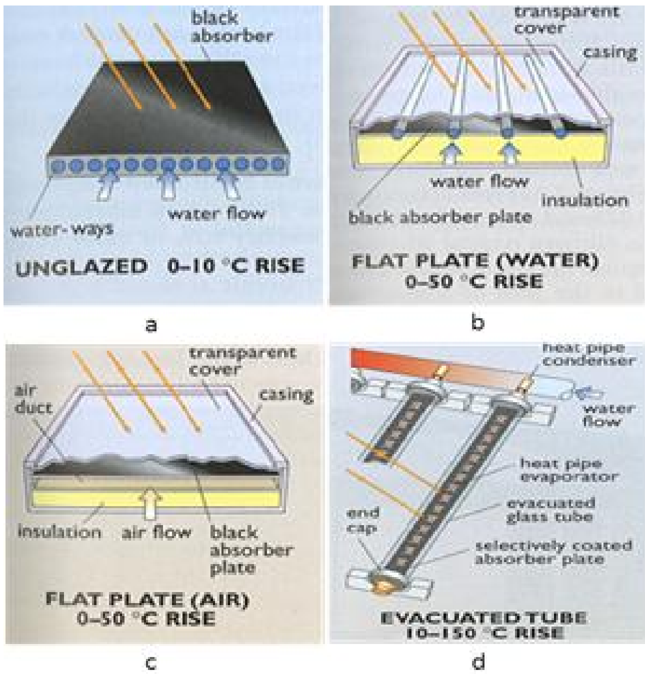

Figure 2.7. Different heat collector options [10].

Solar collectors can be either installed into roofs or facades of buildings, or deployed on the ground to form larger solar collector fields. Solar collectors are to be placed in places where less shadowing is caused by the environment, in order for them to produce more heat. In Finland, it is estimated that solar collectors could have the potential to generate half the heat needed for domestic hot water in a residential family home (Motiva).

2.3 Power generation options for microgrids and other small-scale systems

The most common power generation sources for microgrids and small-scale power systems are diesel generators, PV solar, and small-scale wind turbines. Case by case, other options like hydro and biomass combustion can be considered. Hydro needs a river, and bio power generation needs an abundant local fuel source for economical long-term operation. Biomass is usually only profitable when there is a larger heat load to use the heat from combined heat and power (CHP) units. This means CHP units must be dimensioned using the heat load.

When microgrid operation as a backup power source is desired, the system needs at least a couple of different sources. The reason for this is that regulating power, power that can be adjusted to follow the load, is always needed, and usually it is not economical to cover the whole load with these controllable units. Sources capable of regulating power quality include diesel generators and energy storage.

PV solar power is the most popular option for a small-scale power system. The reasons for the popularity are the availability of a resource, sunshine (compared e.g. to wind, the availability of which depends on location); the simplicity of devices when in operation (no practical maintenance); and a rapid decline in investment costs during the last five years. Although PV systems have been used for a long time, dimensioning the converter is still not always done economically with respect to panel capacity. The converter is the electronic device that transforms power from the generation unit into usable format. In the case of PV, it converts the direct current (DC) output of the panel to alternating current (AC) when connected to the power grid. As a rule of thumb, in a typical case in Finland, converter size should be limited to 70% of the installed panel peak power capacity. This results in savings because that missing 30% of capacity is rarely needed and the value of energy lost in these situations is less than the savings that come from smaller investment costs. In the case of small-scale wind power, dimensioning the converter is an integrated part of the design of the turbine, and therefore dimensioning of the converter and generator usually go hand in hand, and generator nominal power output is the same as converter input power. It is estimated that the PV generation cost will be equal to the end-user market electricity price in Finland in the year 2016, according to Christian Brayer of LUT [11].

2.4 Urban planning

Urban planning in Finland is mainly about land use planning, where the focus is on the needs of inhabitants. Land use in Finland is dictated by the Land Use and Construction Law (maankäyttö- ja rakennuslaki, MRL), in which the process of urban planning is stated.

Urban planning dictated by the Land Use and Construction Law

The Land Use and Construction Law (LCL), which contains rules for both land use planning and construction, was founded for the purpose of creating a healthy, safe, and comfortable living environment, where the needs of different population groups are taken into account. The purpose of the law is to:

- Organise land use and construction objectives to provide a good living environment,
- Promote development in terms of ecological, economical, social, and cultural sustainability,
- Secure the possibility of individuals to take part in the preparation of matters, the quality of planning and interactivity, the versatility of expertise, and open publicity [12].

The hierarchy of urban planning in Finland is shown in **Figure 2.8**. The Finnish Ministry of the Environment elaborates the Nationwide Objectives for Land Use (NOLU) (valtakunnalliset alueiden käyttötavoitteet, VAT) based on the LCL, international agreements, and EU directives. The NOLU is for balancing the development of regions and contains strategic decisions on a higher level, and therefore affects all urban planning in the country. Based on the NOLU, regional councils prepare their own regional plans (RP), which are to be approved by the Ministry of the Environment [13], [14].

Regional councils declare their own land use plan for their own region, which usually includes several municipalities. This so-called regional plan (RP) serves as a framework for urban planning in these municipalities. Urban planning on a municipal level is about bringing forward a master plan (MP), a town or detailed plan (DP), and in some municipalities also a shore plan.

The MP is made to direct the development and land use for the municipality as a whole, while the DP is more detailed and concerns specific sections of the municipality. The MP forms, in that sense, a bigger picture consisting of several DPs. The shore plan, on the other hand, dictates the use of shore-land (often for vacation settlement) [14].

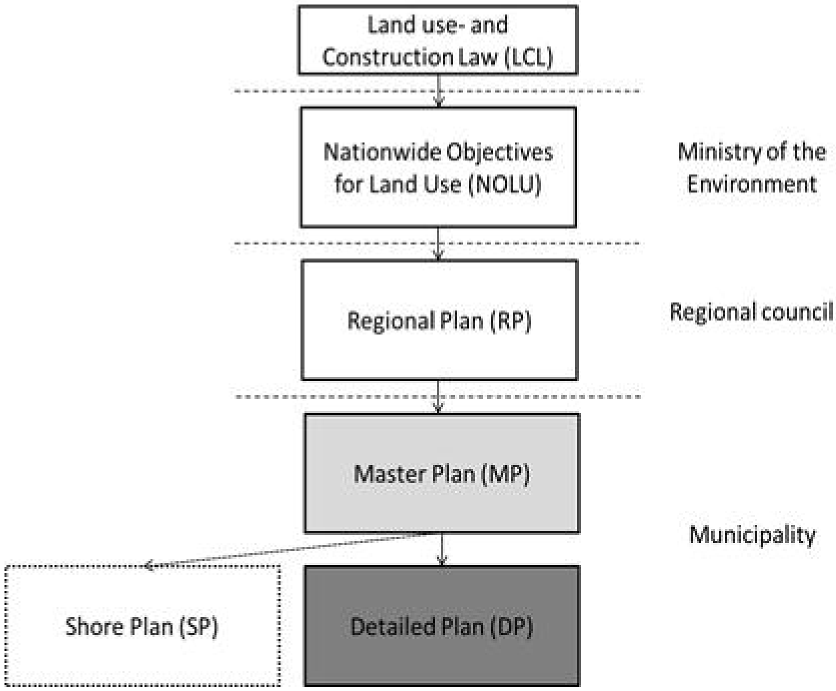

Figure 2.8. The hierarchy chain of urban planning in Finland. [11], [12]

The possibilities for utilising renewable energy can be influenced in practice by urban planning at municipality level. The detailed level of planning is most responsible for ensuring optimal operating conditions and economic feasibility of renewable energy systems.

The MP is, as mentioned above, a general plan to direct the societal structure and land use of a municipality in its entirety. Existing social structures, economic and ecological sustainability, and natural values are to be given attention when an MP is being developed. It also has to secure the inhabitants' access to social infrastructure and services, such as water supply and sewage, energy and waste management, and roads.

A detailed plan includes a map on which borders are marked for the planned areas. The map contains further information about zoning, buildings and their attributes, and the building principle to be used. The municipal council approves both the master and detailed plan. However, According to the LCL, those people who are to be affected by the plans also have the right to influence them [14].

Once a DP is approved, it is the task of the building inspection of the municipality to follow up on its implementation. The building inspection is responsible for ensuring that all construction is following plans and regulations, and that the built environment is safe and sustainable. They are in direct contact with constructors, whom they might advise when it comes to building energy efficiently [12]. Regarding the factors that have been mentioned, it can be concluded that the DP is a considerable tool for supporting the increased utilisation of renewable energy sources.

2.5 Microgrid standards

Currently there are not many microgrid standards, but related standards on integration of distributed generation are used in most cases. A European smart grid standardisation work group was started by CEN, CENELEC, and ETSI in 2010. Microgrid-related use cases are planned to be integrated in upcoming standards. Here is an illustration of how this work group sees the application area for microgrids. **Figure 2.9** displays the application area according to the previously mentioned EU standardisation organisations.

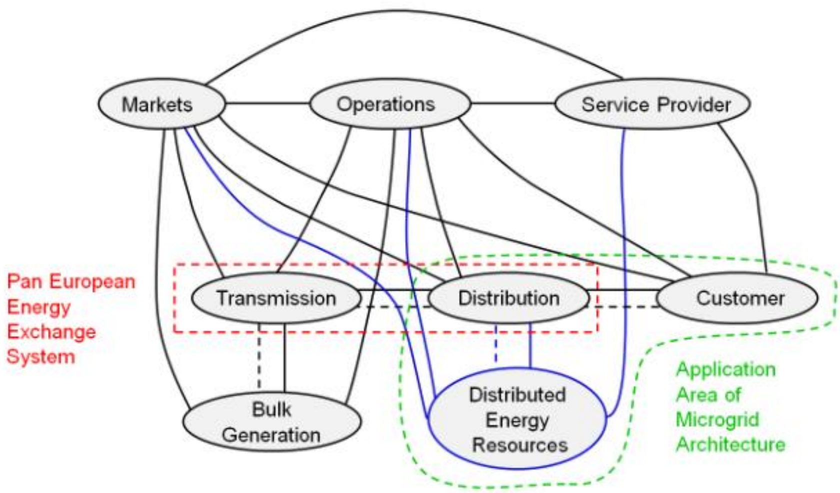

Figure 2.9. EU extension of the NIST Model by CEN, CENELEC, and ETSI [15].

The most complete microgrid standard is IEEE 1547.4: Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems. The standard covers planning and engineering islanded microgrids and their operation. The standard also gives examples of different system layouts, with pictures to give a common understanding of islanded power systems. The standard is directed at grid operators and technical designers of microgrids.

2.6 Finnish Energy Industries recommendations for small-scale power production

Finnish Energy Industries recommendations for small-scale production cover guidelines for technical compliance and processes for households to set up their contracts, permits, and technical aspects correctly, with small-scale production, in the right order. It should be noted that these recommendations only apply to grid-connected systems. Here are the main points of the guidelines:

1) Find out whether a permit is needed for the production units from the municipality.

2) Contact the local distribution grid operator and make sure that the power generation equipment meets the requirements.

As a rule of thumb, equipment (inverters) complying with the VDE-AR-N-4105 standard are accepted.

Other matters for the distribution system operator (DSO):

- Ensure, with the grid operator, that the place for the production unit is suitable
- Get a network service contract for production
- Connection of the equipment must be done by professionals
- Measurement of the production can be done with an existing electricity meter when it can measure power drawn and supplied to the distribution system separately at connection points equal or under a main fuse of 3X63A (a separate meter is needed for larger connection points)

3) Contact your retail electricity supplier.

To sell production, a sales contract is needed for the supplied electricity. Many electricity retailers buy excess production from small-scale production units. A retailer may, however, also require that a purchase contract is made with the same company, so contact your current electricity retail supplier first. All referred recommendations can be found at [16].

2.7 Motiva guide for small-scale power producers

Motiva has published a guide for small-scale power producers. The guide includes information on required permits, notices to different parties, taxes, available financial support, technical requirements, and required contracts [17]. Here are the main points that were not already mentioned in the Finnish Energy Industries recommendations in the previous chapter, and also a reference to the latest tax guide from customs to energy producers.

1. Taxation

Small-scale producers, which here means producers with maximum power under 50 kVA, are exempt from electricity tax on consumption of locally produced energy and the supply security fee. Fuels used in production electricity are exempt from fuel tax. Heat production is taxed so that consumed heat is multiplied by 0.9. Produced heat is divided among all fuels used in same amount that the fuels are consumed. For clarification, only heat in combined heat and power generation is taxed [17]. VAT is not required on producer income that is under €8500/year. In addition to taxation, producers with a unit over 50 kVA, and when grid supply is not prevented, must pay taxes on their own consumed electricity, including the part that is covered by their own production unit [19]. The 50 kVa limit is quite generous for PV because this would mean a 330 m^2 area of panels with 15% efficiency.

2. Financial support

The feed-in tariff system in Finland gives financial support for certain types of renewable power plants. The minimum plant size to be included in the support structure varies from 100 kVA to 500 kVA, depending on the type of plant. The generation plant must be a wind turbine or must use wood, wood chips, or bio gas as fuel to be included in the tariff system [17].

Investment support of up to 40% of investment costs for energy production can be given to companies, municipalities, and communities [17]. In short, this support is not applicable to individuals, but individuals can form an energy co-operative or similar entity to apply for the support. For example, solar energy could get 30% investment support in 2013 under this support scheme [18]. Note that investment support can change yearly.

3. Fees

A connection fee might be charged by the distribution system operator (DSO) for connecting the production unit to the distribution system. However, usually there is already a connection contract for electricity consumption, and this contract is just expanded to include production, and no fees apply in this case. There is a transmission fee for production, with a maximum amount of 0.07c/kWh charged by the DSO [17]. Information on fee structures for small-scale production can be found on the DSO's websites. Examples of fees and requirements in Fortum Oyj can be seen at [20].

3. Case study

For a case study, we have chosen a small area in the centre of the city of Närpiö. Närpiö is a city on the west coast of Finland, with a population of 9 000. The study is in the form of a techno-economic evaluation of a smaller solar panel system for power production and backup power. The case area is situated in the centre of Närpiö city and contains four apartment buildings, a hotel, a grocery store, a bank, and one petrol station (see **Figure 3.1**).

Figure 3.1. Map of Närpiö.

The buildings were chosen because they provide a considerable amount of roof area for the installation of solar panels, and because most of them provide services that would be vulnerable to power outages. The main benefits from investing in the solar and backup power systems, as we see it, would be that the costs are shared amongst partners, renewable power is utilised by the buildings (or sold), and businesses can partially continue to operate even during blackouts. More information about Närpiö can be found from the official website [21].

Energy demand of the buildings

Since the case buildings are both residential and commercial, heating and electricity demands are to be considered. Cooling is needed in some of the commercial buildings, and the power need for it is included in the electricity demand in our analysis. Currently, heating is provided by the district heating network, and all electricity through the local electricity grid. Consumption data of some of the buildings was available, while the rest had to be estimated (see **Table 1**).

Table 1. Energy consumption estimates for buildings.

Building name	S-Market		Bank		Hotel		Gas station		Residential buildings (4)	
Energy type	Heat	Power	Heat	Power	Heat	Power	Heat	Power	Heat	Power
January	27.9	86	15	4.3	53.7	37.8	0	1.6	56	22.5
February	25.5	78.9	14.8	**4.3**	55.4	37.8	0	1.3	57.4	22.5
Mars	17.1	86.4	9.8	4.3	44	37.8	0	1.3	48.2	22.5
April	12.1	79.4	9.5	4.3	41	37.8	0	1	45.7	22.5
May	4.9	82.1	6.7	4.3	32	37.8	0	0.7	38.4	22.5
June	3.1	80.3	4.4	4.3	26.8	37.8	0	0.6	34.2	22.5
July	2.4	88.1	3.3	4.3	19.9	37.8	0	0.7	28.6	22.5
August	3.2	87.6	3.9	4.3	22.7	37.8	0	0.8	30.8	22.5
September	4	84.7	6.5	4.3	29.1	37.8	0	1	36	22.5
October	7.2	86.5	9.8	4.3	38.5	37.8	0	1.3	43.7	22.5
November	8.5	85.1	9.2	4.3	41.1	37.8	0	1.5	45.8	22.5
December	24.2	89	14	4.3	58.3	37.8	0	1.4	59.7	22.5
Sum	140	1014	107	51	462.6	453	0	13	524	271

**Either from measurements or estimations, using available data*

Local sources for excess energy and renewable energy utilisation

The area is in the centre of the city and surrounded by mainly commercial and residential buildings, and the availability of renewable and excess energy is limited. There are no forests, open fields, water bodies, or industrial buildings from where renewable or waste energy can be utilised. However, the roofs of the buildings could provide installation surfaces high enough for solar panels and wind turbines to avoid obstructions. The area is not adjacent to any sources of groundwater that would make geothermal heat-energy a possible option for effective space heating and cooling. In this study, we focus on the benefits of solar power for the buildings under investigation.

3.1 Microgrid performance calculation and system optimisation

The tool selected for optimising renewable power for the case is HOMER®. HOMER is a hybrid power system optimisation program, the development of which was started by the US Department of Energy in 1992. Program version 2.68 was used in this report. The program bases comparisons mainly on economics, but adjustments can be made for emissions and renewable fraction. The program can be used to optimise component selection of the system and hourly operation, using given information and restrictions.

3.1.1 Electric load models for buildings

Petrol station
Petrol station electricity consumption was given for each month. This data was used to generate an hourly load curve for the whole year, assuming that petrol pump usage is concentrated in the middle of the day. Figure 3.2 displays the load curve for January.

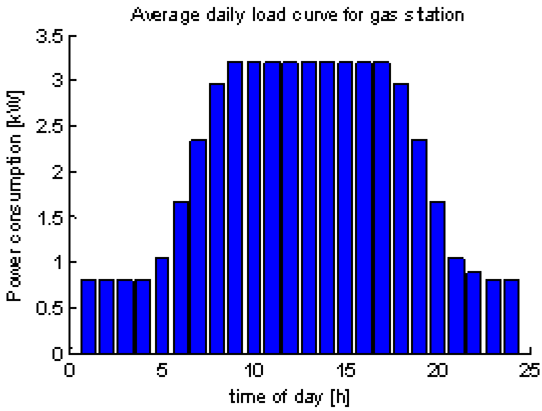

Figure 3.2. Petrol station load curve for a day in January.

Each month has an individual load curve, so that monthly total energy consumption matches the given values.

Supermarket

Electricity consumption for the S-market shopping centre was provided as monthly totals and a sample of hourly data. **Figure 3.3** displays a sample of the measurement data, and **Figure 3.4** displays a sample of the simulated yearly power demand.

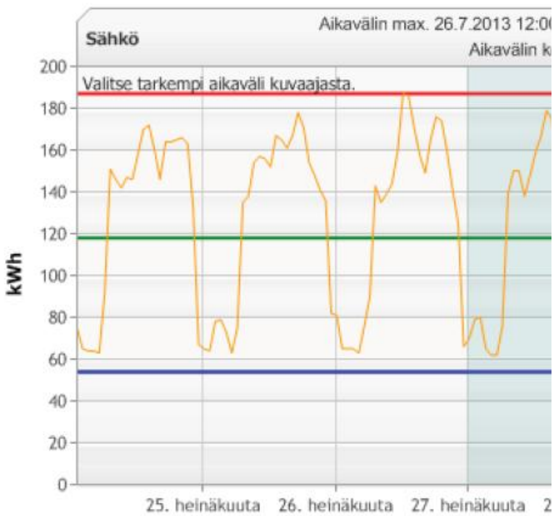

Figure 3.3. Measurement sample of S-market power consumption.

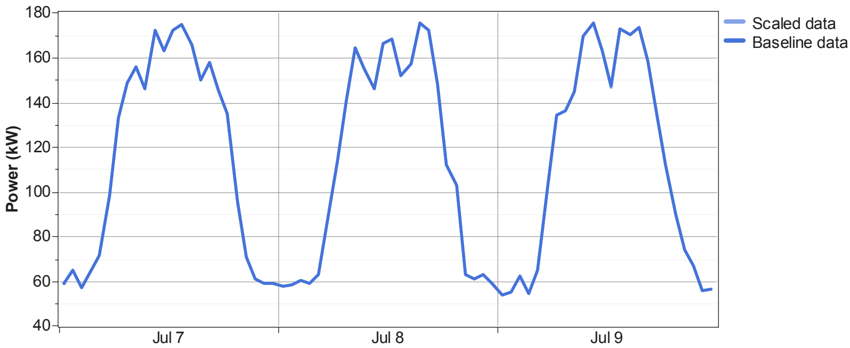

Figure 3.4. Sample of generated yearly curve of power demand for S-market.

The yearly power curve was made similarly to that for the petrol station, but random noise was added to mimic the fluctuation in measurement samples.

Hotel

An estimate of total power consumption of 446778 kWh per year was given for the hotel. **Figure 3.5** displays the base load curve for the hotel.

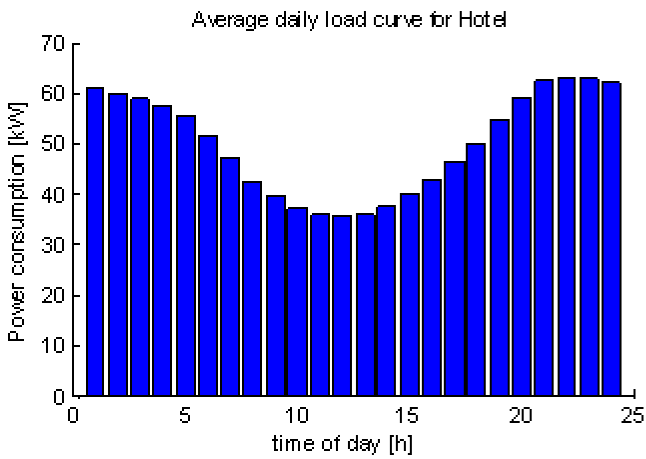

Figure 3.5. Base load curve for the hotel.

The estimation of the shape of the load curve is from [23], and is adjusted so that a yearly total of 446778 kWh is used. Random noise was added to the final yearly load curve and a sample of this is presented in Figure 3.6.

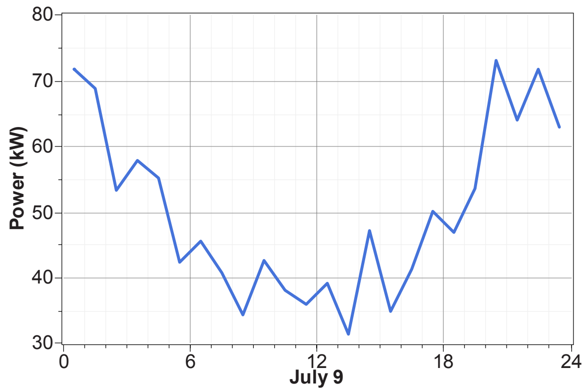

Figure 3.6. Sample of the hotel load curve with added random noise.

Apartments

An estimate of total power consumption of 67.64 MWh per year was given for each of four apartments. Total yearly consumption is therefore 270.56 MWh per year. **Figure 3.7** displays the average daily load curve used in the simulations.

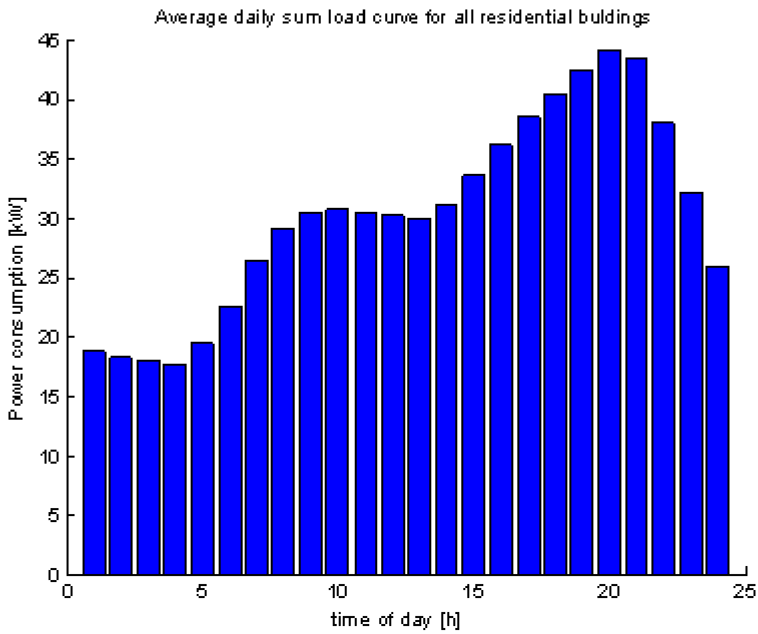

Figure 3.7. Average daily sum load curve for all residential buildings in the case study.

A sample of the yearly load curve with added randomness is presented in **Figure 3.8**.

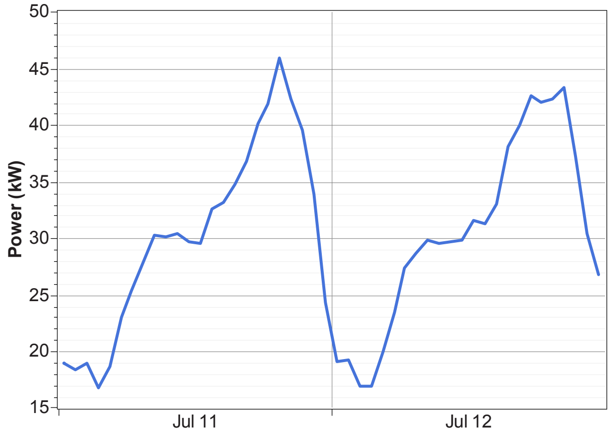

Figure 3.8. Sample of two days from the sum load curve of the residential buildings for the year.

Bank

The bank load curve is assumed to be similarly shaped to that of the supermarket, with consumption being concentrated in the daytime. **Figure 3.9** displays the load curve estimation.

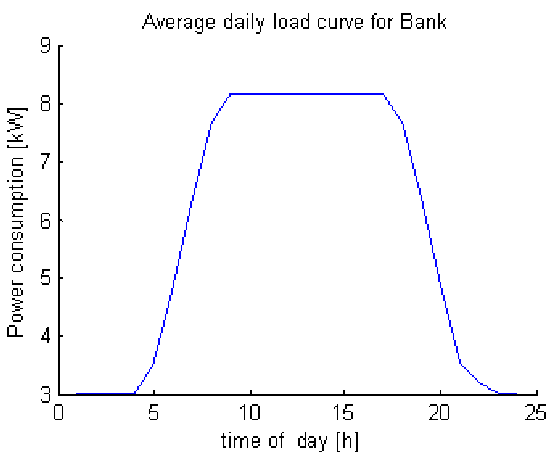

Figure 3.9. Load curve estimation of bank.

3.1.2 Production and storage equipment data

Price and performance data of available equipment is needed for the simulation to analyse the optimal amount of different equipment. The total roof area of the case buildings is about 5120 m^2. If 40% of this can be used for solar panels that are inclined by 30%, the maximum panel area is about 2100 m^2. All prices in the study are without VAT, because VAT is deductible for the business owner. Parameter ranges in sensitivity are set there to investigate profitability limits when prices or interest rates change.

Solar panel type
Name: Heckert PV Module NeMo® P 230W
Area of panel: 1.47 m^2
Maximum PV power of the system with area limitation of 2100 m^2: 328 kW.
The rest of the simulation parameters of the solar panel are displayed in **Figure 3.10**.

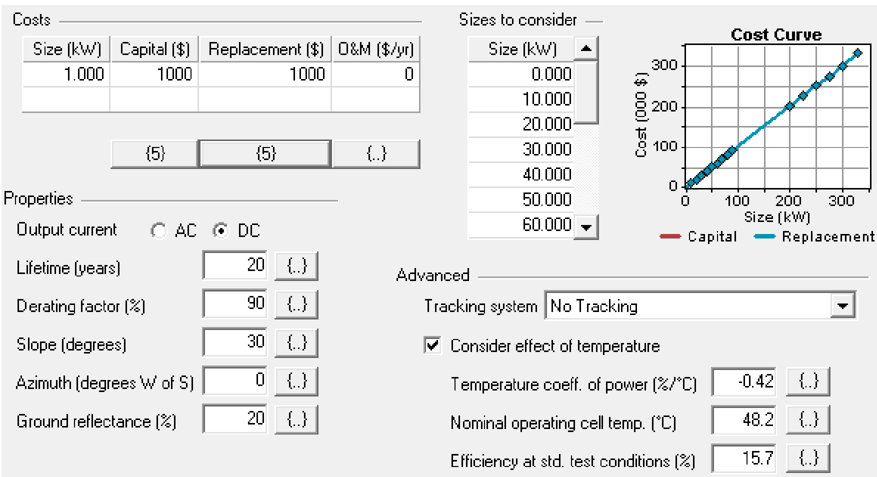

Figure 3.10. Solar panel parameters used in the simulation. Costs (without VAT) are in euros even though the dollar sign is used in the software.

The optimisation program selects the most cost-efficient size for the PV installation.

AC/DC converter parameters
An AC/DC converter is required between the PV panels and the power grid. The AC/DC converter also acts as a maximum power point tracking device, which ensures the maximum amount of energy is harnessed from sun radiation. The type of AC/DC converter for the simulation is selected to be a Kaco Powador 60.0

TL3 [29]. Although sizes to consider in simulation range from 0 to 300 kW, efficiency and cost information of 50 kW can be used to be quite accurate with smaller and larger units. Figure 3.11 displays the simulation parameters in Homer software.

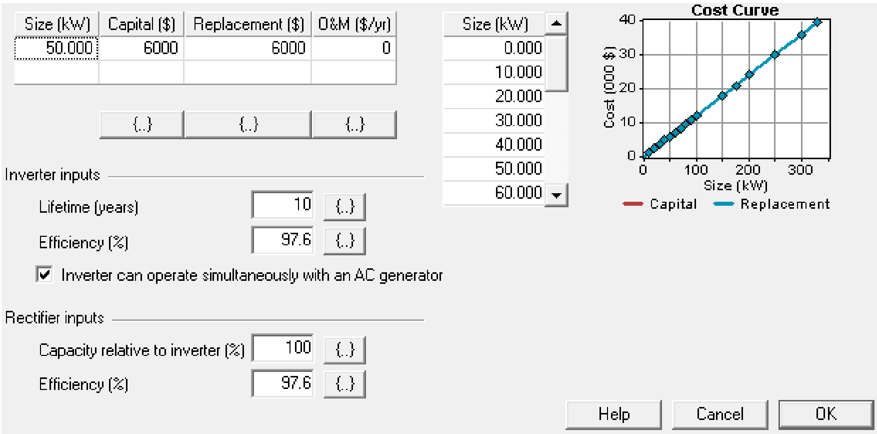

Figure 3.11. AC/DC converter simulation parameters. Costs (excluding VAT) are in euros even though the dollar sign is used in the software.

Electricity parameters
Electricity price data for the year 2013 is used in the simulations. Price data is built so that there are separate prices for production and consumption.

Electricity price for purchase: 2013 Elspot hourly data + €31.1/MWh of transmission fee + €19.03/MWh of electricity tax (tax class 1, without VAT)

Electricity price for sales: 2013 Elspot hourly data with €0.6/MWh subtracted for a supply fee for small-scale production (without VAT)
Figure 3.12 displays a sample of yearly price curves.

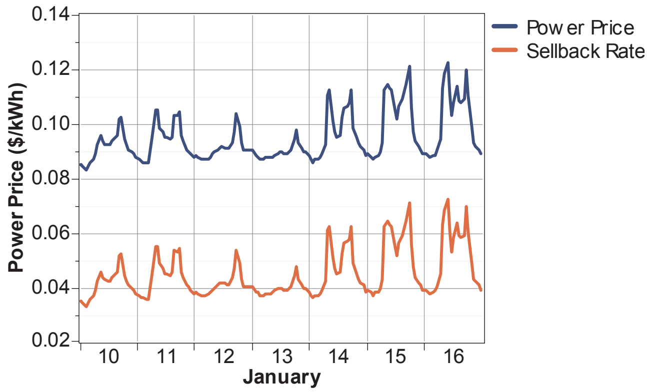

Figure 3.12. Sample of hourly price curves for purchase and sales

Homer simulation software can also be used to calculate emission savings from installed renewables. This calculation requires the CO_2 emissions from the production that the installed system replaces. Renewable energy emission savings in Finland are estimated to be between 472 and 611 gCO_2/kWh in 2013 [30]. The average of those numbers, 541 gCO_2/kWh, is used in the calculation.

Weather data and other settings in the simulation

Temperature data with one-hour time steps is added so that the effect of temperature on solar panel performance can be calculated. **Figure 3.13** displays the monthly variation range in temperature.

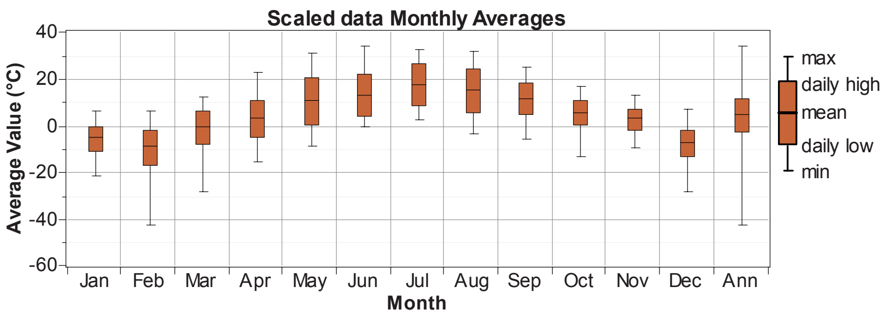

Figure 3.13. Temperature data as scaled monthly averages.

Solar energy data was downloaded from the NASA database using Homer's integrated option. Figure 3.14 displays radiation for different months, and the clearness index, which shows how much radiation actually reaches the Earth's surface.

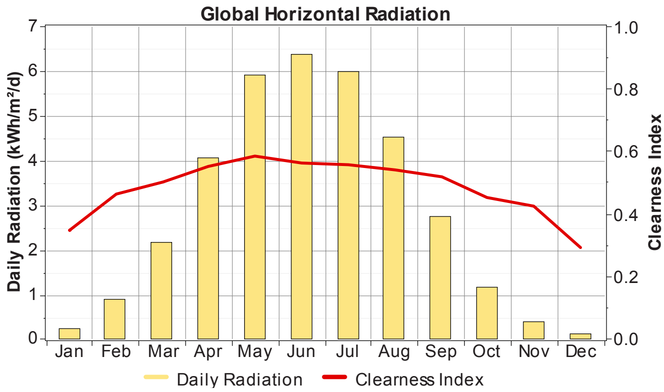

Figure 3.14. Solar radiation data. The red curve shows the clearness index, which indicates a fraction of how much solar radiation reaches the Earth's surface.

Other settings and sensitivity value options used in the simulation

Interest rate options: 2%, 3% 4%, 5%, 6%.
Period of simulation: 20 years
PV panel capital costs: €1000/kW, €1200/kW, €1380/kW, €1500/kW, €1700/kW (excluding VAT, labour included)
Minimum renewable percentage: 0% and 18%

3.1.3 Optimal system for energy production and calculation of DER costs

This chapter presents the results to answer the question on the profitability of installing solar panels in the case area in Närpiö. **Figure 3.15** displays how optimal system composition depends on the costs of financing and the cost of PV panels.

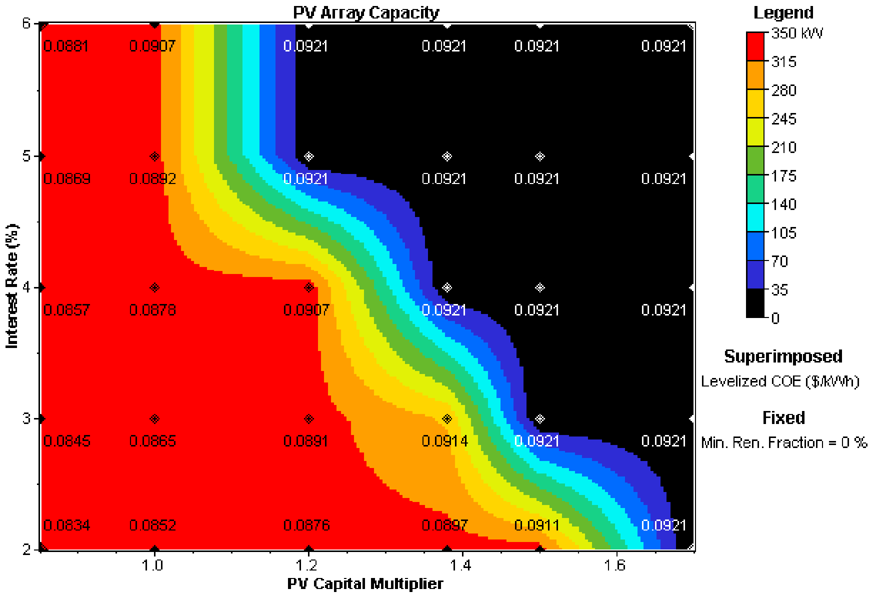

Figure 3.15. Optimal PV array capacity as a function of panel price and financing costs. Numbers (black and white) on the graph are costs of energy in each case (€/kWh)

The red area represents a situation in which installing maximum capacity is profitable and the black area represents a situation in which it is more beneficial to just buy all the energy from the grid. Numbers on the graph are the levelized cost of energy (€/kWh) for 20 years of operation, in each case in EUR (the figure says “$” because the currency marker cannot be changed).

Typical scenario:
PV capital cost €1380/kW with labour (exc. VAT), €120/kW for inverter, interest rate 4%. The rest of the costs and settings are as in **Figure 3.10** and **Figure 3.11**. The following figures represent calculation results with these assumptions.

PV Capital Multiplier 1.38 | Interest Rate (%) 4 | Min. Ren. Fraction (%) 0

Double click on a system below for simulation results.

			PV (kW)	Conv. (kW)	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.
					1000	$ 0	157,541	$ 2,141,027	0.092	0.00
			10	10	1000	$ 15,000	156,512	$ 2,142,053	0.092	0.01

Figure 3.16. Summary of the results with a 4% interest rate.

In this case, it was not profitable to invest in solar power. Things, however, change if financing costs are under 4%. Here is the result with 3%.

PV Capital Multiplier 1.38 | Interest Rate (%) 3 | Min. Ren. Fraction (%) 0

Double click on a system below for simulation results.

			PV (kW)	Conv. (kW)	Grid (kW)	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)	Ren. Frac.
			275	200	1000	$ 403,500	129,219	$ 2,325,953	0.091	0.19
					1000	$ 0	157,541	$ 2,343,805	0.092	0.00

Figure 3.17. Summary results with a 3% interest rate.

With only a 2% interest rate, the optimum solution was to limit the inverter to 250kW capacity, and the maximum area was covered with panels, resulting in a capacity of 330kW for the panels. **Figure 3.18** and **Figure 3.19** display yearly statistic of the simulation with this maximum PV installation.

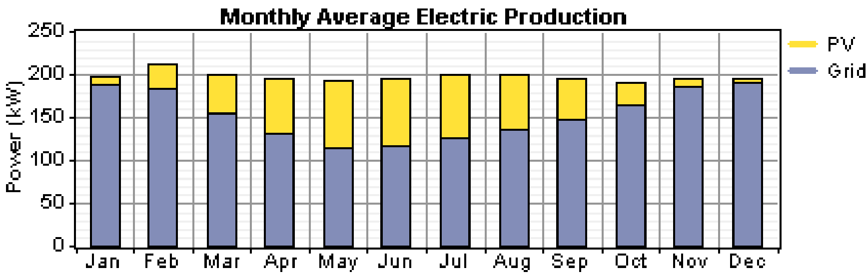

Figure 3.18. Monthly distribution of source of energy.

Production	kWh/yr	%
PV array	387,862	22
Grid purchases	1,341,762	78
Total	1,729,624	100

Consumption	kWh/yr	%
AC primary load	1,710,758	100
Grid sales	6,503	0
Total	1,717,261	100

Figure 3.19. Total production and load values

Overall, the load in the case fits well with the use of PV power. This can be seen from a sample week of summer load and the PV production chart presented in **Figure 3.20**.

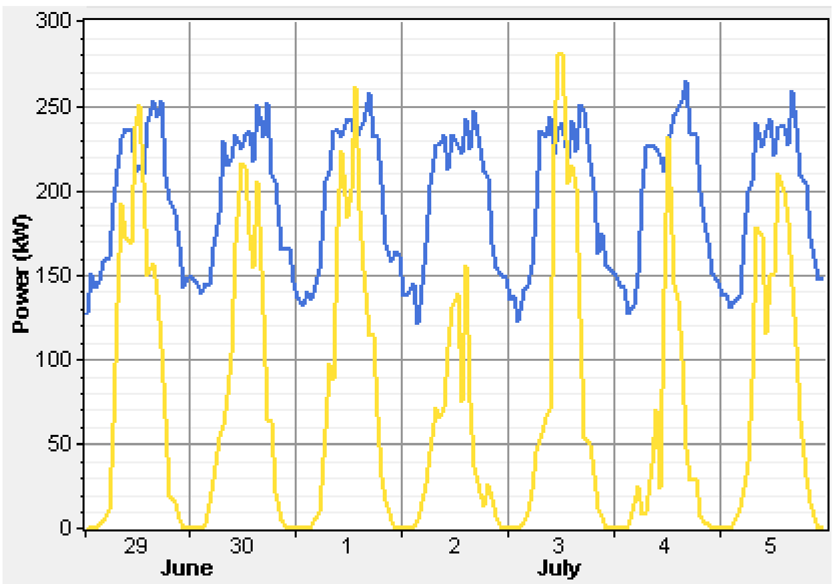

Figure 3.20. Sample of PV production (yellow) and load (blue) from one week in the simulation.

Cost information from the scenario with a 2% interest rate and PV installed is displayed in **Figure 3.21**.

Total net present cost	$ 2,065,642
Levelized cost of energy	$ 0.089/kWh
Operating cost	$ 123,414/yr

Figure 3.21. Costs in the case with PV.

Cost information from the scenario with a 2% interest rate without PV installed is displayed in **Figure 3.22**.

-

Total net present cost	$ 2,576,014
Levelized cost of energy	$ 0.092/kWh
Operating cost	$ 157,541/yr

Figure 3.22. Cost without PV.

Carbon emission savings in a typical scenario:

When 541 gCO_2/kWh is assumed to be the average emission figure of replaced production, and 70 gCO_2 eqv/kWh life-cycle emissions for the PV system, emission savings in this case can be calculated by:

387862kWh X (541 gCO_2/kWh -70 gCO_2 eqv/kWh) = 182.7 tonne CO_2 eqv

Dimensioning of the backup system

The local district heating network is available in the case area, which means that the building will be heated by district heating. The power from the solar panels will be used in the buildings and for charging batteries in the backup system. Excess electricity could eventually be, in the best case, sold or fed to the local grid.

The backup system needs to provide electricity during blackouts and thereby ensure that the activities in the buildings are (partially) maintained for a certain amount of time. The following are the demands that need to be covered by the backup system.

- **Pumps**:
  Since the buildings are heated by district heating, it would be important for the consumer units to be powered at all times, especially during the winter. It has been regarded that the electricity is mainly for keeping the pumps of the heating system running. The pumping needed for the supermarket and the hotel is considered to be 1 kW each, for the bank 300 W, and for the apartments 100 W each.

- **Lighting and appliances:**
  Lighting and appliances are crucial for maintaining the services offered by the commercial buildings. This includes cash register machines, cooling utilities (products), computers, servers, and necessary network connections: 10% of capacity for the supermarket and the hotel, 25% for the bank. Lighting capacity for the apartments is 100% while other appliances are not accounted for.
- **Power for pumping at the petrol station:** One pump in operation during a blackout (one for each fuel type).

Practical considerations for a combined backup power system

Although there are interesting possibilities in combining a backup system with many buildings and individual loads, there are lots of practical problems to sort out. The backup system has to be taken into account in the early stages in the design of the power system. In practice, a backup system would be possible only if buildings are connected to the same feeder in the distribution system. This way, a microgrid could be formed by disconnecting the whole feeder from the medium voltage grid and disconnecting excess load, to keep only critical loads operational. This could be done, for example, with a large energy storage unit. In practice, a cheaper alternative could be to use many small separate backup units. This way there is no need to make many changes to current electric system, when all backup units form their own microgrids when there is a failure in the main power supply. Renewable generation units could also be installed in the vicinity of the backup system, so that they can be switched to supply the backup storage when in need. Figure 3.23 displays this type of system.

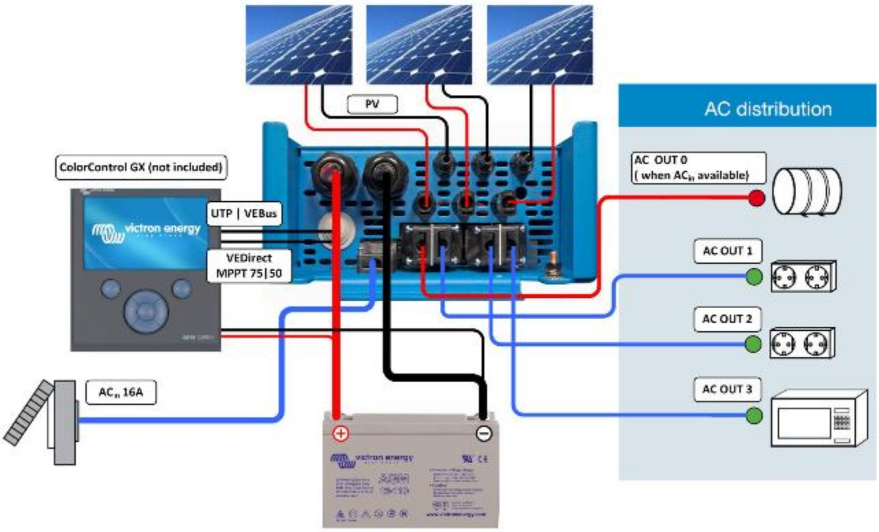

Figure 3.23. Solar power system with backup power capability [22].

Battery competitiveness of PV against diesel

PV panels can provide a limited amount of backup power with energy storage. Here, the system is configured to operate as an island continuously, to investigate the optimum backup power system for long-term outages. This analysis gives the maximum profitable amount of batteries in a backup system, together with PV and Diesel. If this amount is enough for critical loads in outages, diesel is not needed. If not, then there also has to be a diesel generator.

The assumption is that there is a 330kW PV system and a 250kW inverter installed, and the usage and size of the battery back and diesel generator are optimised for islanded operation.

Capacity shortage penalty: €2/kWh (penalty for generation shortage)
Interest rate: 4%
Investigated time period: 20 years
Diesel price: €0.7/l [23] (no taxes or fees for backup power usage [24])

Figure 3.24 displays diesel generator cost parameters and the options used.

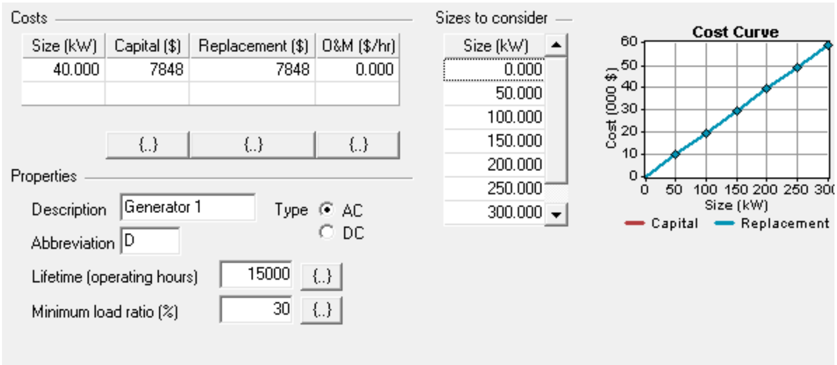

Figure 3.24. Diesel generator costs and options. Costs are in euros even though the dollar sign is used in the software. [25]

Figure 3.25 displays the efficiency curve of the generator and the properties of the fuel.

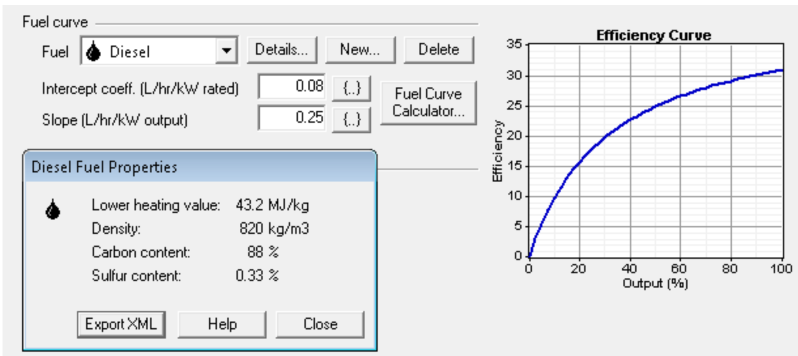

Figure 3.25. Efficiency curve of the generator and fuel properties.

Battery information:

The battery in the study is a Vision6FM200D. Battery information is displayed in **Figure 3.26**.

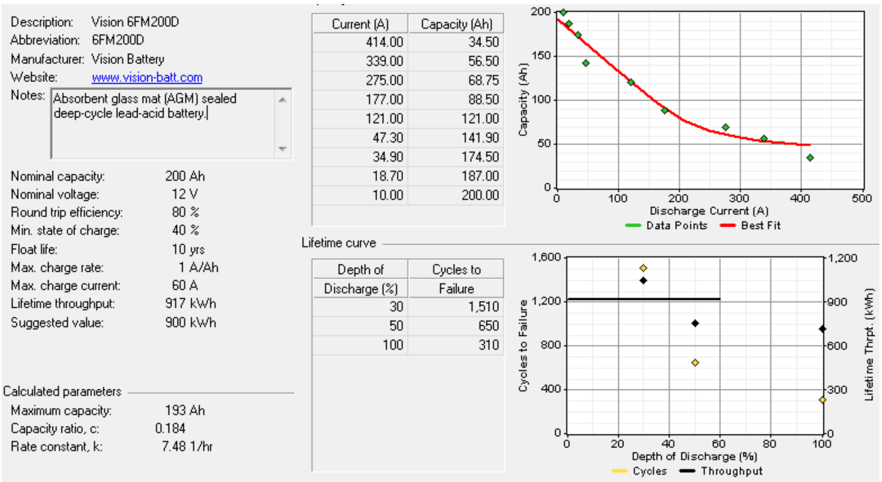

Figure 3.26. Battery technical data.

The cost of the battery is €332 (19% VAT is subtracted from [27], a battery with similar performance).The rest of the parameters are the same as in the previous calculations.

Results:

Overall results are displayed in Figure 3.27.

PV Capital Multiplier 1.25 Interest Rate (%) 4

Double click on a system below for simulation results.

	PV (kW)	D (kW)	6FM200D	Conv. (kW)	Disp. Strgy	Initial Capital	Operating Cost ($/yr)	Total NPC	COE ($/kWh)
	330	250	100	250	CC	$ 81,250	382,524	$ 5,279,873	0.227
	330	300		250	CC	$ 58,860	425,085	$ 5,835,908	0.251

Figure 3.27. Results of islanded mode optimisation.

Optimal power production for the example consists of 250 kW of diesel and 20kAh of batteries (100 units). All available energy from the panels can be served to the load using the batteries, which means 22% of the energy can be supplied by the panels, compared to cases with grid connection. Detailed information about battery usage is presented in Figure 3.28.

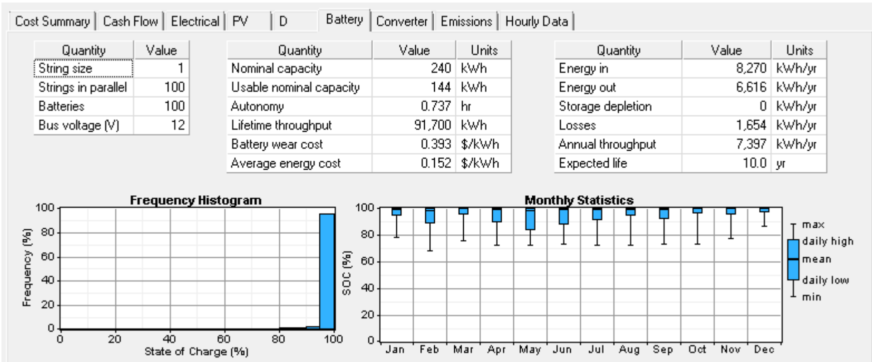

Figure 3.28. More detailed information about battery usage.

The batteries lasted for only 10 years, so a new set had to be purchased half way through the inspected period of 20 years. The average load in the simulation is 195kW. The usable capacity of the battery stack is 144 kWh. This means that, on average, the battery system could supply all load of 0.738h. This assumes there is no PV production at the time of an outage. The annual throughput of the battery is 7397 kWh in the simulation. The average power of the converter is 39.88kW. Therefore, it cuts the power need by 195kW-40kW = 155kW. The battery system could sustain this power output for 0.93h. The extent to which PV actually helps depends on whether power is more critical during day or night time.

3.2 Case summary

The case calculation was made for collection to buildings located in Närpiö. The idea was to investigate the possibilities and costs of renewable power in the form of PV panels and energy storage. The results indicate that 22% of yearly energy could be produced with PV panels locally, when most of the roof area is utilised for this. The profitability of the system depends on the cost of financing and investment costs. The interest rate, in practice, has to be 3% or less for the PV system to be profitable. Overall, the use of solar energy suited well the load profile of the case site, due to the high daytime load of the supermarket. Matching the load and production is important, because then local production reduces the requirement for energy purchasing, and purchasing electricity is much more expensive than the value of production on the market. On the practical side, PV installation should be divided into 50 kVA units per owner, to prevent the need to pay tax on personal electricity consumption [19]. Another option is to prevent power supply to the outside grid. This means that, in practice, hourly energy must be positive towards the system. This could be arranged by load control: increasing the load when PV production is larger than the load. For example, air-conditioning units could be a suitable load for this, due to the cooling demand correlation with higher PV production.

A calculation was also made for optimum system configuration for islanded mode operation. In this case, it was cost-efficient to have batteries in the system, so that all PV energy was harnessed. Another option would have been to produce everything using diesel. The optimum solution was to limit diesel capacity and also have batteries in the backup system when PV investments have been made. Backup power capacity from optimum battery stack was 0.74h on average loading. The result also indicates that short outages are more efficient to be supplied by the battery system. For long outages, a diesel generator was understandably the superior option.

4. Step by step guide for RES and microgrid investments

Here is short description of the process for investing in renewable power, or any other small-scale energy system like backup power units. **Figure 4.1** displays one alternative for the process.

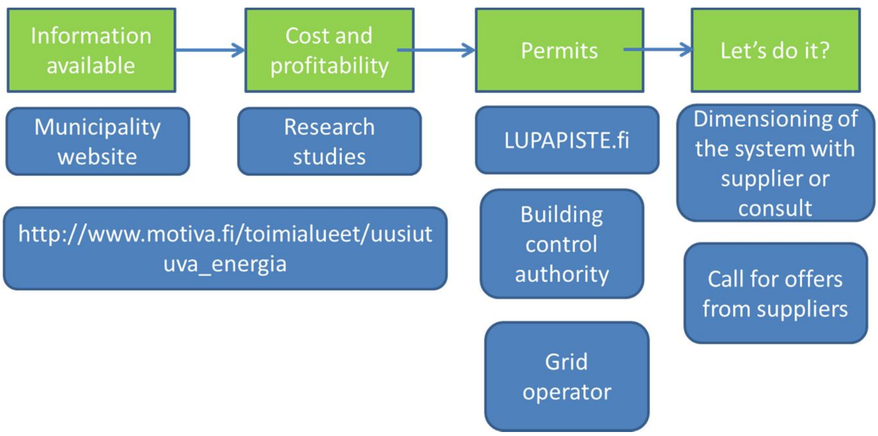

Figure 4.1. Flowchart of process for investing in new energy system.

The process usually starts by gathering general information about local possibilities. The best source for this can be a municipality website, if surveys have been done on local renewable resources and guidance provided for the residents on how to proceed. Lots of general information can be found from the Motiva site for renewable energy. Motiva has also launched a more extensive information package focusing on solar power.

Cost and profitability is usually also of interest in the early stages. Because investment costs are the largest cost component, price development of the devices gives a good indication of where the total cost of operation is heading. However, installation costs are a large portion of the investment costs, and therefore the benefit of cheaper devices is limited.

Getting permits is the next step in the process. It is recommended that the building control of the municipality is contacted in the early stages of the project, so that unexpected obstacles in permits can be avoided before investment decisions are made. Lupapiste.fi is a portal with information about building permits. There is also a possibility to make a permit application via the website. Another alternative is to contact the local building authority. The local grid operator has to be contacted when a system is planned to be connected to the local distribution grid. The grid operator will give the technical requirements for the devices. Excess power can be sold to the grid operator (to cover transmission losses) or to an energy retailer, as mentioned in Chapter 2.6.

The final step is selection of the supplier and more detailed dimensioning of the system. An external consultant can be used in this, to optimise the selection of components, but in smaller systems, this is usually done by the supplier. However, some overall design has to be made before, to send out a call for offers to get the most for the money. This is recommended at least for larger projects, where more resources should and can be put into planning without a large percentage increase in total costs.

5. Conclusions

The profitability of PV production and its possibilities for backup power were studied in this report. The idea was to study the value offered by PV production together with energy storage, when investments in PV power have already been made. In a typical backup power solution, backup generators are only used during outages. With PV and an energy storage sourced backup system, production units operate the whole year and provide additional backup power value on top of normal grid-tie operation revenue. There are already PV converters on the market that offer backup power capability. The backup power capability of fluctuating small-scale production units is, however, limited and cannot be the only source in long outages. They, however, can reduce operating costs in longer outages by reducing, for example, diesel fuel costs and generator investment costs, by reducing the required size for the main backup generator.

A case study was made for an area of buildings located in Närpiö. The idea was to investigate the costs of PV panels and backup power possibilities with energy storage. The results indicate that 22% of yearly energy could be produced with PV panels locally, when most of the roof area is utilised for this. The profitability of the system depends on the cost of financing and investment costs. The system could be profitable if the interest rate is 3% or lower. In practice, financing would have to be provided by entities with low financing costs, like municipalities. PV installation suited best the load profile of the supermarket in the case area, the load of which was concentrated in the daytime.

There are many sources of information available regarding renewable power in Finland in general, but information about combined small-scale production and backup systems is rare. This is understandable because, usually, power infrastructure is quite mature and outages rare.

Overall, the future for renewable usage in Finland looks bright, as small-scale PV production can already be profitable, cutting personal consumption with low financing. In the future, according to some, profitable investments can be made with more typical interest rates and can reach end-user grid parity. It is important that power generation, the grid, and smart cities take each other more into account in the future, so that we get more holistic results instead of partial optimisation.

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Series title and number

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Title	**Microgrids and DER in community planning** **Practices, permits, and profitability**
Author(s)	Riku Pasonen, Ha Hoang
Abstract	The profitability of PV production and its possibilities for backup power were studied in this report. The idea was to study the additional value offered by PV, with investments already made, as backup in conjunction with batteries. In a typical backup power solution, backup units are only used during outages. With a PV and battery sourced backup system, production units operate the whole year round, collecting revenues and providing backup power value, on top of revenue from sales to market. These systems are similar to microgrids, which are usually defined as small-scale power systems shared by multiple buildings, with the ability to operate independently from the main distribution system for short periods. The backup power capability of fluctuating production units is, however, limited, and cannot be the only source in long outages. Small-scale production units can, however, reduce the operating costs in longer outages by reducing, for example, diesel fuel costs and generator investment costs, by reducing the size requirement for the main backup generator. The case study was made for an area of buildings located in Närpiö. The potential and the cost-efficiency of PV panels were investigated, as well as the cost effect of using PV together with battery in backup operation. The results indicate that 22% of yearly energy could be produced with PV panels, when most of the roof is utilised for this. The profitability depends on the cost of financing and the investment cost. The system could be profitable if the interest rate was 3% or lower. In practice, financing would have to be provided by entities with low financing costs, like municipalities. PV production was best suited to the load profile of the supermarket in the case area, the load of which was concentrated in the daytime. There are many sources of information available regarding renewable power in Finland in general, but information about combined small-scale production and backup systems is rare. This is understandable, because the power infrastructure in Finland is quite mature and outages rare.
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Nimeke	**Mikroverkot ja pientuotanto aluesuunnittelussa** **Toimintatavat, lupaprosessi ja kannattavuus**
Tekijä(t)	Riku Pasonen, Ha Hoang
Tiivistelmä	Julkaisussa tarkastellaan aurinkosähkötuotannon kannattavuutta ja mahdollisuuksia varavoimakäyttöön yhdessä akkujen kanssa. Ideana oli tarkastella tilannetta, jossa on investoitu aurinkoenergiaan ja halutaan selvittää sen mahdollisuuksia akuilla tehtävään varavoimakäyttöön. Tyypillisesti varavoimalaitteita käytetään vain sähkökatkojen aikana. Aurinkosähköä ja akkuja käytettäessä varavoima tulee enemmänkin lisäominaisuudeksi verkkokäytön rinnalle. Näin lisäarvoa saadaan sähkön luotettavuuden parantumisena verkkoon myytävän sähkön arvon lisäksi. Näiden järjestelmien toiminnallisuus on verrannollinen mikroverkkoihin, jotka useimmiten kuitenkin koostuvat useamman rakennuksen kattavasta järjestelmästä ja mahdollistavat väliaikaisen käytön irrallaan jakeluverkosta. Olosuhteiden mukaan vaihteleva voimantuotantokyky kuitenkin rajoittaa kykyä turvautua pelkästään akkuihin ja pientuotantoon pitkissä sähkökatkoissa. Aurinkosähköllä ja akuilla tosin pystytään vähentämään varsinaisen varavoimakoneen käyttöä ja polttoainekustannuksia sekä generaattorin investointikustannuksia pienemmän generaattoritarpeen vuoksi. Case-tarkastelussa tutkittiin aluetta Närpiön keskustassa. Ideana oli tutkia kustannustehokkaan varavoiman ja uusiutuvan energian mahdollisuuksia käyttämällä aurinkosähköä ja energiavarastoja. Tulokset osoittavat, että 22 % alueen vuosittaisesta energiasta olisi mahdollista tuottaa paikallisesti kattopinta-alaa käyttäen aurinkosähköllä. Järjestelmä osoittautui kannattavaksi rahoituskoron ollessa 3 % tai alle. Käytännössä tämä tarkoittaa, että rahoittajalla tulisi olla pääsy normaalia edullisemmille lainakoroille. Esimerkkinä tahoista on mm. kunnat. Aurinkovoima sopi parhaiten kauppakeskuksen kuormitusprofiiliin, jossa pääosa kulutuksesta ajoittuu päiväsaikaan. Tietoa uusiutuvan energian käyttömahdollisuuksista on paljon saatavilla, mutta ei niinkään uusiutuvan energian varavoimakäytöistä. Tämä on ymmärrettävää, sillä Suomessa on yleisesti ottaen hyvä sähköverkko, ja sähkökatkot ovat harvinaisia.
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