MAKING-CITY Webinar 3_PED Calculation Methods

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OULU

Jussi Rönty, Klaus Känsälä, Jari Rehu (VTT)

Samuli Rinne (OUK)

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AGENDA

- Definition of PED Boundaries
- Energy Needs
- Energy Use
- RES Production
- Energy Delivered
- Primary Energy Balance
- Energy Flow Diagrams
- Any Failures Faced?

Kaukovainio district in Oulu

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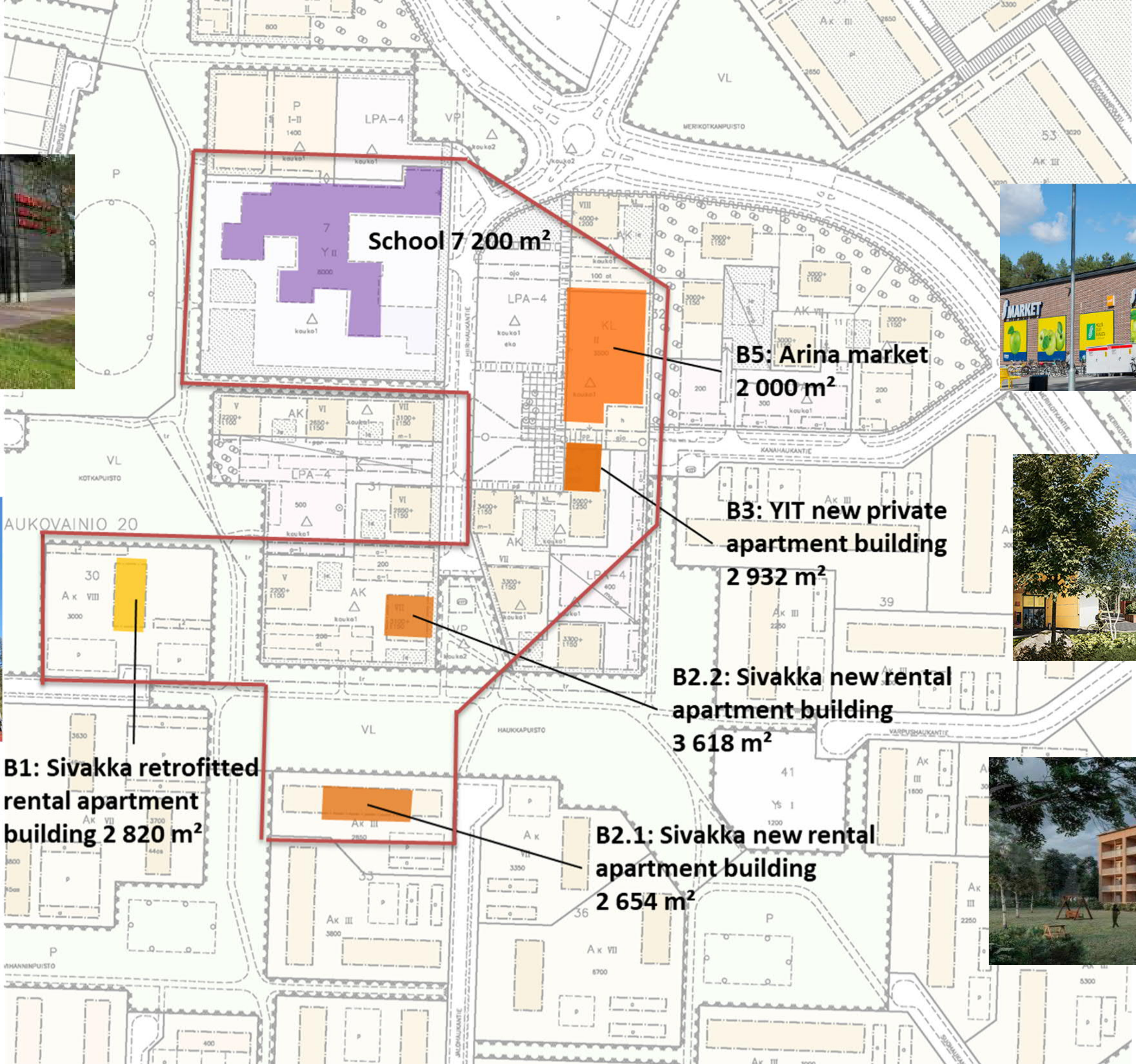
School 7 200 m²
B5: Arina market
2 000 m²
B3: YIT new private
apartment building
2 932 m²
B2.2: Sivakka new rental
apartment building
3 618 m²
B1: Sivakka retrofitted
rental apartment
building 2 820 m²
B2.1: Sivakka new rental
apartment building
2 654 m²
AUKOVAINIO 20
LPA-4
VL

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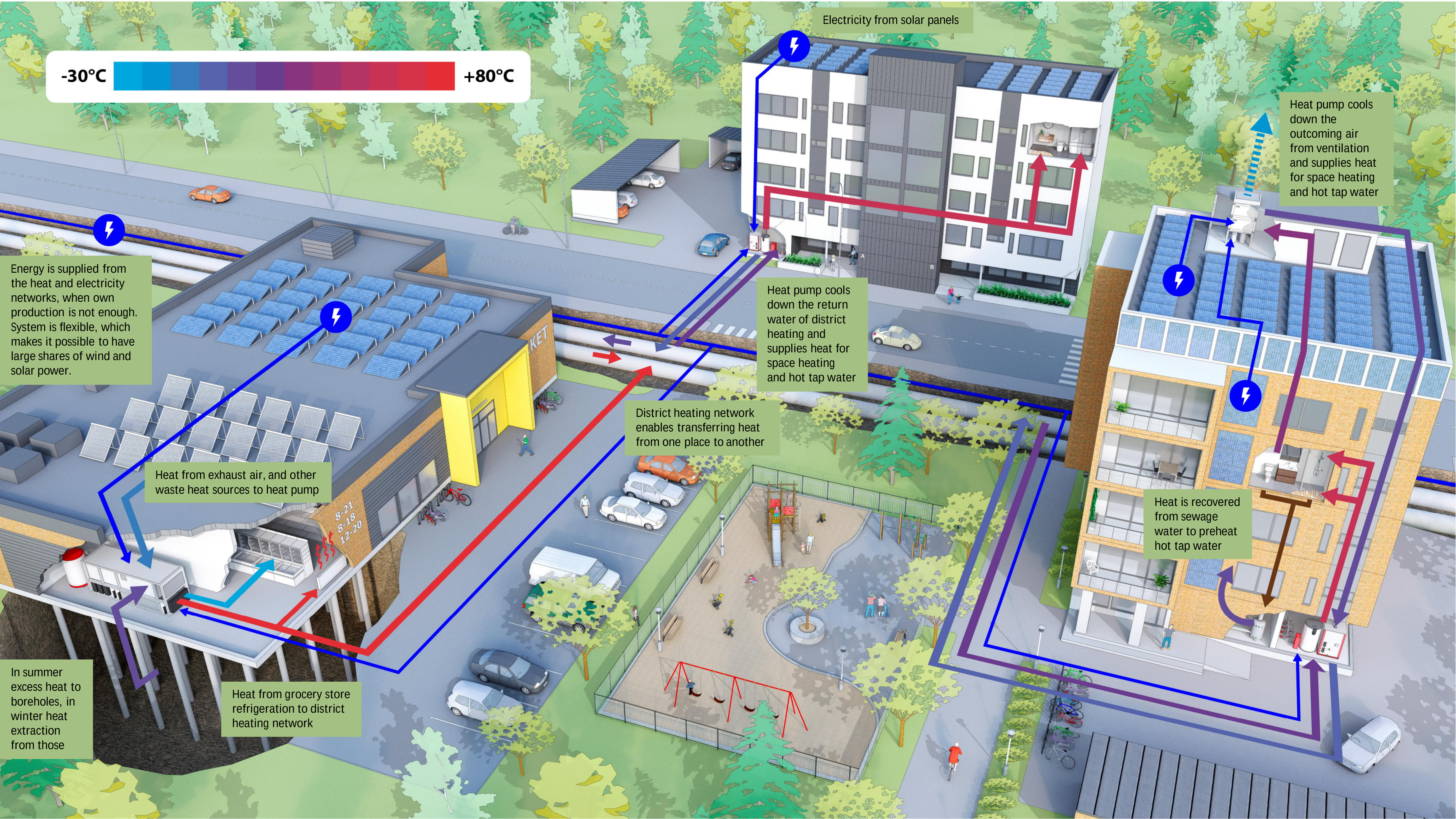

-30°C
+80°C
Electricity from solar panels
Heat pump cools down the outcoming air from ventilation and supplies heat for space heating and hot tap water
Energy is supplied from the heat and electricity networks, when own production is not enough. System is flexible, which makes it possible to have large shares of wind and solar power.
Heat pump cools down the return water of district heating and supplies heat for space heating and hot tap water
District heating network enables transferring heat from one place to another
Heat from exhaust air, and other waste heat sources to heat pump
Heat is recovered from sewage water to preheat hot tap water
In summer excess heat to boreholes, in winter heat extraction from those
Heat from grocery store refrigeration to district heating network

Definition of PED Boundary in OULU

- "Positive Energy Districts are energy-efficient and energy-flexible urban areas or groups of connected buildings which produce net zero greenhouse gas emissions and actively manage an annual local or regional surplus production of renewable energy. They require integration of different systems and infrastructures and interaction between buildings, the users and the regional energy..." (JPI UE & EERA JP SCC, working definition)
- Virtual boundary: Limits of the PED in terms of contractual boundaries, e.g., including an energy production infrastructure owned by the PED occupants but situated outside the normal geographical PED boundaries, for example wind power owned through shares by the PED occupant community

❖ Oulu-demo could be defined as PEDvirtual, with regional boundaries, since a large share of electricity consumption in the area is covered by wind power production co-owned by Arina (S-Group) → Dynamic exchanges with the hinterland to compensate for momentary surpluses and shortages

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Energy Needs in PED Boundary

- Energy demands have been determined based on real measured data as much as possible
- Local energy company, building owners and system operators have both historic and up-to-date data on the energy demands and flows in the area
- Based on similar references if no data available
- In addition, buildings codes, statistics, databases, simulation / estimation tools such as VTT's E-PASS calculation tool, have been utilized

1. Define PED boundary
2. Calculate the energy needs
3. Calculate energy use
4. Calculate on-site generation
5. Estimate energy delivered
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8. Sankey diagram

Estimated Energy Needs in PED Boundary

	Space heating, cooling, and air conditioning [kWh/m2/y]	Space heating, cooling, and air conditioning [kWh/y]	Hot water [kWh/y]	Lighting [kWh/m2/y]	Lighting [kWh/y]	sub-total net energy need [kWh/y]
Building 1 - Sivakka	60	169 200	35 000			204 200
	14	39 480	2 400	5	14 100	53 580
Building 2.1 - Sivakka	40	106 160	25 000			131 160
	10	26 540	2 200	6	15 924	42 464
Building 2.2 - Sivakka	40	144 720	32 000			176 720
	10	36 180	2 500	6	21 708	57 888
Building 3 - YIT	48	140 736	27 500			168 236
	8	23 456	2 200	6	17 592	41 048
Building 5 - ARINA	55	110 000	10 000			120 000
	55	110 000	1 000	20	40 000	151 000
Building 6 - School	130	937 170	30 000			967 170
	12	86 508	15 000	10	72 090	173 598
Heat pump, excess heat from Arina to DH network						
						250 000

TOTAL m2	21 233

Total net thermal energy need [kWh/y]	1 767 486
Total net electricity need [kWh/y]	769 578
Total primary energy [kWh/yr]	1 807 237

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Energy Use in PED Boundary

- Energy consumption is measured at building system level, residents' energy use not monitored (at this stage)
- A set of energy parameters are monitored from all demo buildings, Arina store has the most measurement points (over 1000, minute-resolution data), for the needs of predictive AI-based modelling of the energy system
- As of new buildings, estimations based on design values, references and E-PASS calculation tool
- End use = imported DH + "free heat" from return-line & other free/waste sources to Heat Pumps (+ electricity to HP's & other building systems)

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RES Production inside the PED

- RES estimation software for PV
  - Photovoltaic Geographical Information System (PVGIS)
  - https://ec.europa.eu/jrc/en/pvgis
  - Total estimated PV in the area: 200 kWp, up to 172 000 kWh/yr
- Time resolution of data collected
  - From minute resolution used for predictive energy modeling to month resolution used for KPI calculation and evaluation procedures
- Heat pumps
  - For dimensioning the heat pump systems, technology providers, building owners and the energy company have done estimations to optimize life cycle costs, production volumes and energy prices – total production still to be estimated

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Energy Delivered to the PED

- All demo-buildings are connected to the national power grid, and to the city-wide district heating network.
- DH-network is used efficiently by utilizing the return water pipeline (can be considered as zero-emission waste energy) with the help of heat pumps (increases electricity use).
- Energy is imported from outside the boundaries to cover the remaining energy (heat & electricity). Generation is efficient CHP/biomass, hydro & wind power → low environmental impact
- PEDvirtual: Wind-power and other regional RES co-owned by building owners delivered to PED (mainly Arina calculated for now)

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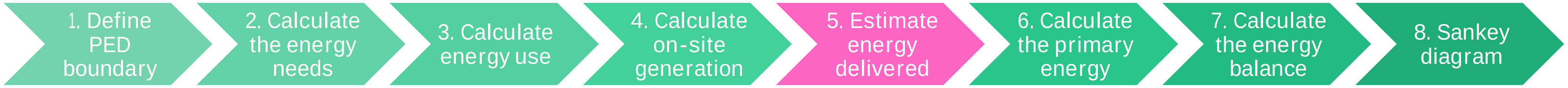

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Projected result for the yearly Primary Energy Balance, with virtual PED boundaries (incomplete consumption data)

Total net thermal energy need [kWh/y]	**1 767 486**
Total net electricity need [kWh/y]	**769 578**
Total primary energy [kWh/yr]	**1 807 237**

National primary energy factors

FACTOR PRIMARY ELECTRICITY	1,2
FACTOR PRIMARY THERMAL	0,5

CO2 electricity	0,072	kgCO2/kWhe
CO2 district heat	0,15	kgCO2/kWhth

Building energy consumption related GHG emissions emitted within the district boundaries

-	51	tons/yr

Total local thermal from RES [kWh/y]	450 000,0
Total local electrictiy from RES [kWh/y]	538 600,0
% of total net thermal energy need covered by local RES:	25 %
% of total net electricity need covered by local RES:	70 %

Total balance primary energy incoming [kWh/y]	175 417
Total eletricity incoming [kWh/y]	230 978
Total thermal energy incoming [kWh/y]	- 203 514
% of total net energy need covered by resources coming from outside district boundaries:	10 %

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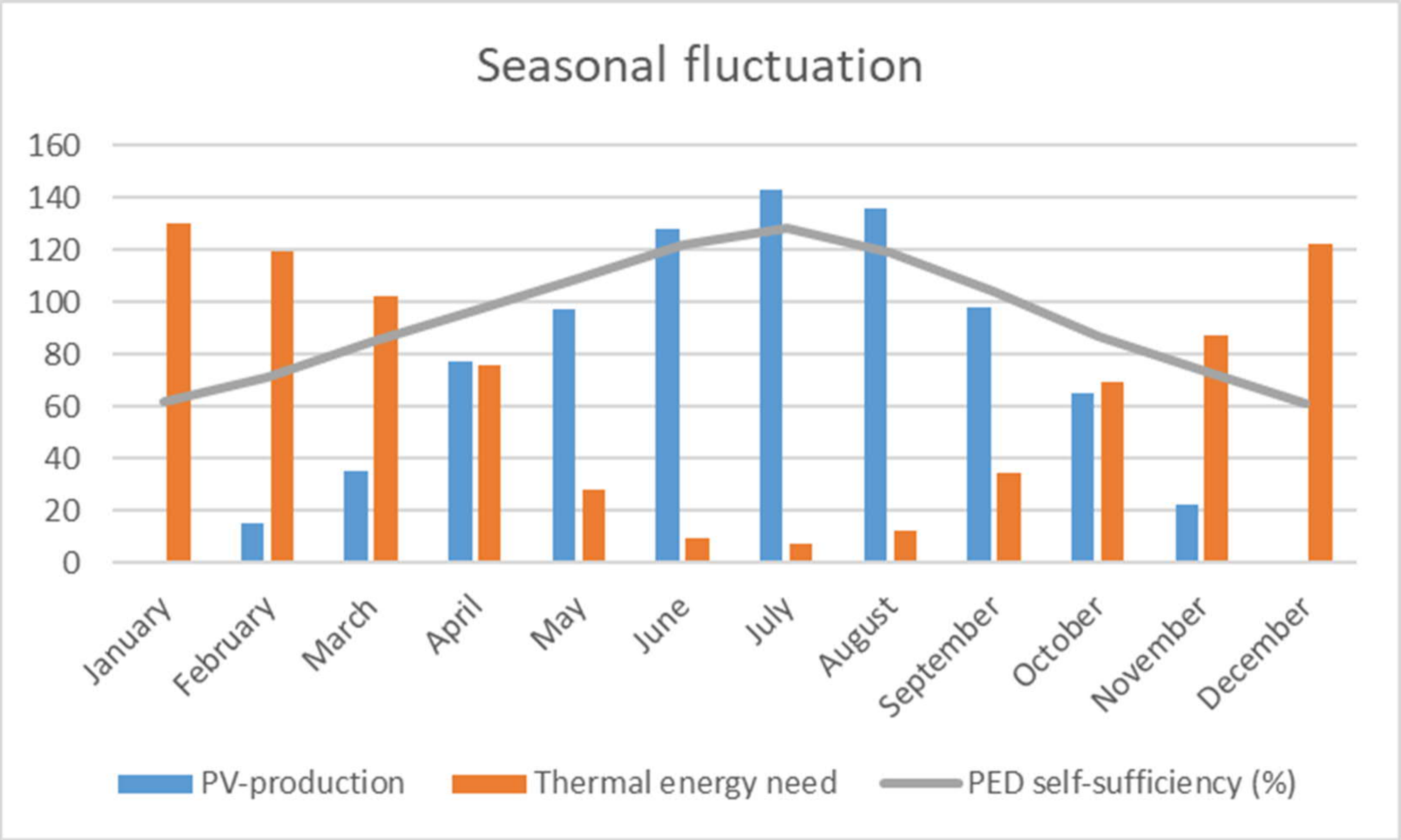
The effects of seasonal fluctuation

- From the system-optimal point of view
  - ”I.e. in spring time when days are getting longer, there’s plenty of sunlight and wind, but still need for heating energy to be produced efficiently from return pipeline with heat pumps”
  - Hottest time of the year not quite optimal, need for cooling rather than heating, but on the other hand Arina store is able to produce ample amount of thermal energy to DH-network.

- From the energy balance point of view
  - In principle, the PED is self-sufficient during the summer months, since there is plenty of solar power, and the need for heating is low (only DHW).
  - Coldest months of the year are most problematic, thus the need for centralized energy systems.



Best-case scenario: "Store with bigger heat pump system"

- There is now a larger heat pump system installed in a similar Arina-store elsewhere in Oulu, just to serve to boost the DH-network. If we had that in the PED, we could easily cover the thermal energy need in the whole PED-area.

Total net thermal energy need [kWh/y]	1 767 486
Total net electricity need [kWh/y]	1 119 578
Total primary energy [kWh/yr]	2 227 237

Total local thermal from RES [kWh/y]	1 800 000,0
Total local electrictiy from RES [kWh/y]	888 600,0
% of total net thermal energy need covered by local RES:	102 %
% of total net electricity need covered by local RES:	79 %

Total balance primary energy incoming [kWh/y]	- 439 583
Total eletricity incoming [kWh/y]	230 978
Total thermal energy incoming [kWh/y]	- 1 433 514
% of total net energy need covered by resources coming from outside district boundaries:	-20 %

Building energy consumption related GHG emissions emitted within the district boundaries

-	253	tons/yr

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Energy Flow Diagrams

- Dynamic energy flow diagrams under development: visual output for the (almost) real-time situation picture of the PED-area energy flows.
- With comprehensive monitoring & data gathering (energy parameters, market prices, outdoor/indoor conditions etc.) and predictive modelling, this could be used in the energy system optimization = how to drive the system.

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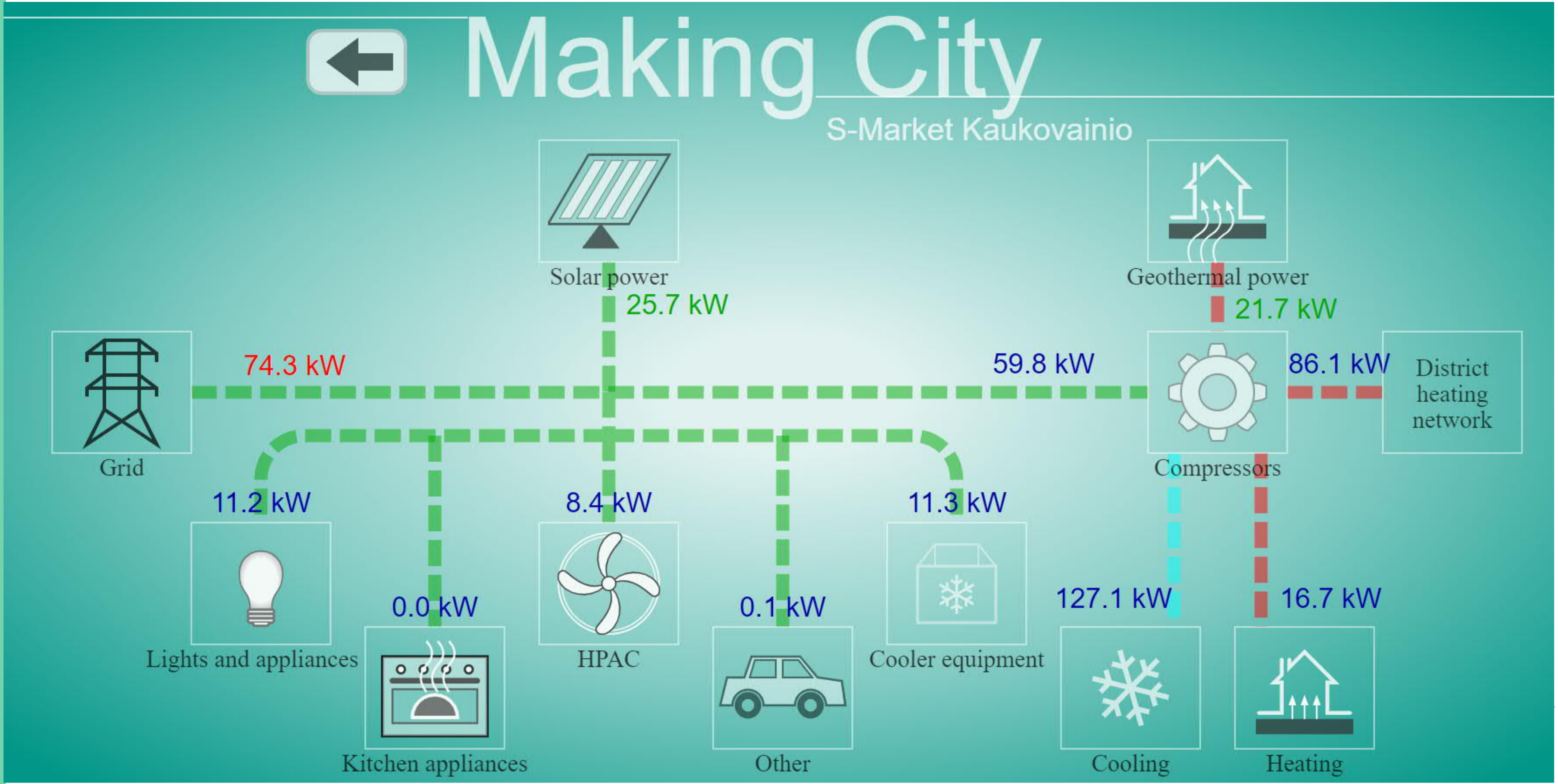
Energy Flow Diagram (Arina store)



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Any Failures? Not Success Story?

- The project is a good opportunity to demonstrate new ways of doing and technologies for replication. PED not necessarely the ultimate objective.
- Strict PED boundary is by far not the most feasible solution in the cold climate – the focus should be at city (DH-network) level, region level or even broader level, and the target should be the reduction of overall emissions as (cost-)efficiently as possible
- How to improve MAKING-CITY methodology?
  - 1) Focus needs to shift from yearly energy balancing to dynamic balancing or optimization of energy & emissions & euros. Doing right things at the right time.
  - 2) From district boundary to regional boundary -> reduction of overall GHG-emissions. This requires comprehensive retrofitting of building stock, more flexibility and cost-/co2-optimal energy production at right times combining centralized and distributed solutions, not only local RES, but also regional RES.

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The next step: net-zero emission regions?

Thank you

Get in touch for more information!

Jussi Rönty
jussi.ronty@vtt.fi

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Project information available on the MAKING CITY website: www.makingcity.eu
Contact us: contact@makingcity.eu