Design Your City's Net Zero Strategy: Online Planning Lab

NetZeroCities online course for all cities

September 16th- December 11th 2025

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30/10/2025

Module 4 - Spotlight session 2

Systemic energy transition at buildings, districts and city level

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Agenda

1. Introduction
2. Energy transition in cities
3. Systemic approach to developing the action plan for the energy sector
4. Real life example: leading the systemic energy transition in Espoo, Finland
5. Speed up the energy transition – the implementation support
6. District energy planning

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Learning objectives for this session

- The role of cities in energy transition
- How cities can lead and speed up energy transition in a systemic manner
- To learn about the holistic approach to reducing carbon emissions includes heating, cooling, and electricity demand, distribution and production through practical cases:
  - Espoo's process and approach to systemic energy transition
  - district level energy planning,
  - positive energy district development process and principles

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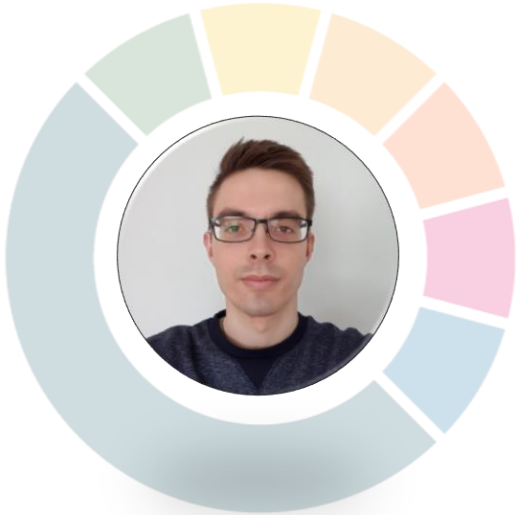
Who we are…

Mari Hukkalainen

Principal Scientist

VTT Technical Research Centre of Finland



Joni Mäkinen

Energy Specialist

City of Espoo, Finland

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Let’s get started: Energy transition

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System of systems

Interconnected, complex structures that shape how cities produce, distribute and consume energy

Systemic approach, focus on stationary energy

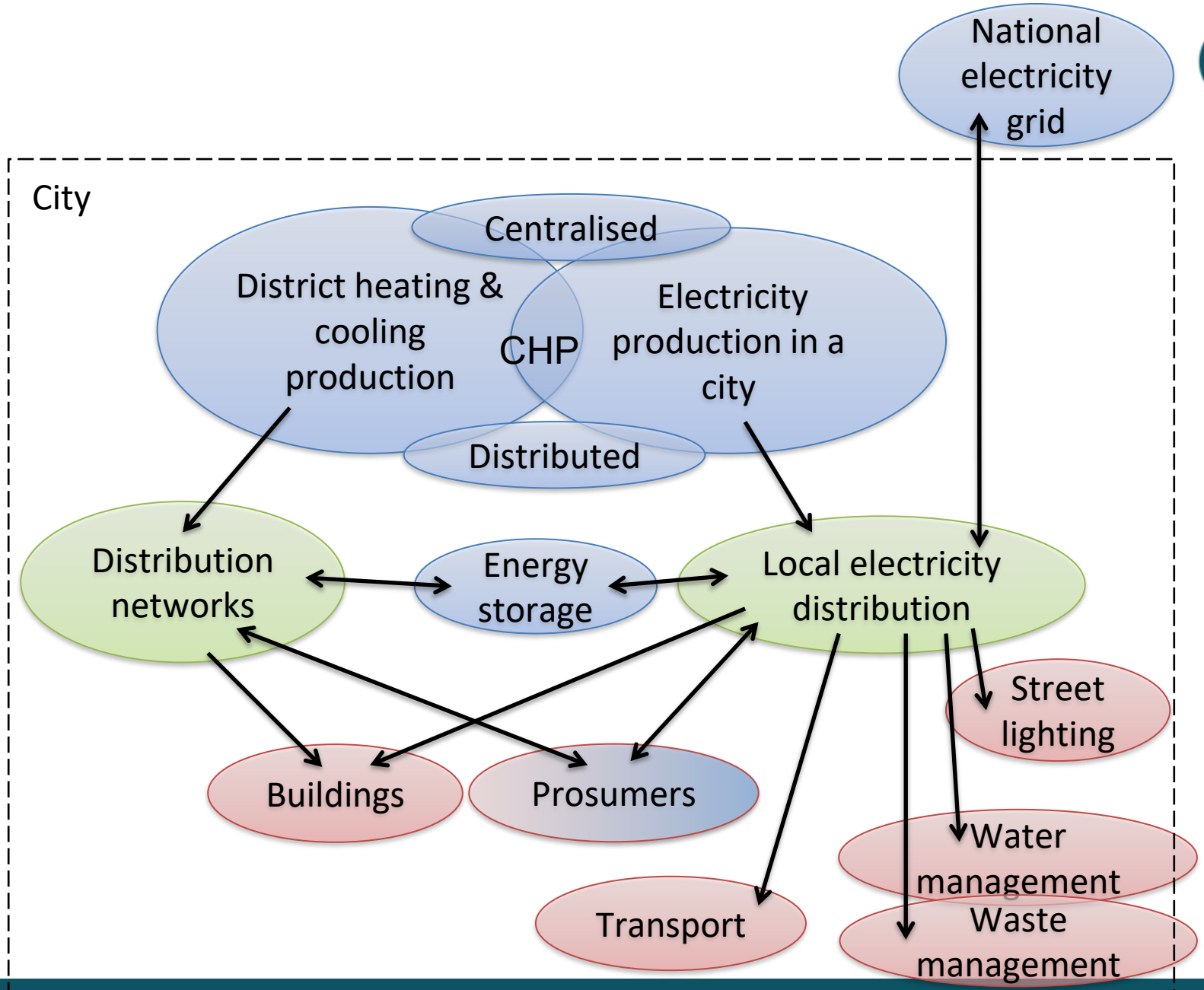

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Figure from: https://aaltodoc.aalto.fi/items/02e6bda9-28e5-4d49-be01-9f7d9533d19b

Systemic approach to cities' energy transition towards climate neutrality

- Energy efficiency
- Replacing fossil fuels with renewable, greenhouse gas emission free energy sources
- District heating and cooling: alternatives for fossil energy and burning based heat production, low temperature networks
- Energy flexibility
  - Buildings and energy users as active nodes of the energy system
- The resilience of energy system (security, safety, reliability)

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How to speed up the transition?

Across levers of change:

- policy, regulations and governance
- citizen and stakeholder engagement, social equity
- finance,
- monitoring, evaluation and learning

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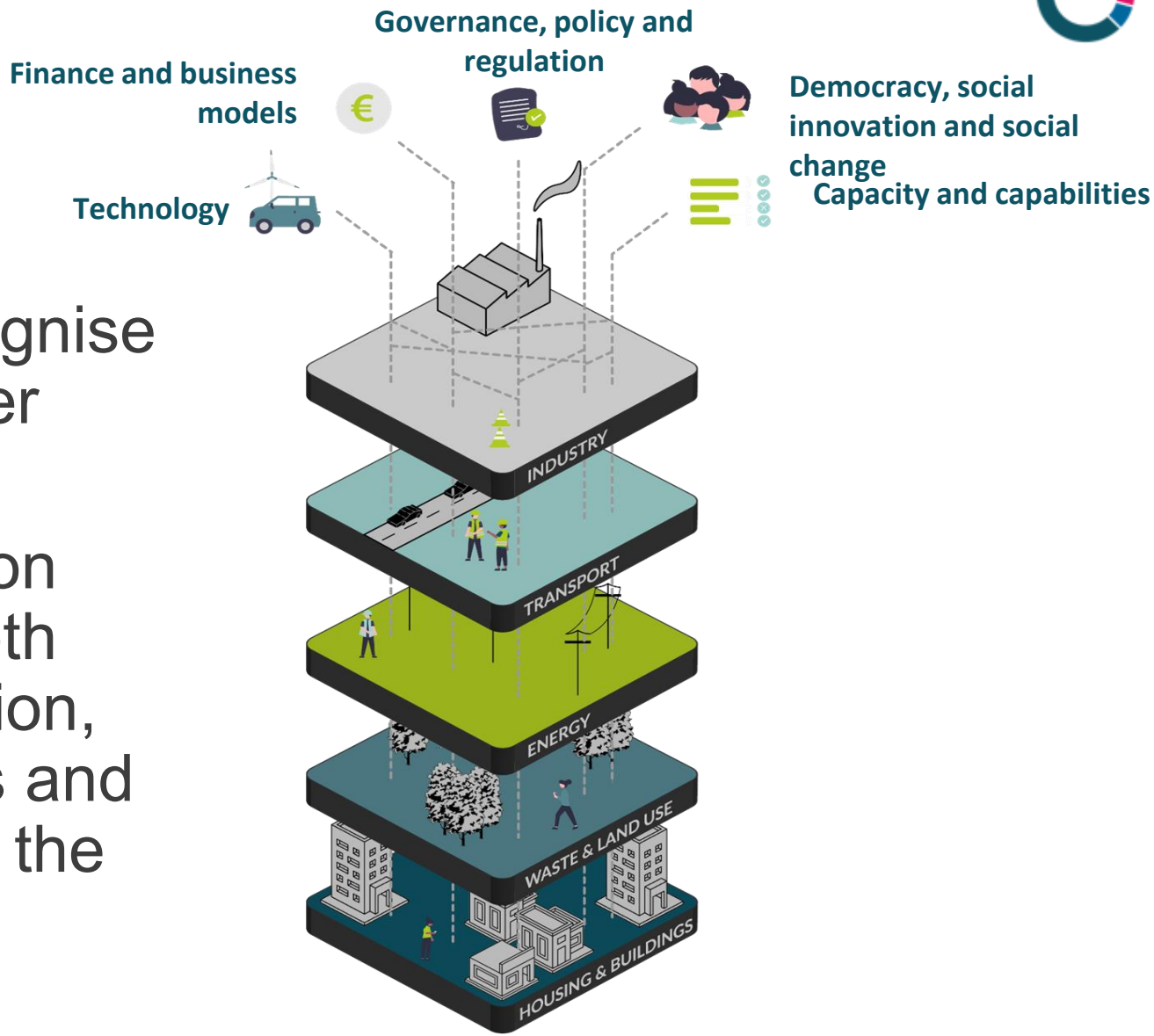
Systemic levers for energy sector

- During action planning: regognise the connection points to other sectors' emissions
- Implemening energy transition requires often support for both direct technical implementation, but also on removing barries and utilising the enables through the systemic levers



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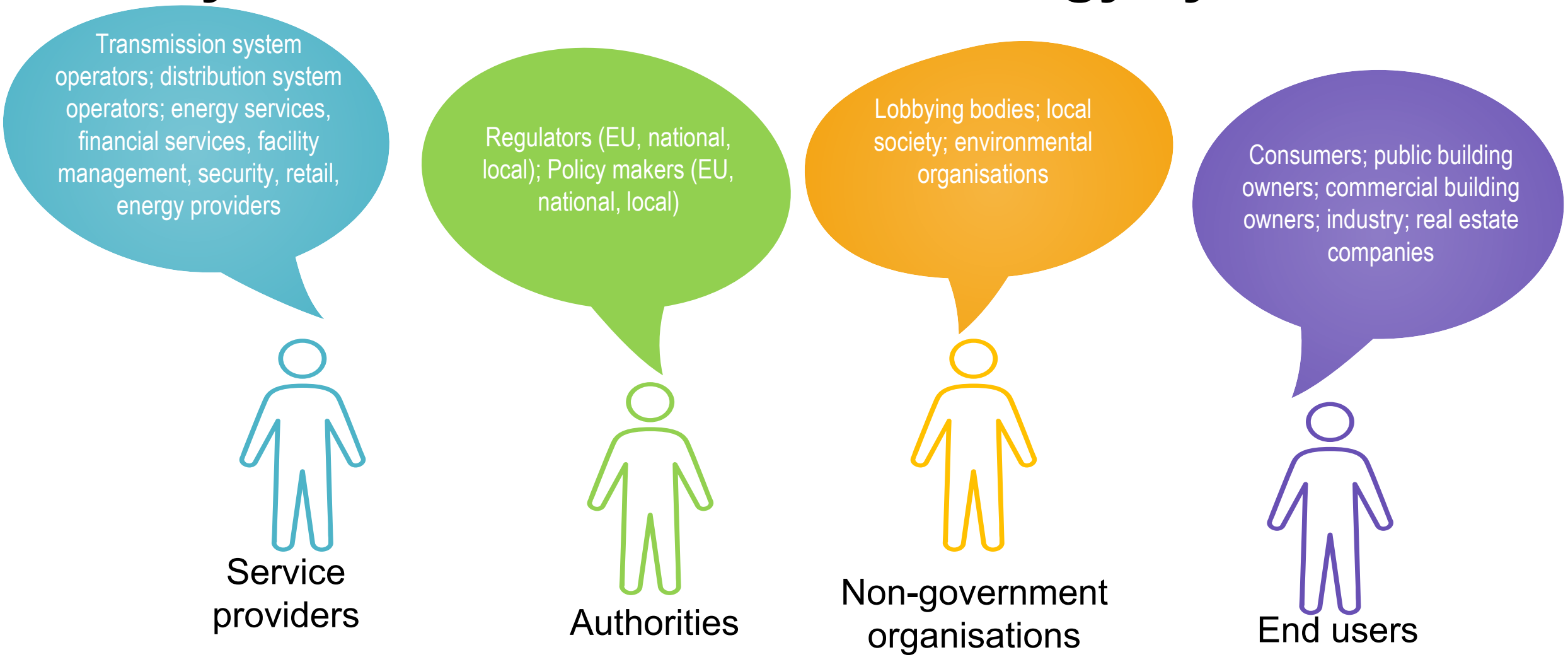
Energy transition needs actions at different governance levels

- National level & EU:
  - Electricity production from large central plants
  - Sustainable fuels (biogas, hydrogen)
- Cities:
  - Broad range of sectors and levers of change
  - The role and the responsibilities of the cities
- District/neigbourhood and buildings:
  - Energy efficiency
  - Local sustainable energy sources
  - The charasterics and master planning, local services, citizens and businesses

NZC EU Policy Lab on Heating & Cooling and Electrification Policies is now on-going.
Policy Lab document;
Policy Labs group at the mission portal

The focus of this session

Key stakeholders of district energy systems



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Collaborating with stakeholders

- Additional energy focused examples from NZC seasonal school
- Module 2 sessions: spotlight 2 and 3
- NZC Civic engagement mapping tool
- NZC Shaping Narratives Canvas

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What are the roles of local government in energy transformation

Planner	Public buyer	Regulator	Enabler	Convener
• urban planning and infrastructure development	• public procurement	• Local regulation	• supporting actors	• facilitating collaboration and co-creation

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Portfolio mapping for energy transition

Action planning: Identify and plan the actions needed at local level

→ These should be part of your CCC

→ Implementation of the action plan: often needs more specific portfolio planning

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Thermal energy: heating and cooling

The portfolio approach to speeding up energy transition

1) Phasing out the use of fossil fuel for heating in buildings

   Retrofit of buildings through policy and citizen & stakeholder engagement: citizens and companies will need to retrofit incl. e.g. buying heat pumps and/or connect to district heating

   Nearly zero energy buildings, active and passive solutions

2) District heating and cooling transition:

   via policy, citizen and stakeholder engagement, and business models and governance/collaboration models: full ownership like in Copenhagen, PPPs (Bristol), concessions (Paris), or private but regulated (Warsaw).

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Electricity

The portfolio approach to speeding up energy transition

1) Electrification of heat production (heat pumps), mobility (EV charging) and industries:

Increase of the power demand

increasing of energy efficiency is important

2) Distribution grids: smart grid solutions: energy flexibility and storage, and upgrades to the electricity grid.

3) Green electricity contracts, local low carbon electricity production

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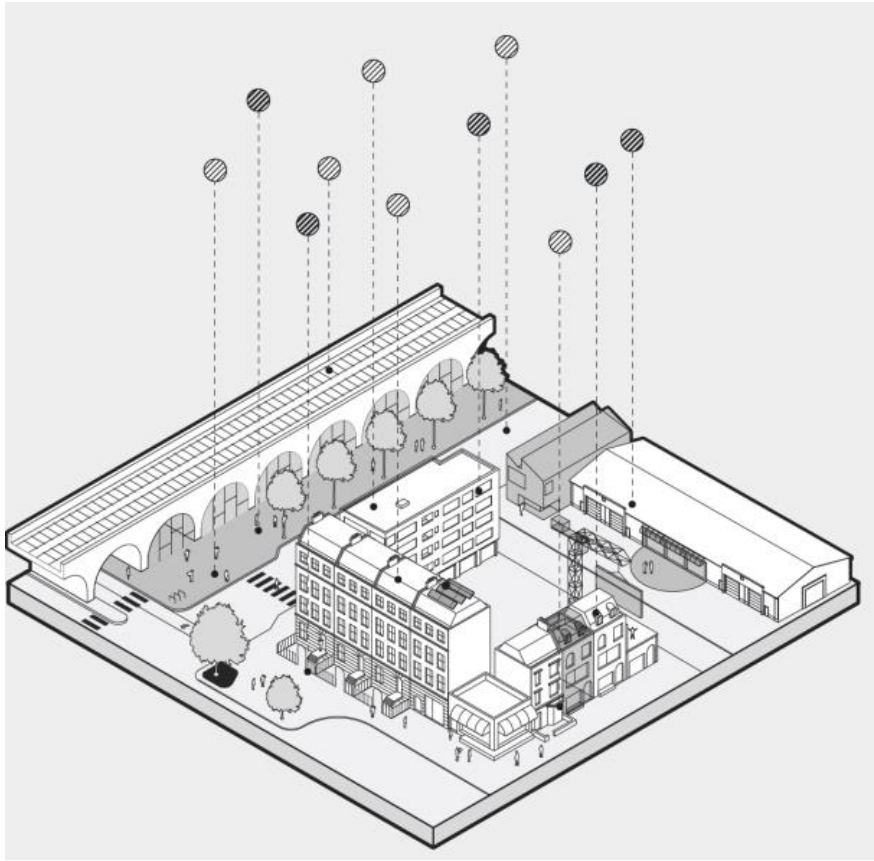
Portfolio planning approach

- Many cities have strong ambition level. The real challenge is the coordination and implementation.
- Systemic portfolios can help connect the dots, turning isolated actions into change across systems.
- Additional reading, examples and visualisation: NZC seasonal school presention on energy focused portfolio planning



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Example: Umeå, Sweden: best practises

Systematic pathways for transformation

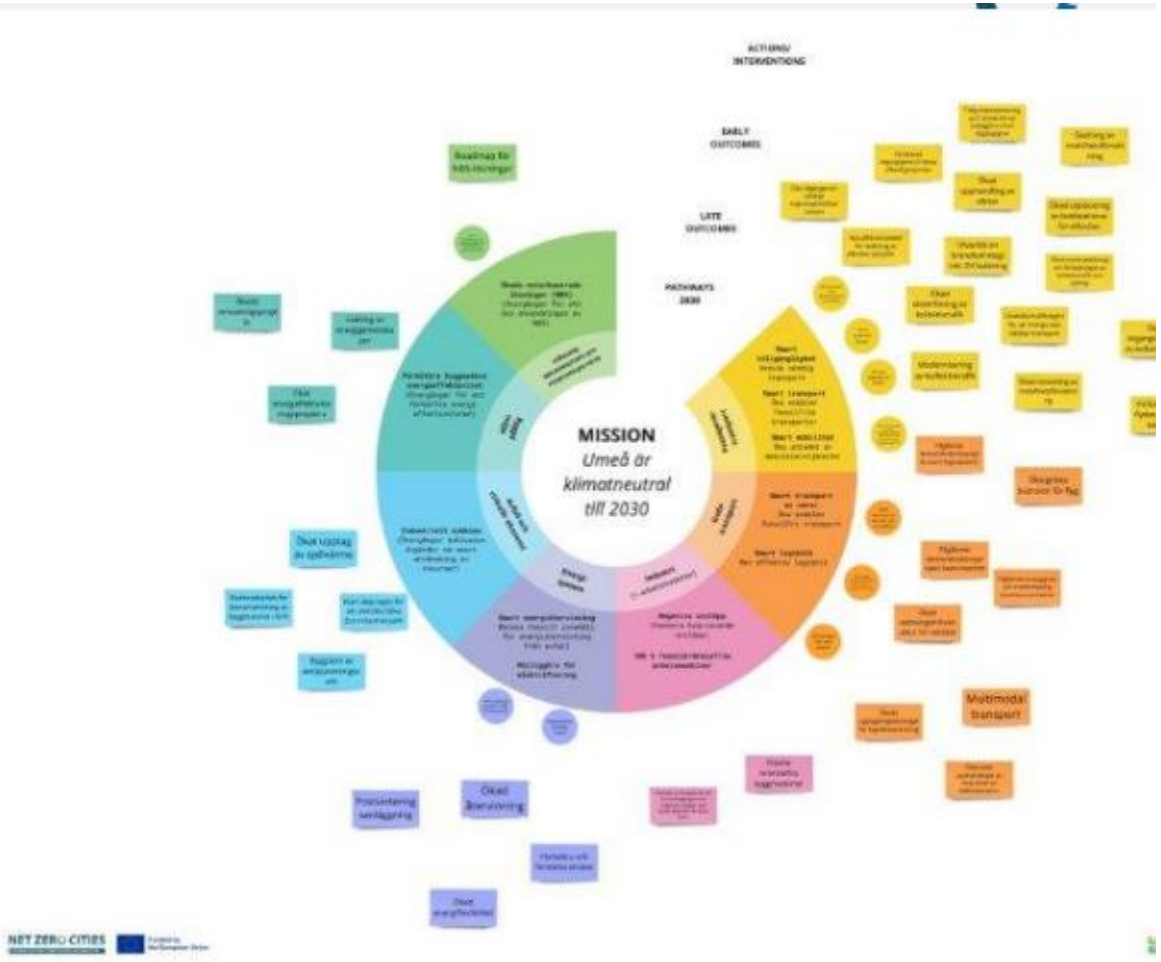
Umeås Pathways show structured paths that describe how Umeå can approach climate neutrality by 2030.

Comprehensive pathways for long-term sustainability

Each Pathway is designed to actively transform key sectors of society, such as electrifying transport, streamlining energy use and developing circular systems.

Dynamic and co-designed

Umeås Pathways are not static; they develop over time through collaboration between different actors, including the municipality, businesses and citizens.



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What systemic energy transition practically means? How to advance it?

How is it possible approach such a complex and ambitious goal?

Let’s hear an example from the City of Espoo, Finland

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Systemic Energy Transition in Espoo

Progress on the Climate Neutral Espoo 2030 target

Espoo has defined as its climate neutrality goal an 80% emission reduction from the 1990 level by the year 2030. The remaining 20% share can be absorbed in carbon sinks or compensated by other means.

From 1990 to 2024:
Regional emissions -33 %

From 1990 to 2024:
Emissions per capita -64 %

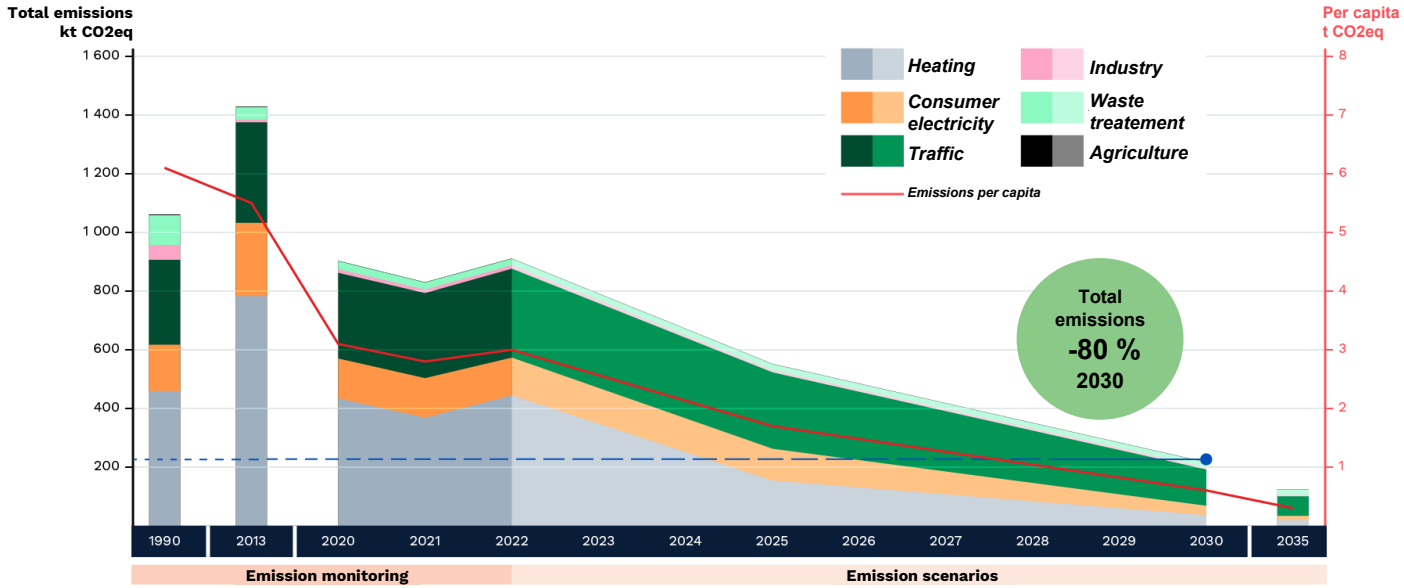
To achieve the climate neutrality target, significant emission reductions will need to continue in the coming years.

Emissions development from 2021 to 2025:

- Climate emissions in the Espoo region have decreased significantly despite strong population growth.
- Climate emissions per capita in 2024 were the lowest in the metropolitan area for the eighth consecutive year.

Main climate actions that have reduced emissions:

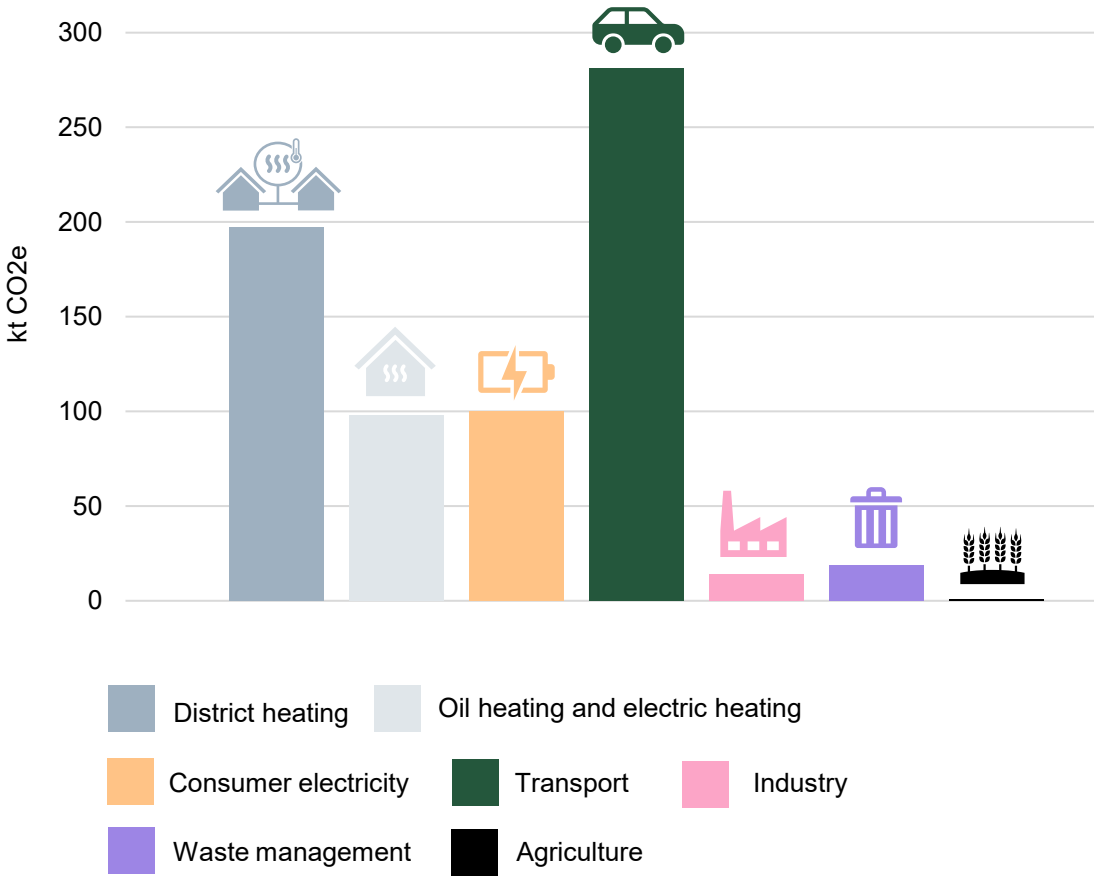
- **Heating:** phase-out of coal in district heating in April 2024, investment decisions by Microsoft and Fortum on waste heat recovery from the Hepokorpi data centre.
- **Consumer electricity:** clean-up of national electricity generation, increase of local renewable energy and improvement of energy efficiency.
- **Transport:** electrification of the vehicle fleet ahead of the rest of the country, significant investment in rail infrastructure and promotion of sustainable transport modes. The share of public transport, cycling and walking increased from 53% to 59% in 2019-2023.
- **Land use and construction:** directing urban growth to rail connections, sustainable construction and renovation.



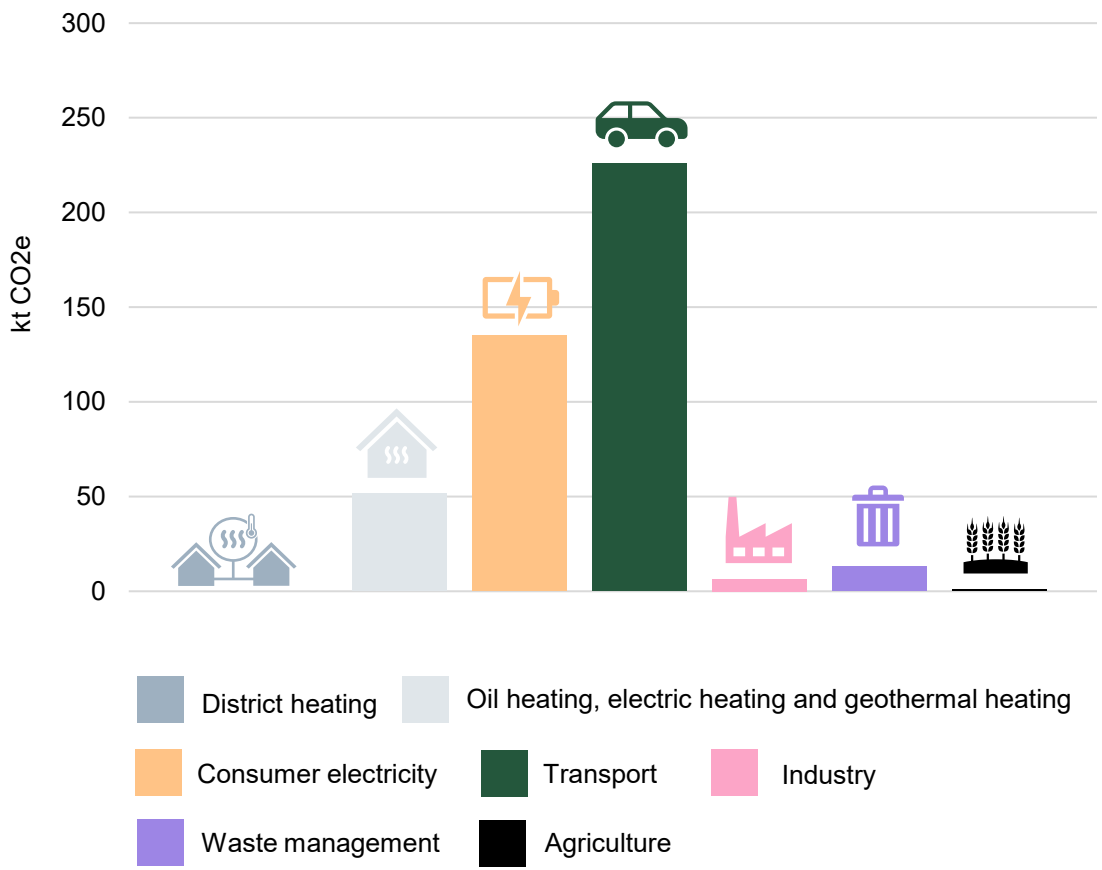
Source: Greenhouse gas emissions in the Helsinki Metropolitan Area HSY 2023 and Climate Neutral Espoo 2030 roadmap scenario work 2025.

Emissions from transport and consumer electricity dominate climate emissions as district heat production becomes climate neutral

Emission distribution in 2024



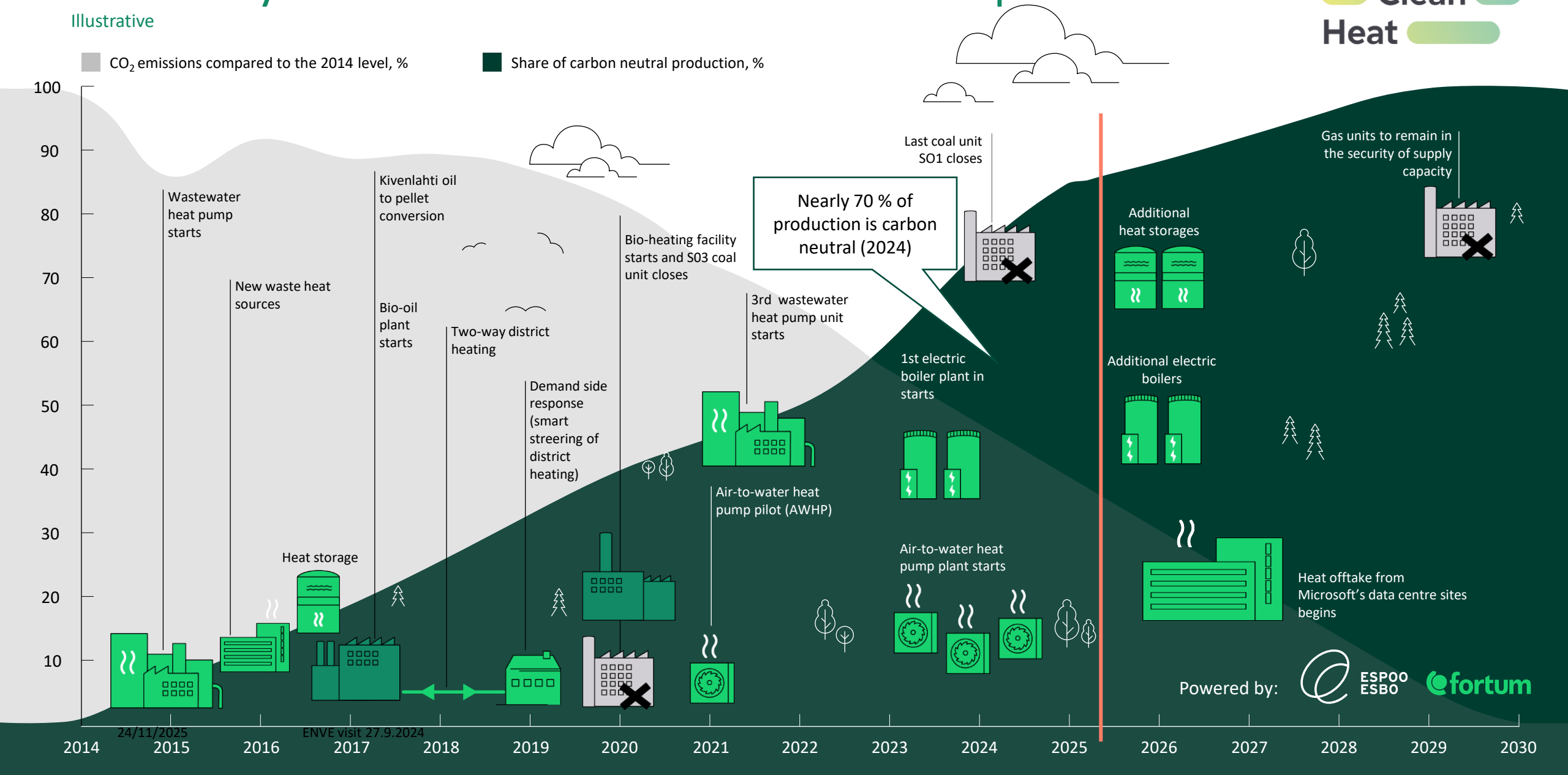
Estimated emission distribution in 2030



Electricity-based heat decarbonisation in Espoo

Illustrative

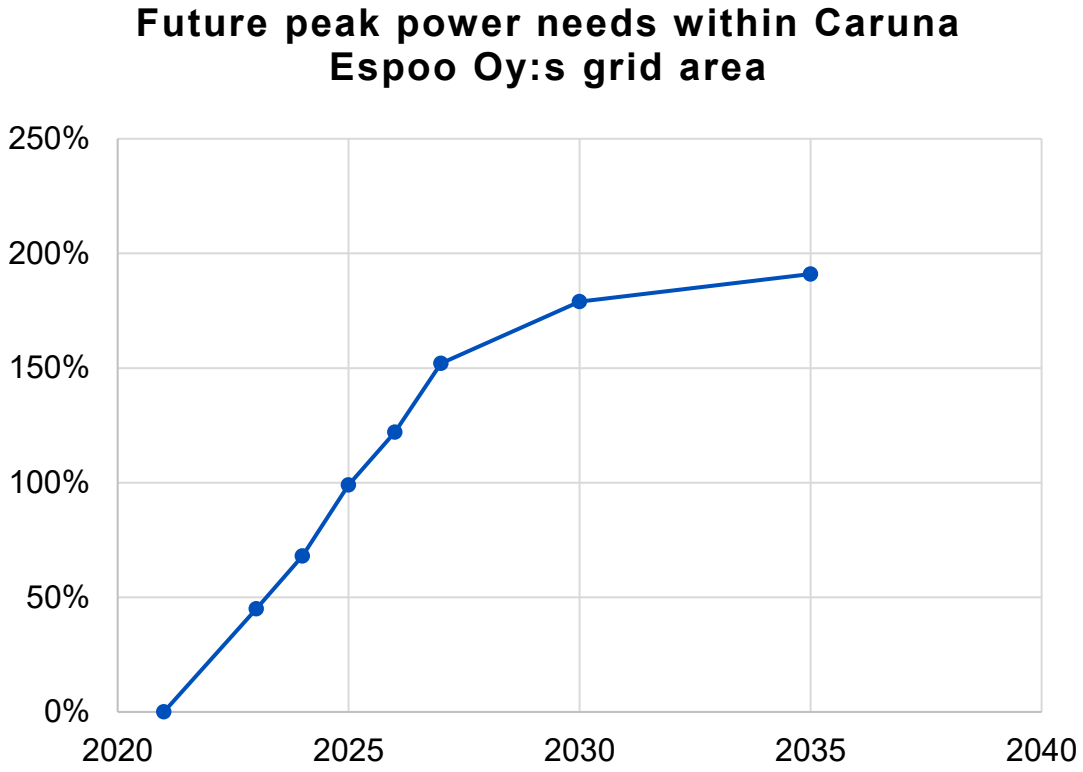
Espoo Clean Heat



Powered by: ESPOO ESBO fortum

Major future challenge is proactive development of the power grid to meet increased peak power needs

- Electrification of district heating significantly increases electricity consumption and peak use through electric boilers, heat storage and heat pumps. Meanwhile, local production is reduced through the closing of CHP plants, leading to increased needs of transmitting electricity from other parts of the country
- Use of ev's and battery storage increases electricity consumption peaks of household consumers, as consumption is optimized towards the cheapest hours
- Peak consumption in Espoo has risen 46 % between January 2023 and 2024
- Peak power needs are forecasted to rise even over 100 % during this decade
- Answering the challenge of rapid electrification requires proactive development of transmission and distribution grids, and new flexible solutions as support



Forecast of future peak power needs within Caruna Espoo Oy:s (local DSO) grid area. It must be noted that this includes a few other urban areas, such as Joensuu. Source: Caruna

Study on the direct and indirect impacts of investments made towards the development of the Espoo energy system

Report has been funded by

City of Espoo's share of the work is a part of the Espoo Climate Community (COMET) –project. This project is funded through the EU Pilot Cities programme, which is a learning and piloting programme aimed towards cities chosen for the 100 climate neutral cities mission.

Executive summary

This study assessed the impacts of the development of Espoo's energy system

Core question: What does the development of Espoo's energy system enable?

- The clean transition has great potential to create significant added value in Finland. However, the transition is an entity consisting of interconnected parts of the value chain and investments in them. Grid investments are an essential part of the clean transition as a whole and a significant enabler behind the economic impacts of the phenomenon.
- The future growth of the City of Espoo and the carbon neutrality targets require the development of the energy system and a significant increase in the capacity of the electricity system. The goal is to double the capacity of the electricity network by 2030.

The objectives of the work: Caruna, Fingrid, Fortum, CLC, and the City of Espoo requested a study from Sweco to examine:

- What investments are required for the development of Espoo's energy system, what are their regional economic and emission impacts, and what further investments do they enable?
- What activities will energy system investments enable in Espoo and what is the impact of these activities on the economy and emissions?
- What is the overall schedule for investments in the development of the region's energy system?

Overview of the findings:

Hundreds of millions of euros have been invested—and will continue to be invested—in Espoo's energy system in the coming years…

fortum	Investments in district heating 2015-2029	300 M€
caruna	Distribution network investments 2020-2033	250 M€
FINGRID	Transmission grid investments 2020-2033	440 M€

Enables the development of the energy system through e.g. own investments and land use planning

CLC is Europe's largest non-profit network of companies in the climate sector, supporting its members in strategic climate work

… which creates a **wide range of benefits**

*Direct and indirect investments bring **approximately 1 000 jobs and EUR 23 million annual tax revenue to Finland** during their life cycle.*

*The additional network capacity **enables new investments** – such as data centers – to be implemented.*

*Investments in district heating will **reduce carbon dioxide emissions from district heating production by more than 95% by phasing out fossil fuels**. Network investments enable the **electrification of transport**. Espoo's emissions are decreasing, even though the population is growing.*

*Infrastructure investments are a prerequisite for **housing construction** and for the development of Espoo, for example with regard to **rail connections**..*

*The development of the electricity network increases the **resilience** of the infrastructure and enables active **consumer participation in the energy market**.*

Summary of the impacts of the development of the energy system in the Espoo region

Billion-euro investments in Espoo's energy system will create hundreds of jobs and enable a 65% reduction in emissions

Climate goals, Espoo's population growth and electrification require...

Carbon-neutral Espoo by 2030

Strong growth of the city

A pioneer in electrification

.. investments in the development of Espoo's energy system...

1 000 M€

Investments in district heating and electricity distribution networks and the transmission grid

fortum

caruna

FINGRID

Enablers

ESPOO ESBO

CKC

... which create significant economic impacts and emission reductions...

240

Jobs from direct investments[1]

790

Potential jobs from indirect investments[2]

23 M€

Tax revenue to Finland annually[3]

-65%

CO2 emission reduction[4]

... and enable other benefits for city residents and the economy

Enabling vibrant and sustainable growth

Electric transport makes everyday life smoother

Opportunities to participate in the energy market will improve

Enabling the development of residential areas

The level of security of supply will improve

1) Annual jobs created in Finland by investments in district heating, electricity distribution networks and the transmission grid, 2) Annual jobs created in Finland by indirect investments (data centres, hydrogen plant and electrification of industry) enabled by direct investments (theoretical estimate), 3) Corporate and income tax generated by direct and indirect investments in Finland annually, 4) Espoo's CO2 emission reduction 2015–2030, current and forecasted

SWECO

Benefits of energy system development from the perspective of city residents

A sustainable energy system adds flexibility to everyday life and improves the quality of life for city residents in many different ways

In addition to supporting economic and emission targets, city residents' personal opportunities to influence daily life are also improved

Investments create jobs and generate tax revenue	• In addition to their direct employment impact, investments also improve economic security in other ways, as increasing tax revenues enhance the city's ability to provide services such as education and support sustainable economic planning.
Electric transport makes everyday life smoother	• The development of the electricity system has already made everyday life and mobility easier for city residents, for example through the expansion of rail transport and the electrification of public transport, and the improvement of transport continues.
Opportunities to participate in the energy market will improve	• Increasing connection capacity improves households' opportunities to participate in the energy market, for example through solar panels, battery systems, and private charging points. This also increases the possibilities to optimize energy use and achieve cost savings.
Electrification reduces emissions significantly	• The electrification of district heating with fossil-free energy is one of the most significant ways to reduce emissions in Espoo. Residents' opportunities to make more sustainable choices in their energy use are also improving, both in terms of electrifying transport and housing.
Enabling the development of residential areas	• Investments in electricity and district heating networks are a prerequisite for developing both new and existing residential areas. In addition, infrastructure for electric vehicle charging, low-carbon public transport, and competitive district heating are becoming increasingly accessible to city residents.
The level of security of supply will improve	• Investments in the electricity grid and sector-integrated district heating that enables demand-side flexibility improve security of supply by reducing the risk of network disruptions, such as power outages. They also reduce dependence on fossil fuels and increase the share of domestic production in district heating.

SWECO

Proactive development of the energy system is a prerequisite for sustainable growth and the achievement of climate goals

The growth of the population and energy demand, as well as strong electrification, require investments in the energy system

Key principles for the development of Espoo's energy system

Strong growth while achieving carbon neutrality targets

Espoo's population is estimated to grow by more than 40% between 2015 and 2033, which also means a strong increase in energy and power demand. Espoo is one of the fastest electrifying cities in Finland, which is reflected, for example, by the highest number of electric cars per capita.

Espoo is committed to implementing growth in a climate-friendly manner and has set itself the goal of achieving carbon neutrality by 2030.

Maintaining and promoting the vitality of the city

Espoo's goal is to be Finland's most vibrant and safe international pioneer of education, competence, innovations and business.

Investments in the energy system improve the conditions for business and improve attractiveness with direct and indirect effects from the perspective of both business and housing.

Securing the availability of fossil-free electricity and sufficient capacity

Electrification enables a significant reduction in emissions when the electricity used is fossil-free.

In order to ensure the uninterrupted supply of fossil-free electricity, the electrical energy system must be developed by increasing transmission and distribution capacity.

To meet the need for power, the electricity network operators, Caruna and Fingrid, aim to double the capacity of the electricity network by 2030.

Proactive climate cooperation with energy sector actors

The city does not own energy companies or electricity networks, so cooperation with industry stakeholders is key to achieving the goals.

One of Espoo's most important climate actions is the carbon neutrality project, implemented with Fortum, which aims to reduce emissions from district heating. Electrified district heating is a prerequisite for sector integration that benefits the entire city, allowing investments to support one another.

ESPOO
ESBO

The financing, procurement and policy innovation for energy transition

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The elephant in the room: How to finance the transition?

- Cities cannot finance the largest part of the transition.
- The investments of businesses and citizens are the game changer
- Cities have power to lead the transition, through the levers of change to speed up the decarbonisation of urban energy systems
- Own module about financing up-coming at module 5
- Link to additional reading: project preparation (NZC seasonal school material)

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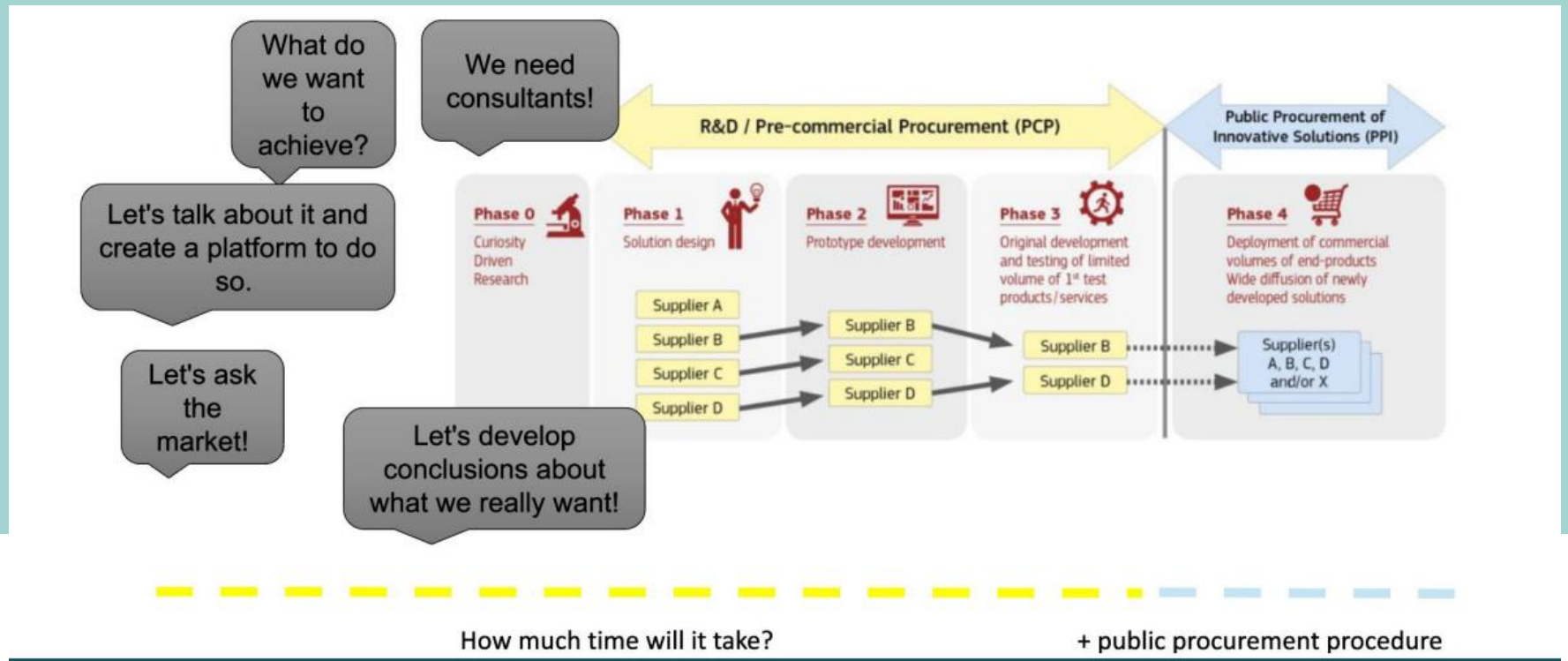
Innovation in Procurement

- Cities spape the markets, not just respond to them.
- Module 6, spotlight 6 session upcoming.
- Additional energy specific reading: link



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Let's talk about policy

A simple yet powerful trio:

➔ multi-actor (diverse perspectives & coalitions);

➔ multi-instrument (broadening the policy toolbox); and

➔ multi-level (considering various scales of governance)

Additional reading: link

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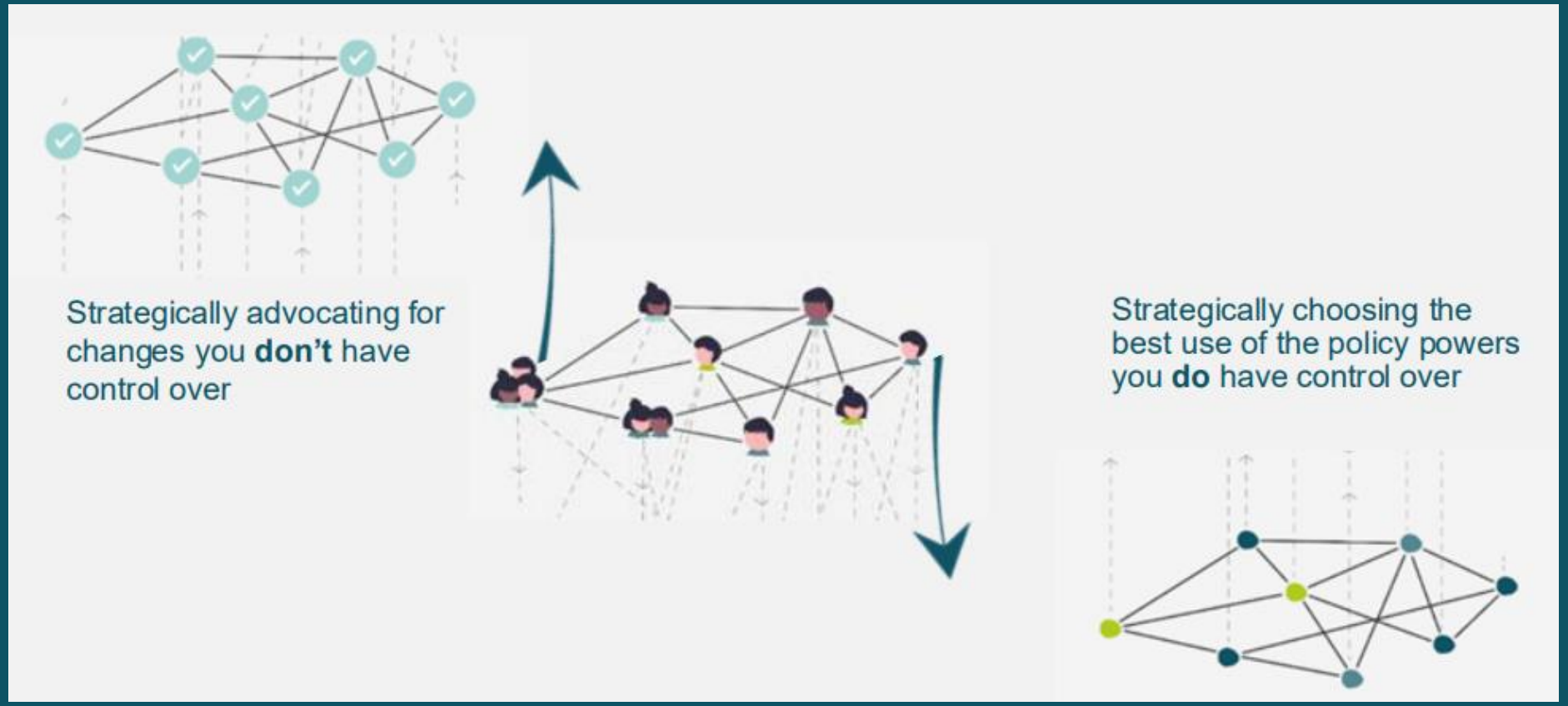
Let's talk about policy

Join to the Module 6 – spotlight 1



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Concepts and approaches for the district energy planning and energy transition

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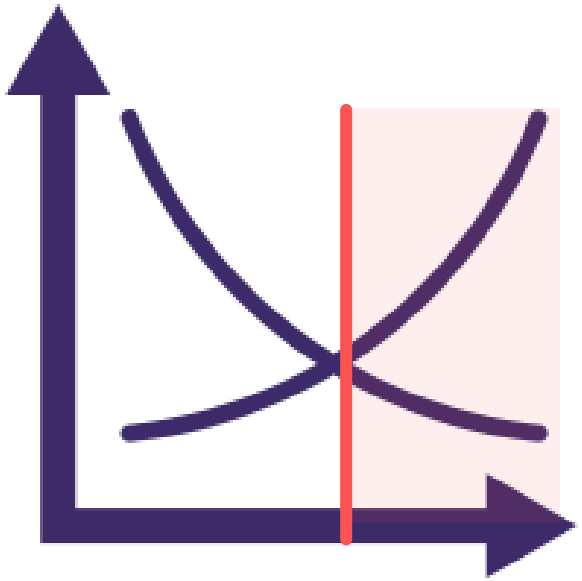
Positive energy district approach



Energy flexibility
Connections to energy grid, district heating and cooling

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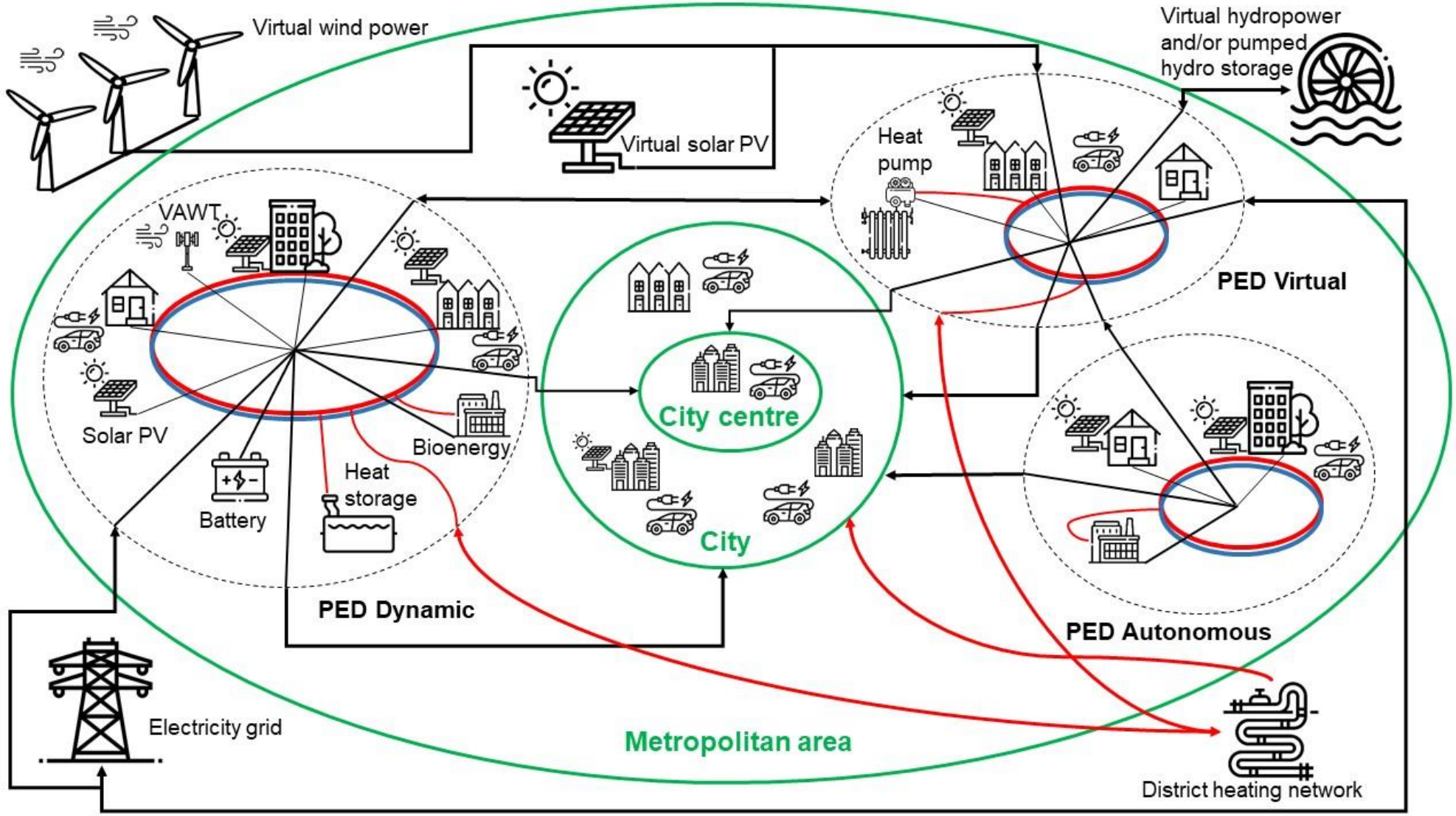
Localising PED & renewable energy solutions



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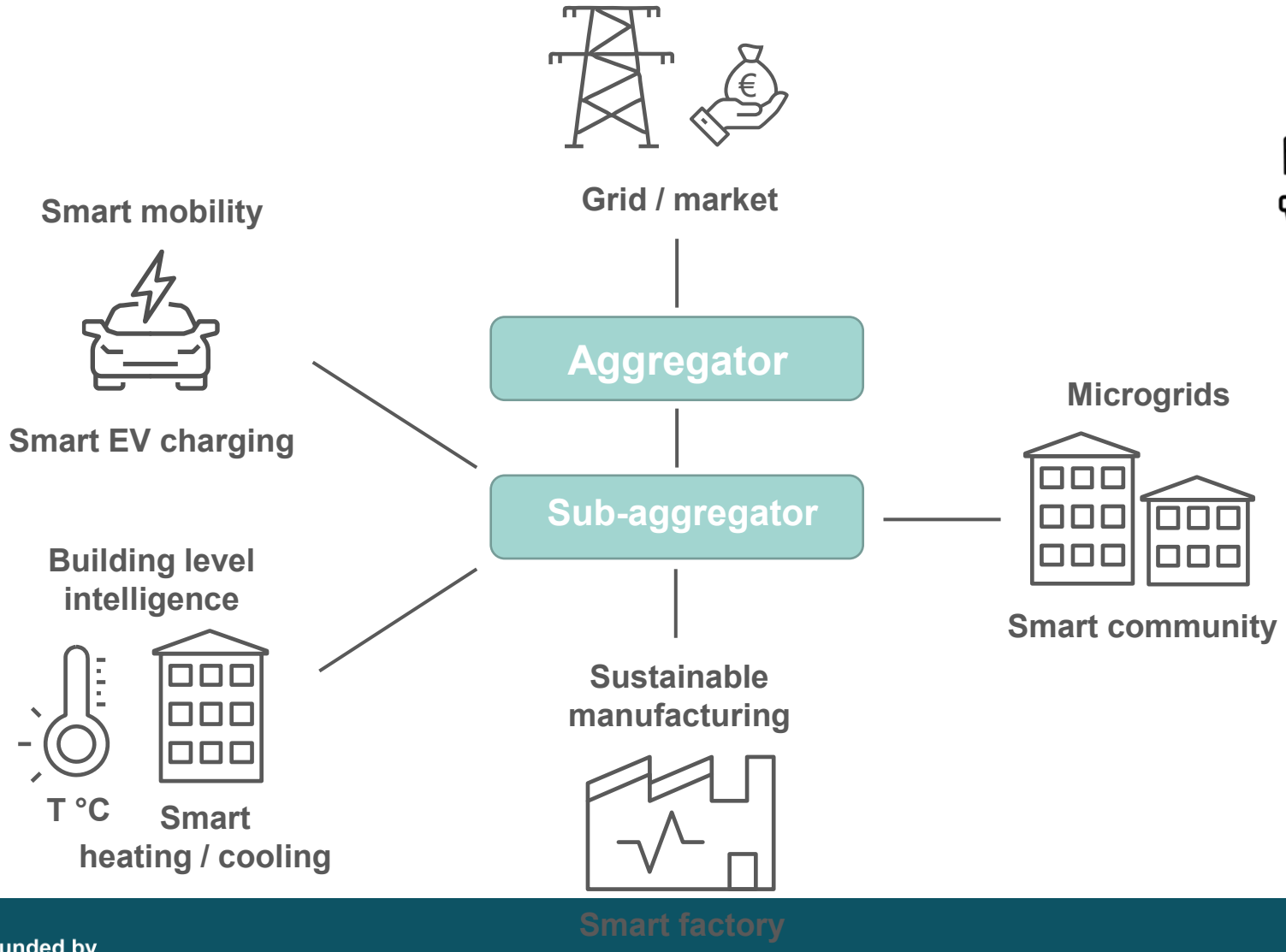
Power grids: Energy flexibility value chains



New business logics and possibilities around flexibility provision

New roles and actors

Interfaces are essential

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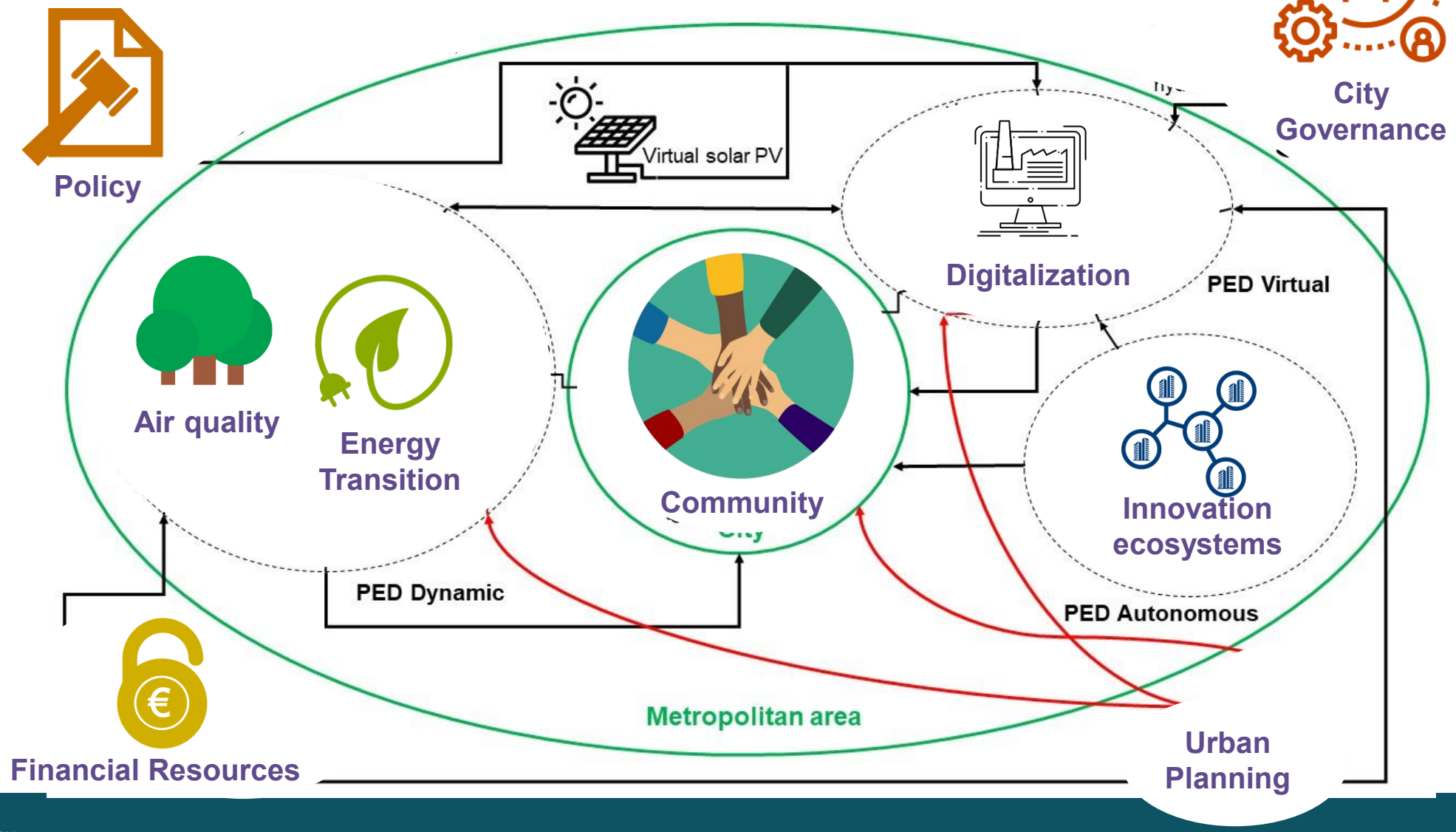
BUT PED is also…



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Monitoring, evaluation and learning

Real data behind PED demonstrations

Why data-driven approaches are very important in assessing the impact of PED projects?

- Real time monitoring and adaptive management
- Optimization of resources
- Benchmarking
- Data visualization
- Stakeholders' engagement
- Social equity

More in Module 3 – spotlight; and ppt on MEL energy examples

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Integrating energy into urban planning

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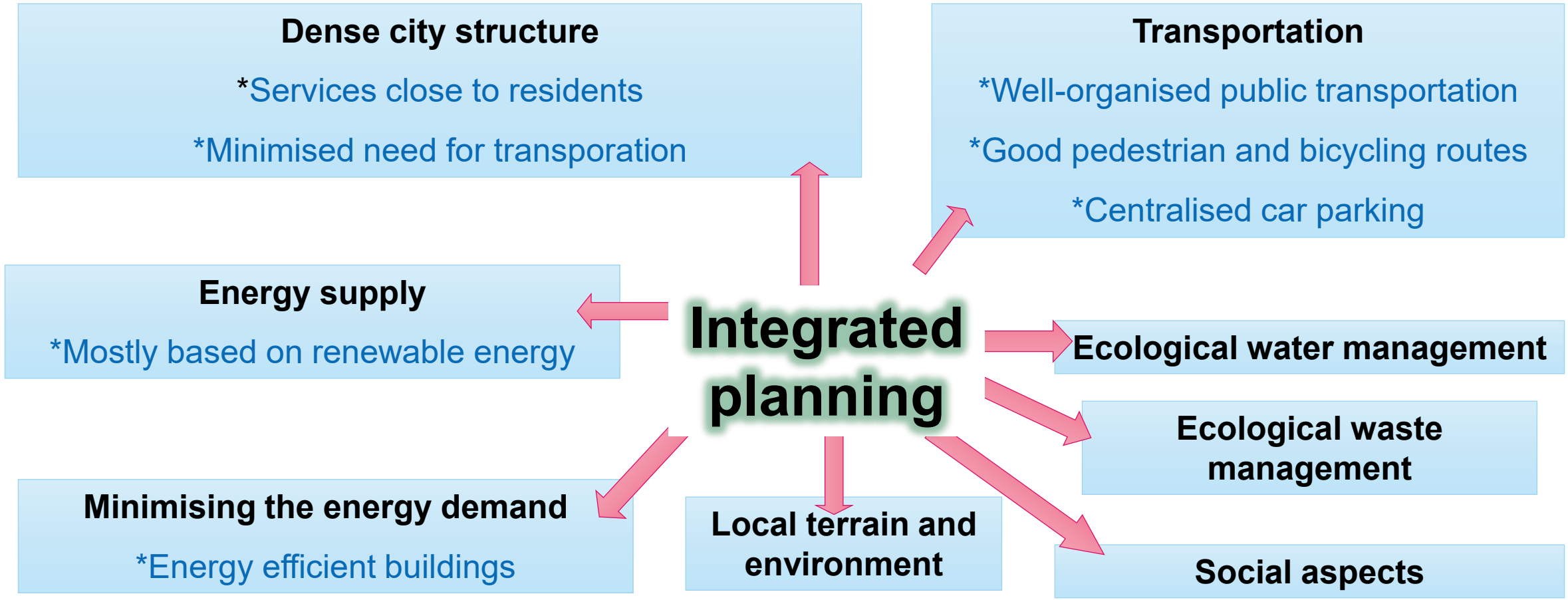
Basic elements of integrated urban energy planning



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PED-readiness enabled by urban planning

- Goals for energy performance (demand, integrated energy solutions, storage, EV integration, demand response, buildings smart readiness indicator, energy flexibility capabilities) can be enacted through urban planning for new areas
- Eg. Via terms in the lot release terms – if land is owned by municipality
- Co-creation model for
- (D3.7 Replicating the smart city lighthouse learnings in Espoo: technical, social and economic solutions with validated business plans - Sparcs)
- Or Co-creation model for finding shared goals Instructions for using the toolkit

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Mapping local renewable energy potential

- Heat pumps: Local heat sources (ground, water, air, industrial processes, data centers, waste water treatment plants etc.)
- Solar energy: Photovoltaics and solar thermal
- Other renewable energy sources, e.g wind, wave, water, green hydrogen, biogas, etc.
- The future strategy for district heating and cooling
  - Low carbon temperatures for distribution in neighbourhoods
- Energy storage needs, space allocations

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Examples about POSITIVE ENERGY DISTRICTS

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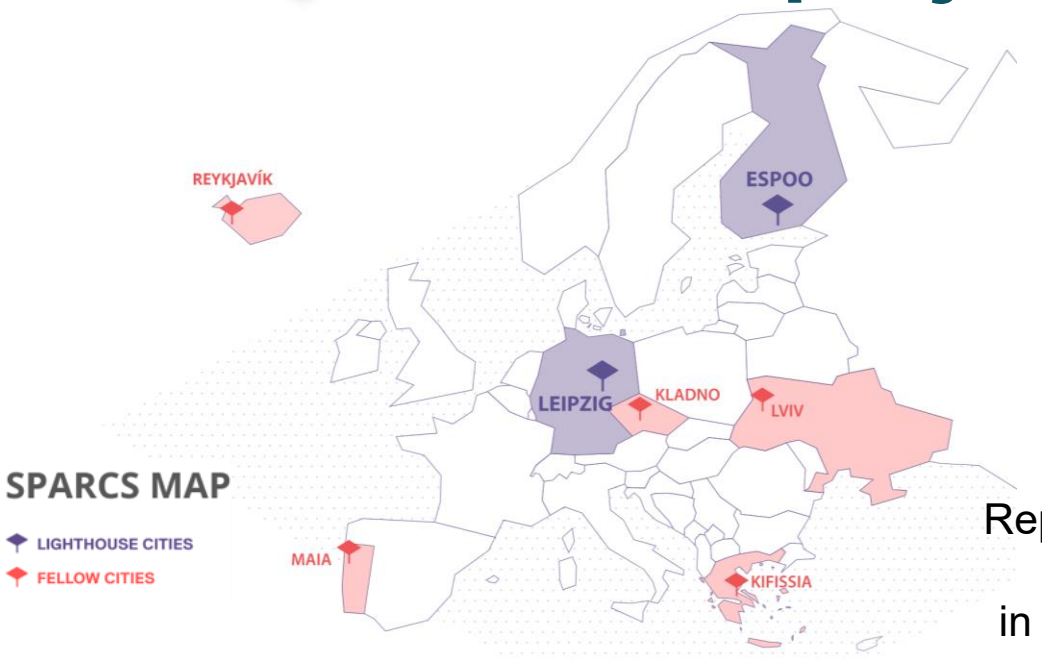
SPARCS PED project



31 partners from Finland, Germany, Portugal, Cyprus, Greece, Belgium, Italy, Ukraine, and Iceland, + 27 associated partners

Community engagement and citizen-centric approach

Generate a bold city-vision 2050

Enable and support urban transformation

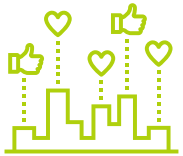
Replicate positive energy district solutions in Kifissia, Kladno, Lviv, Maia & Reykjavik

Demonstrate 44 innovative positive energy district solutions in Espoo & Leipzig

Business models and financing instruments for sustainable PEDs

Monitoring & evaluation of implemented PED solutions

Share SPARCS learnings & experiences



Cooperate with various projects, networks & initiatives

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Energy Positive Solutions

Positive energy transformation
Electrical mobility
Digital Integration
New economy
Urban innovation ecosystem

Building Block-level interventions

- RES integration
- Virtual building heat storage
- Energy storage
- Buildings as Prosumers
- Smart meters solutions
- 2nd G EV-charging strategies
- Predictive building control strategies
- Load shifting
- User centric apps
- Shared RES ownership
- Participation in alternative market

District-level interventions

- Bidirectional district energy infrastructure
- Virtual power plant
- District energy storage (Seasonal and batteries)
- EV-sharing
- Last E-mile strategy (E-bicycling, E-buses, fast E-tramline)
- User centric platform
- Virtual energy community
- AI prediction energy demand
- People flow prediction
- EVs peak load control
- Peer-to-Peer energy marketplace

Macro-level interventions

- Positive Energy District strategy in urban planning
- Fostering EV uptake through urban planning
- Innovation ecosystem hub: city planning departments, SMEs, large enterprises and research organisations
- Regulations
- Citizen inclusive governance
- Carbon Free Vision 2050
- Energy community platforms
- GIS integrated service for urban planning
- Urban transformation financing & governance models

Scalable, innovative solutions for planning, deploying and rolling out smart and integrated energy systems as an efficient mean for the urban transition into a citizen centered zero carbon ecosystem, enabling a high quality of life.

Urban energy transformation requires broad collaboration between public and private entities, and creates new business opportunities.

Replicating and upscaling solutions for positive energy districts requires adapting technologies, systems and processes to local environment.

43 Interventions, 2 Years of Monitoring!

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Espoo’s demonstration blocks

Leppävaara center: upgrading existing Sello shopping center toward PEB

Lippulaiva block in Espoonlahti: planning and construction of a new PEB

Kera district: city planning demo with PED

VTT ESPOO KONE SIEMENS PLUGIT CITYCON ril ADVEN

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Pictures from City of Espoo, Citycon and Siemens

Digital twin of Sello: smart energy management in a PED

Possible to utilize when

- Predicting next day energy consumption & production
- 3D BIM based monitoring energy & HVAC data
- Optimizing local energy use
- Detecting and locating faults

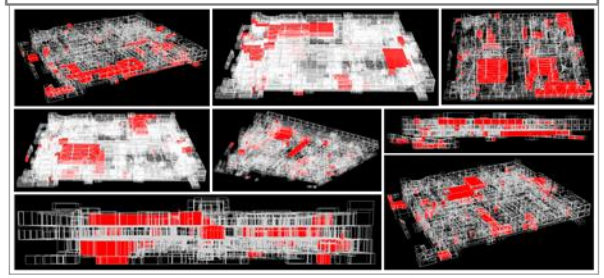
Real building:
Sello shopping center

Online

Virtual Twin: case energy

Behaves the same as real Sello:
Online energy models

Looks the same as real Sello:
Virtual 3D BIM + energy & HVAC data



Thermal peak power optimisation completed
-> 30% reduction

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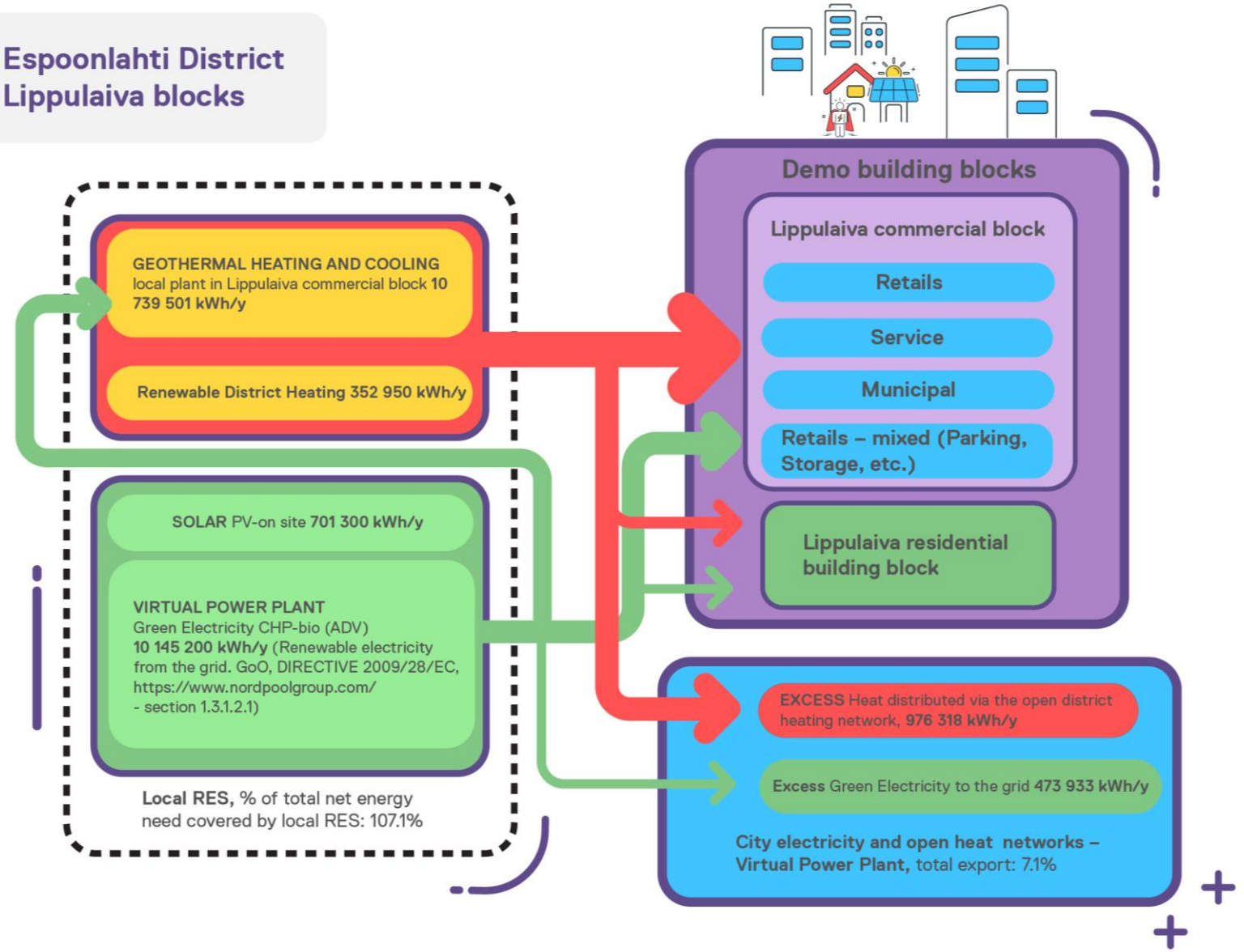
Different PEDs:

SPARCS PED in Lippulaiva, energy flows



SPARCS book

https://doi.org/10.32040/2024.978-951-38-8837-4

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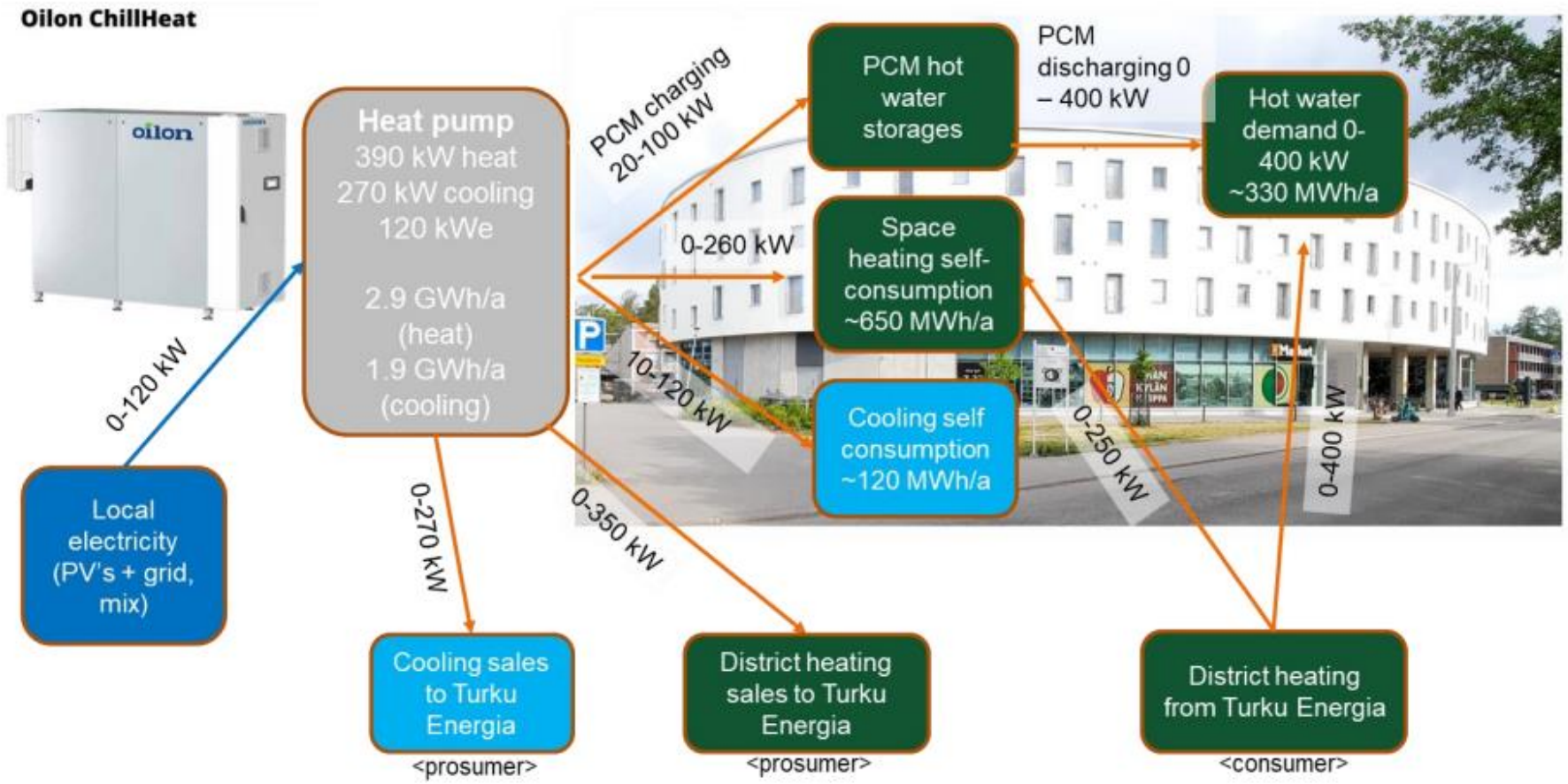
TURKU: PED demonstration on sector coupling



Related NetZeroCites Portal Groups

Design Your City's Net Zero Strategy: Online Planning Lab

Energy systems in cities

Community of Practise

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the European Union

Next Sessions

https://netzerocities.app/resource-4501

MODULE 1	**Core** The NetZeroCities program, service offering, systemic approach, what works for Mission Cities	**Spotlight 1** NetZeroCities Orientation	**Spotlight 2** Shaping Climate Narratives	**Spotlight 3** Climate City Contracts		
MODULE 2	**Core** Developing a transition team, mapping and activating the ecosystem	**Spotlight 1** Transition team & climate leadership	**Spotlight 2** Engaging the private sector	**Spotlight 3** Citizen engagement for systemic climate action		
MODULE 3	**Core** Developing the city's action plan for climate neutrality	**Spotlight 1** Reporting and MEL	**Spotlight 2** Co-Designing a Climate Portfolio	**Spotlight 3** Using NetZeroPlanner to Support Climate Planning, MEL, and Implementation Management to Achieve Net Zero Goals		
MODULE 4	**Core** Levers of change: Technical solutions, social innovation and multi-actor collaborations	**Spotlight 1** Passive solutions to reduce energy demand in buildings	**Spotlight 2** Systemic energy transition at buildings, districts and city level	**Spotlight 3** Data-driven approaches to energy transition in buildings and districts	**Spotlight 4** Mobility	**Spotlight 5** Scope 3 and other emission domains
MODULE 5	**Core** Increase finance knowledge of the public administration & learn about options to finance projects	**Spotlight 1** Preparing a pipeline of projects for external financing	**Spotlight 2** Different investor groups and the key priorities and returns profiles for each and instruments	**Spotlight 3** Financing the ambition: Learning from Mission Cities		
MODULE 6	**Core** Multilevel governance, national platforms and policy strategies	**Spotlight 1** Policy and regulations innovation	**Spotlight 2** Public procurement – national specificities	**Spotlight 3** Just transition		

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Q&A and discussion

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Get in touch with NetZeroCities!

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