Enabling low-temperature renewable district energy in cities

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Workshop: Integrating low-temperature renewable energy sources in District Energy Systems: Focus on Belarus

IRENA - The International Renewable Energy Agency

www.heatroadmap.eu / www.4dh.eu / www.sEEnergies.eu / www.reinvestproject.eu

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What does the future bring for you?

- More or less district heating?
- Net zero emission buildings?
- Passive houses?
- Gas-electricity hybrid heat pumps?
- What types of district heating are fit for the future?
- Should district heating decrease or increase?
- Who should own and profit from heating and district heating system?

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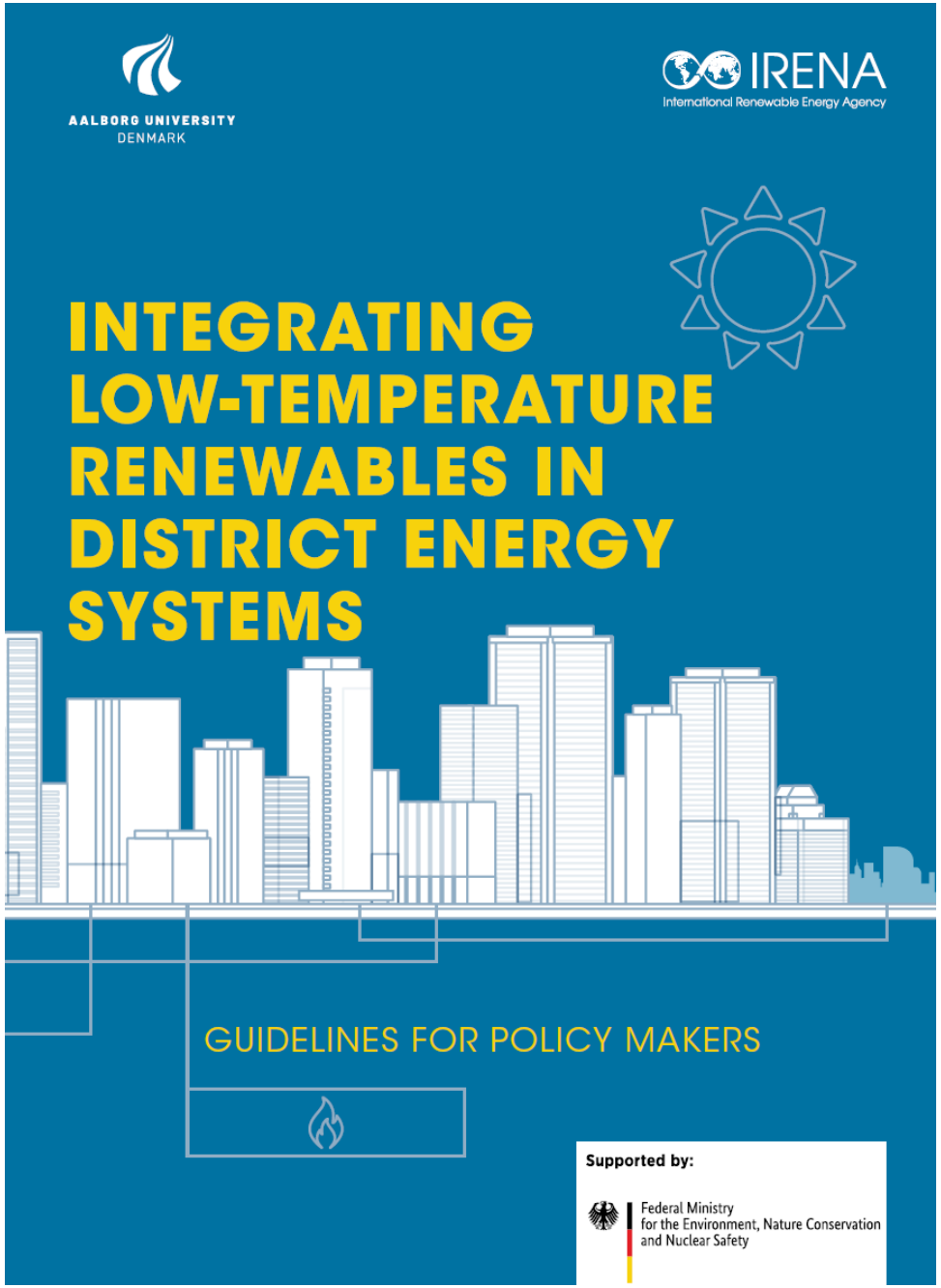
New rapport “Integrating low-temperature renewables in district energy systems: Guidelines for policy makers”

- Understand the challenges
  - Identify challenges, barriers and general renewable energy context
  - Help understand key renewable energy sources and technologies
- Guidelines for policy makers
  - Strategic plans, stakeholder involvement, understand technical challenges, mapping demands and resources
  - Creating an enabling regulatory framework
- Illustrated short cases



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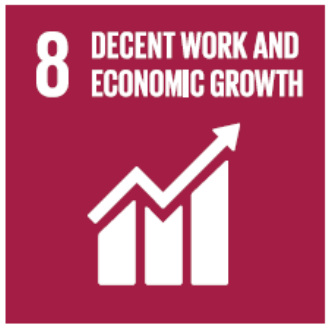
Photograph 1. **Air pollution in Mongolia**

Source: Shutterstock

District energy systems using renewable energy sources contribute to the Sustainable Development Goals

Reducing air pollution and related diseases

Increases access to cleaner technologies



Driving cities along a path of green growth

Acting as an evolutive backbone towards sustainable infrastructure

Contributing to resource-efficient and resilient cities

Contributing to decarbonisation of heating and cooling

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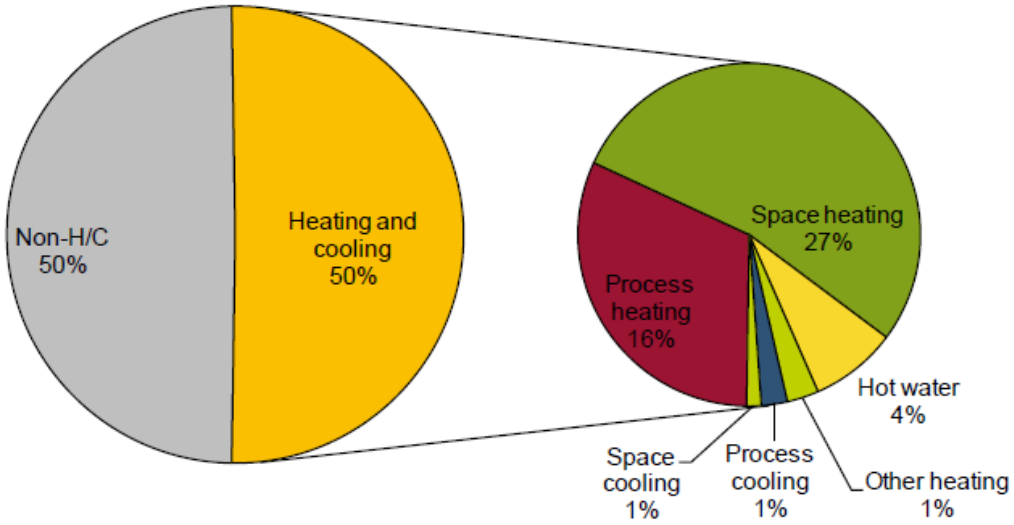
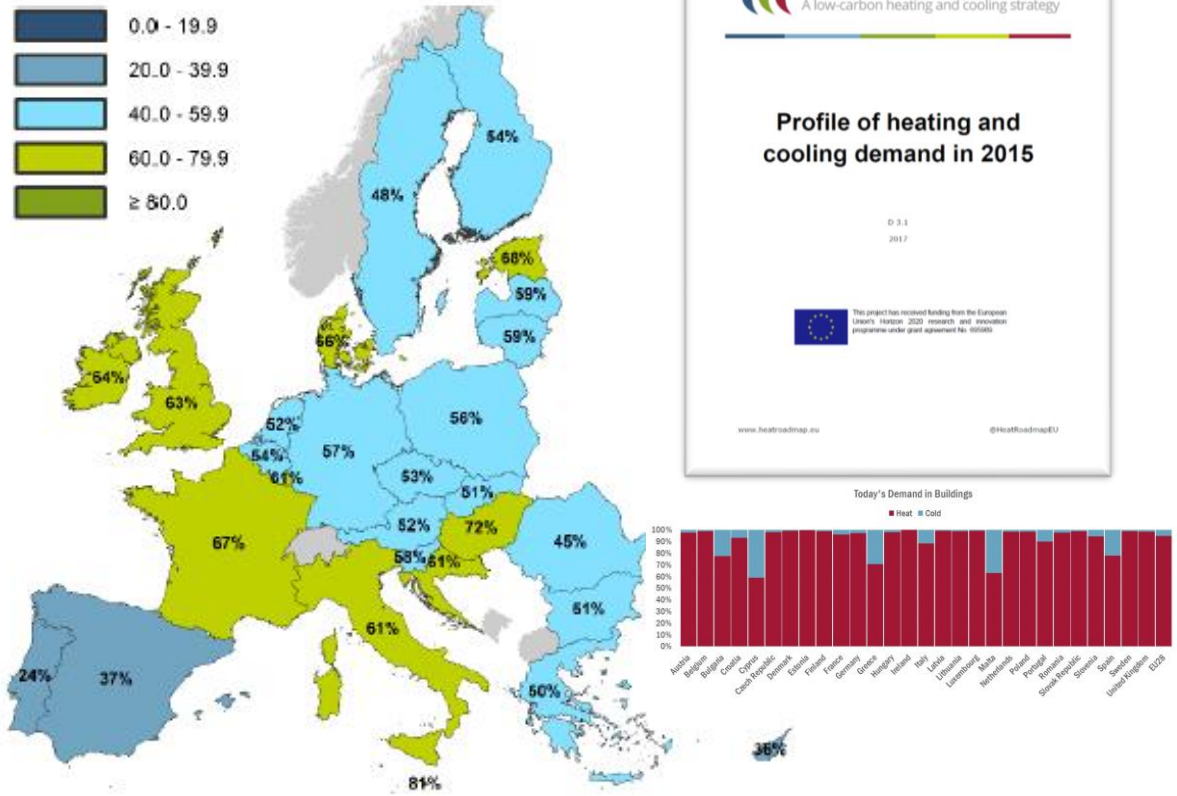
Heating vs. other sectors



Heating and cooling demand in 2015 in the EU28 by end-use compared to total final energy demand

- Large share for All Member States (not just the 'cold' North)
- Overall cooling share in general is 10-15%

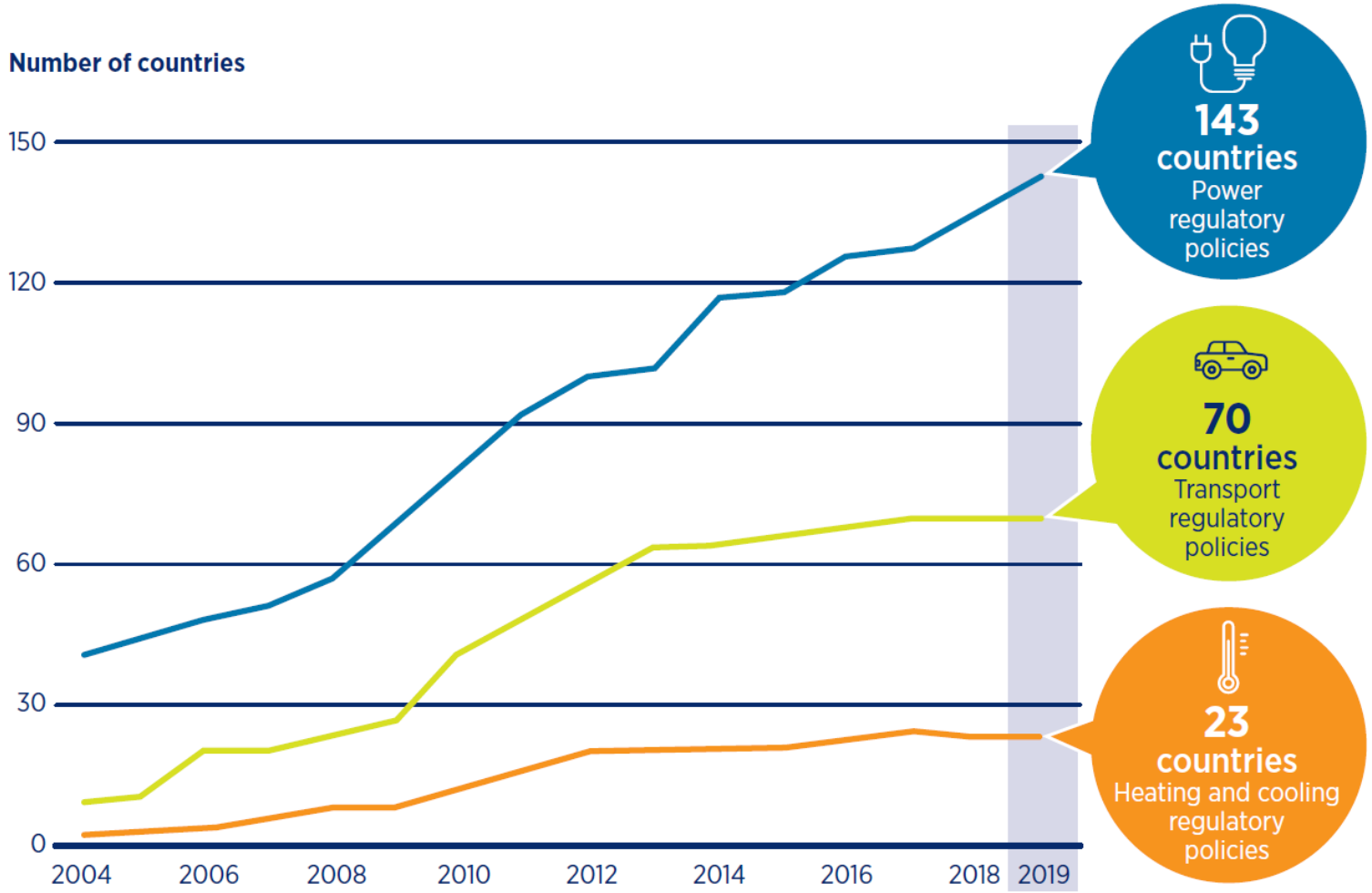


Heating and cooling demand in 2015 in the EU28 by end-use compared to total final energy demand

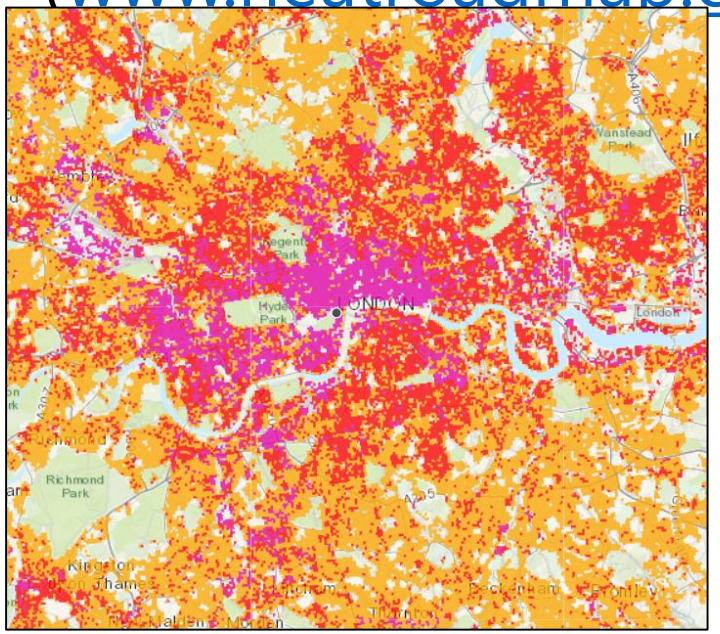
Number of renewable energy regulatory incentives and mandates, by type, 2014-19

The problem for decision makers:

Lack of focus + high complexity

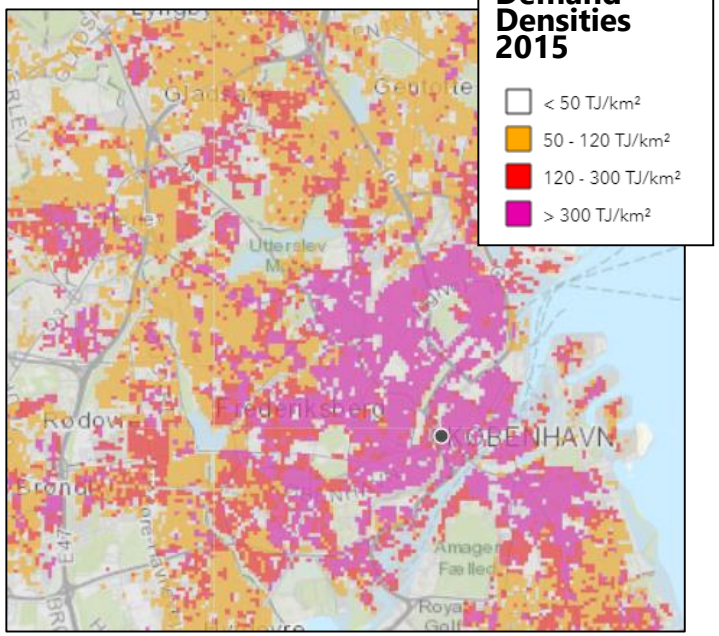


Today's Heat Demand from Peta 4.2 (www.heatroadmap.eu)



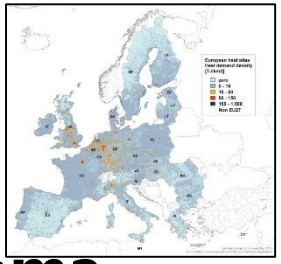
London

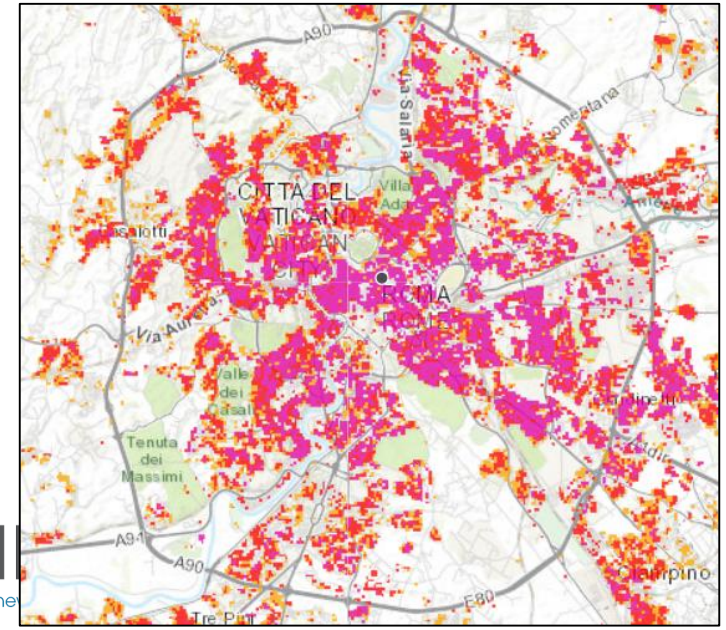
←<5% DH



Copenhagen

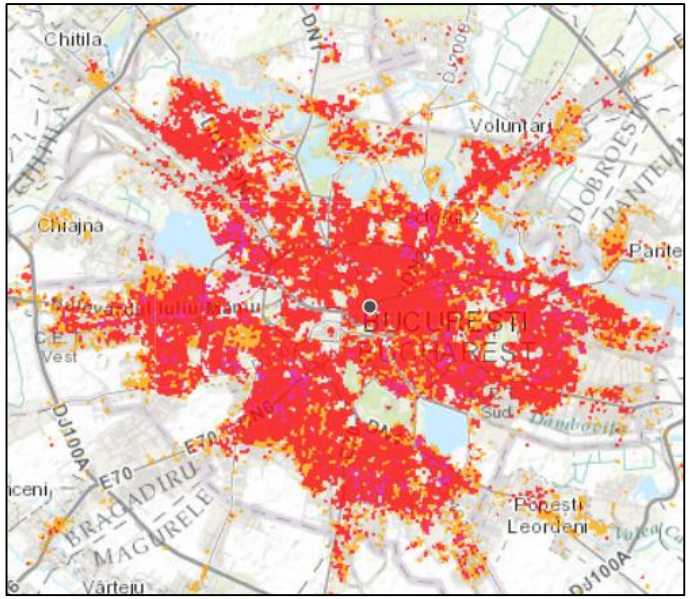
>90% DH →





Roma

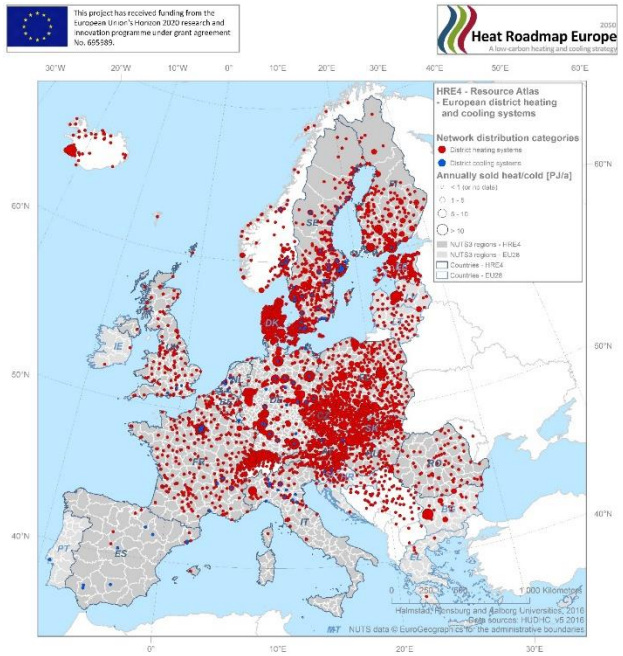
←<5% DH

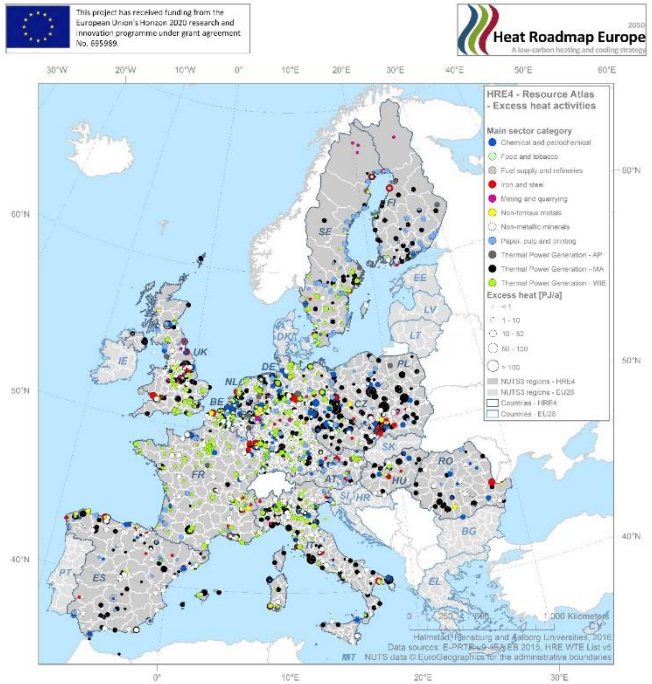


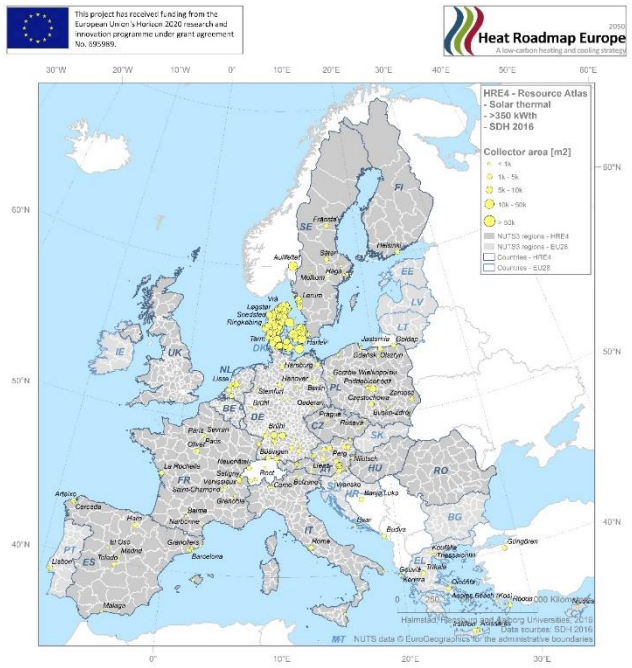
Bucharest

~75% DH →

We have 27+10 regulator experiments in Europe to learn from!







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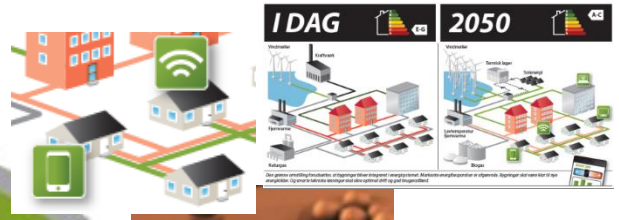
Three focus areas for buildings

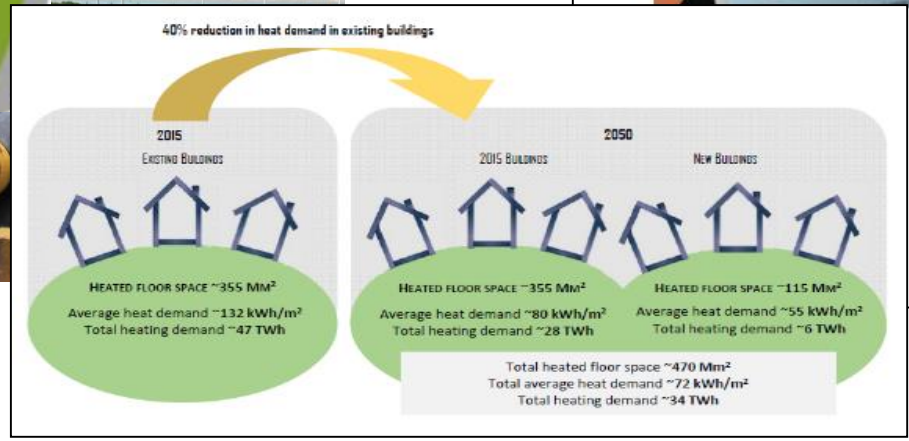


STOP BEFORE PASSIVE HOUSE STANDARDS

FUTURE GREEN BUILDINGS
A KEY TO COST-EFFECTIVE SUSTAINABLE ENERGY SYSTEMS

RENOVERING PÅ DAGSORDENEN

AALBORG UNIVERSITY DENMARK



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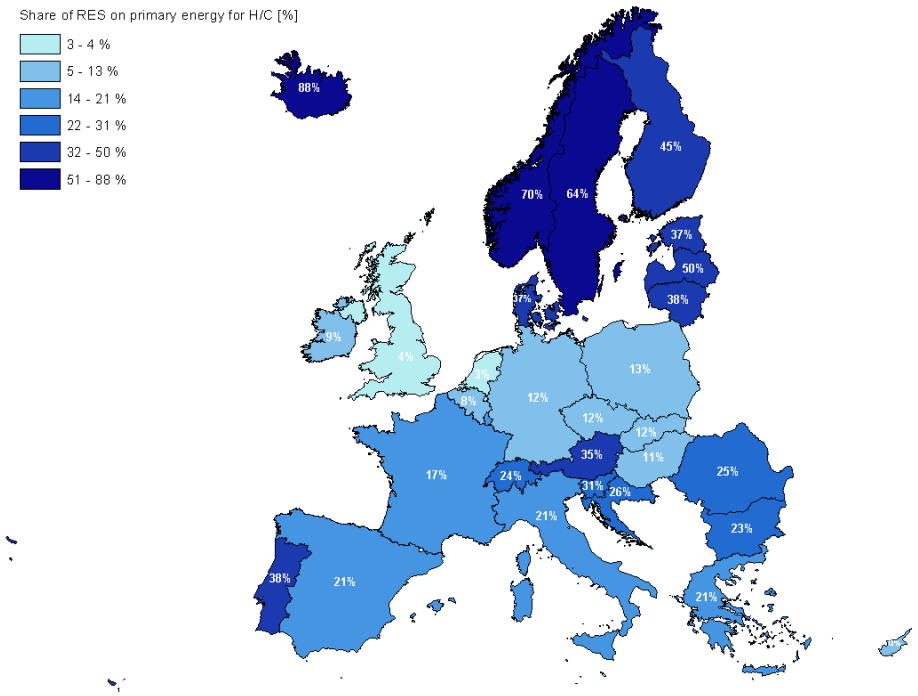
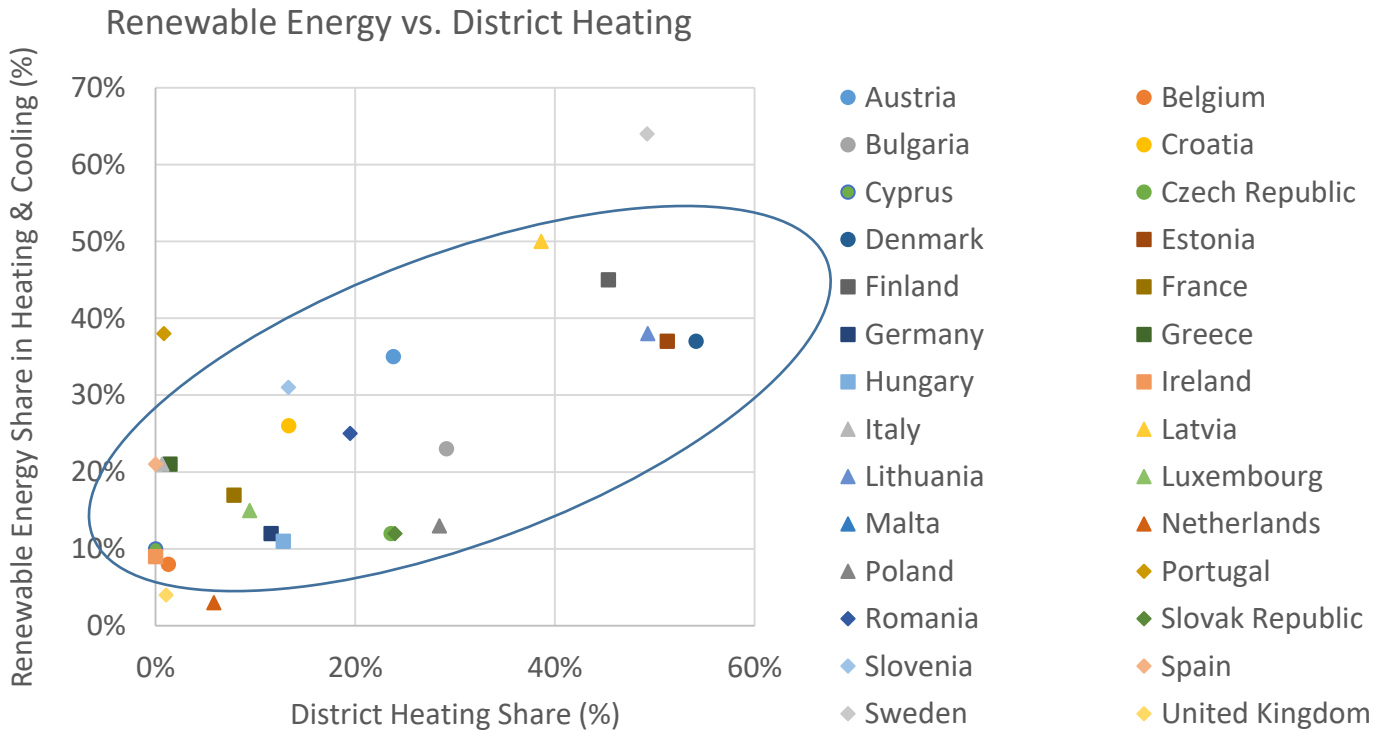
Renewable Energy vs. District Heating





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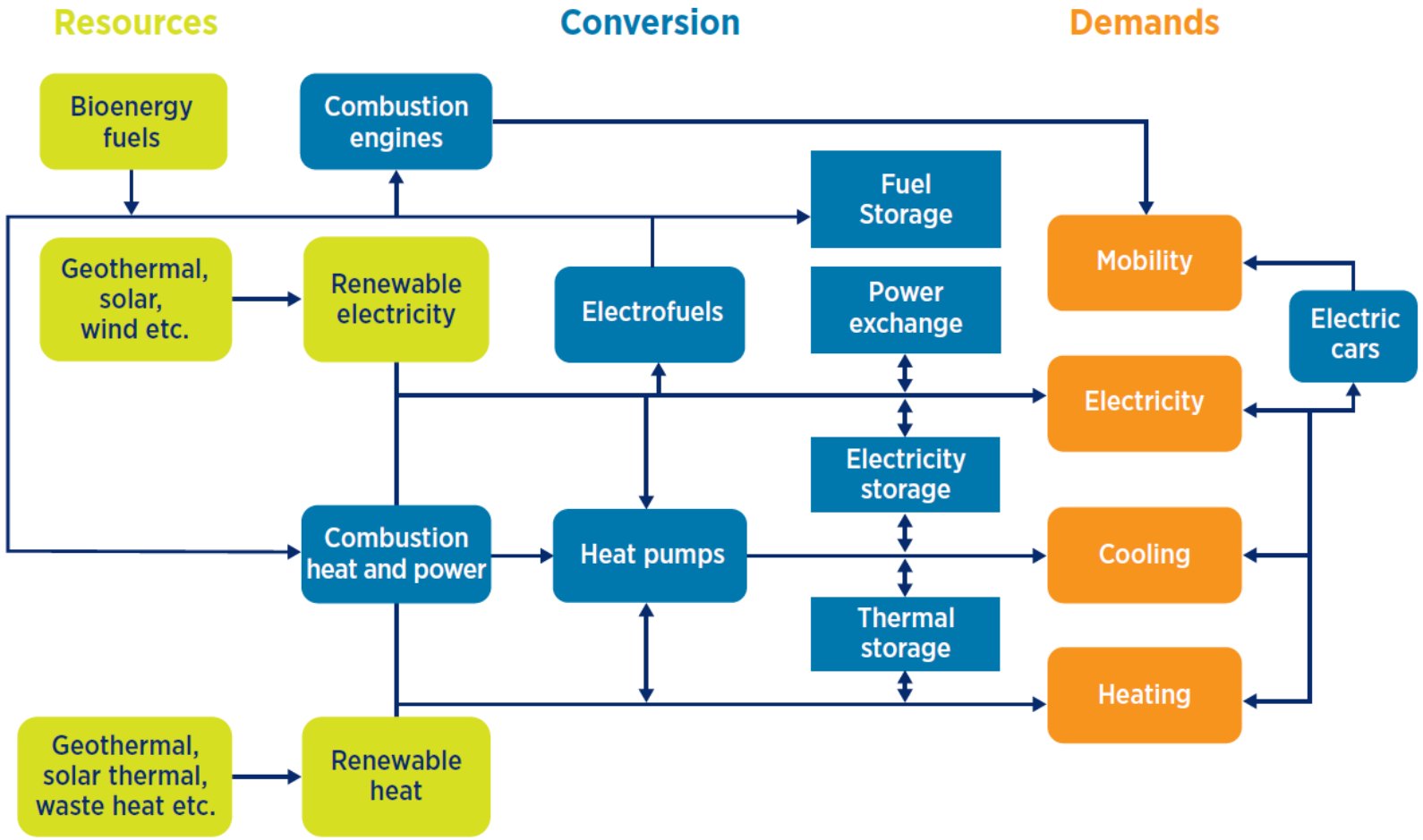
Smart Energy Systems



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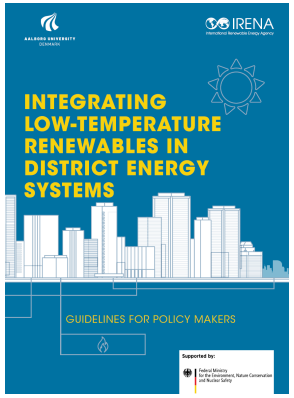
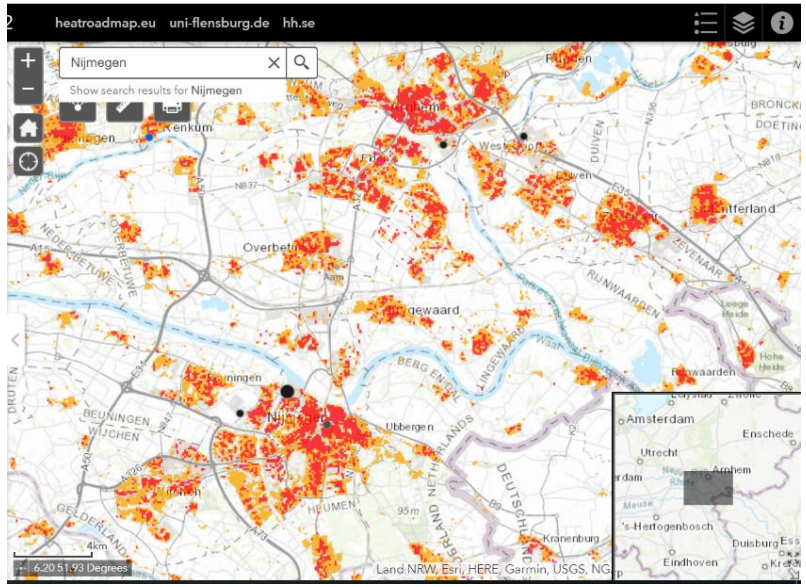
Strategic heating and cooling plans



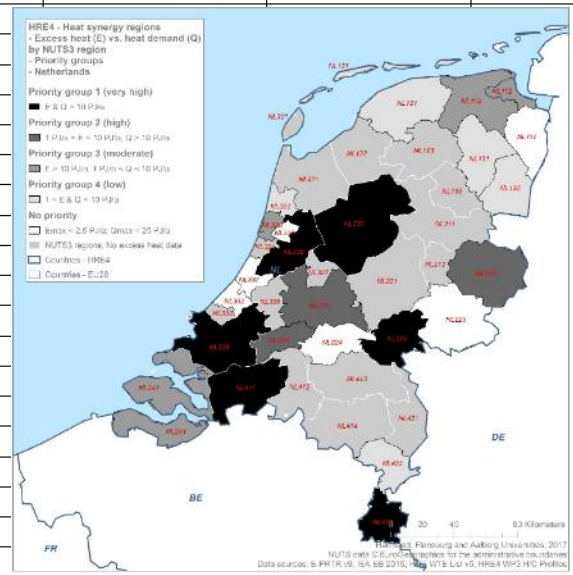
- Clear political drivers and identify the main stakeholders.
  - Lead by local authorities, but it requires key support from national governments to provide ambitious targets and an enabling framework
- At the national level governance and regulatory frameworks,
  - Set direction for the implementation of the entire energy system and the role of district energy in decarbonisation and sustainable development.
- Upgrade the required skills of the workforce, including those involved in individual renewable energy technologies and, in some markets, the modernisation of district energy infrastructure.
- Develop local strategic heating and cooling plans and determine which stakeholders will be involved and on what grounds, and how to engage them in the process.
- Facilitate the public acceptance of the transition to renewable-based district energy projects.
  - Achieved by including citizens, practicing transparency and raising awareness about the merits of district energy systems and renewable technologies.

Heat synergies map in PETA4 - Netherlands



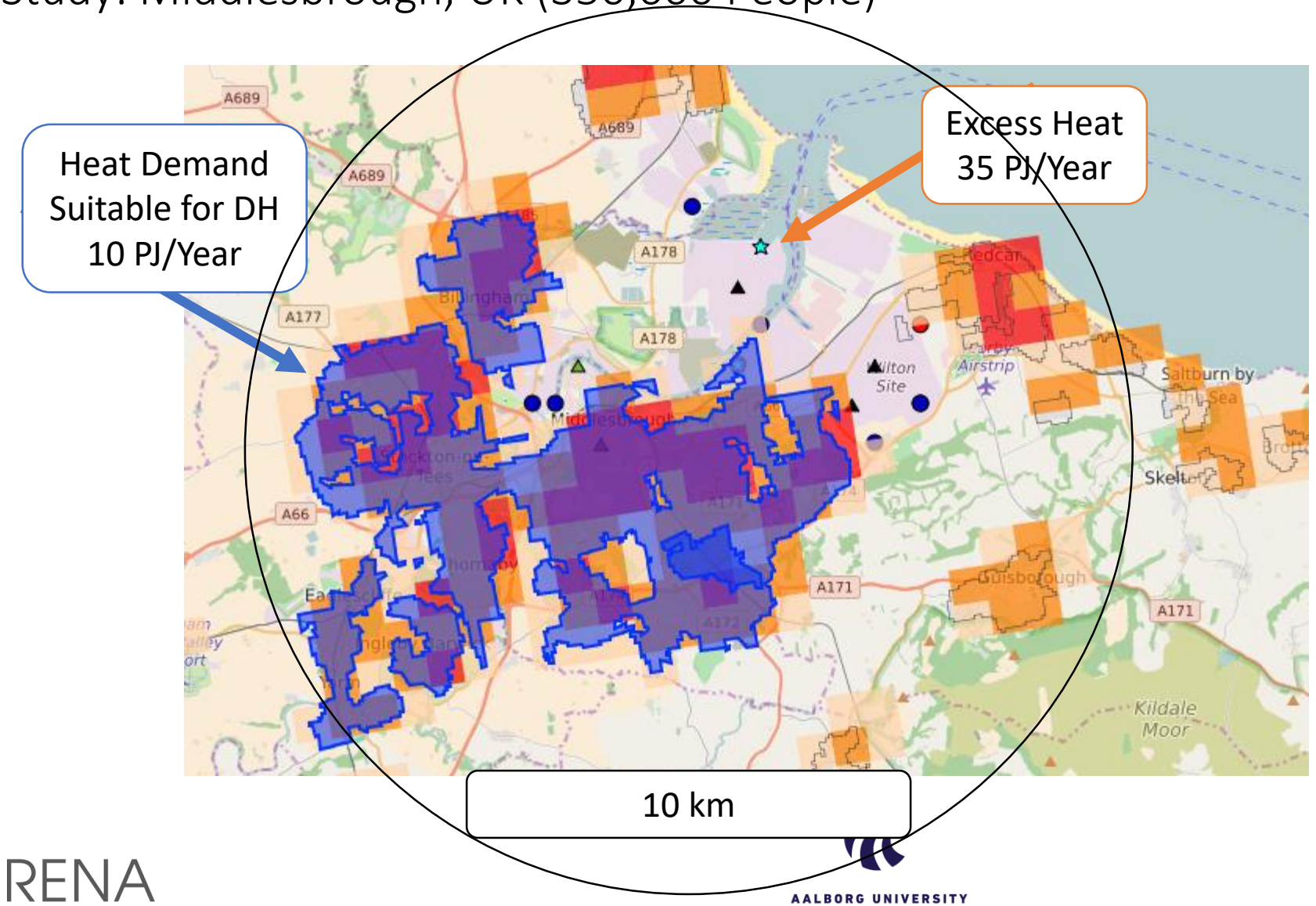
- Heat demands: 296 PJ/y
- Excess heat: 560 PJ/y
- District heating share: 6%
- Renewable energy in heating: 3%
- Not a Technical barrier to improve energy efficiency?

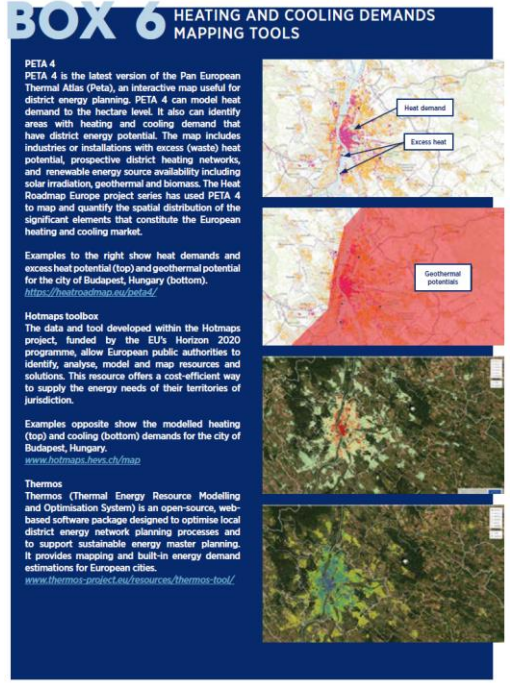
NUTS3 Regions	Heat demand [PJ/a]	Excess heat [PJ/a]	Excess heat ratio [-]
NL111	3.83	0.20	0.05
NL112	1.22	11.32	9.28
NL113	9.90	17.30	1.75
NL121			25
NL131			92
NL132			55
NL213			48
NL224			08
NL225			09
NL226			40
NL230			99
NL310			12
NL322			16
NL323			.27
NL325			05
NL326			05
NL332			05
NL337			09
NL339			06
NL33A			39
NL341			.41
NL342			78
NL411	15.57	73.27	4.71
NL422	5.96	8.10	1.36
NL423	15.28	39.67	2.60
Grand Total	**295.84**	**559.23**	**1.89**



WP2: Pan-European Thermal Atlas: www.heatroadmap.eu

Case Study: Middlesbrough, UK (350,000 People)





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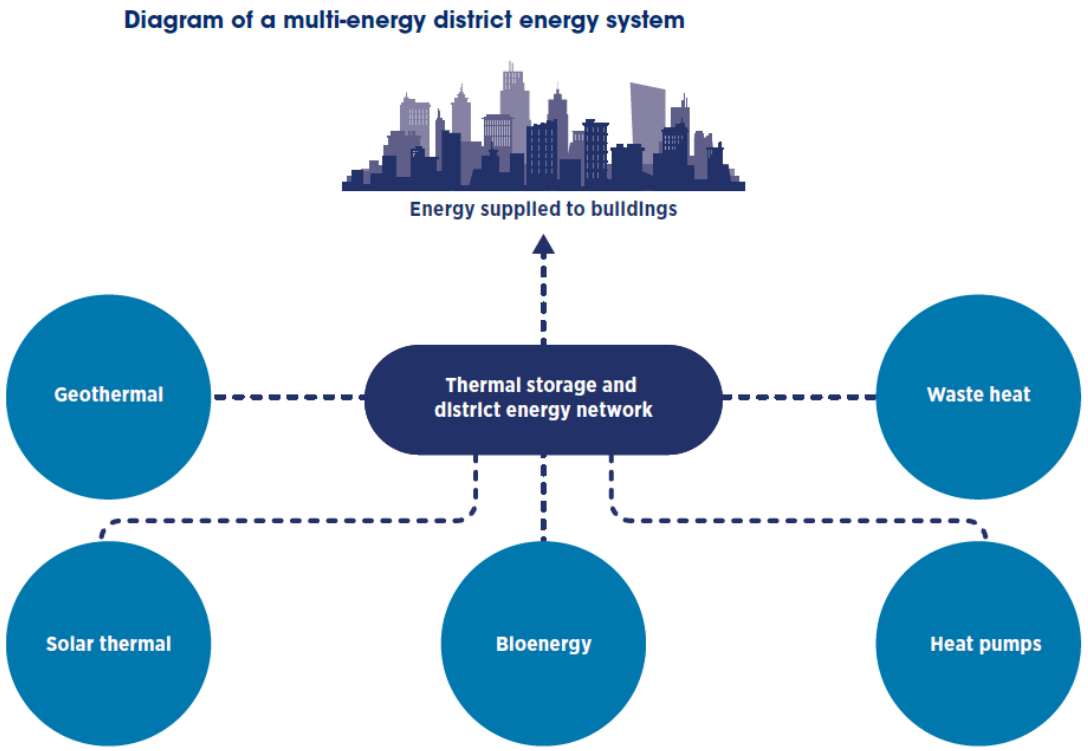
District heating sources and technologies



		ADVANTAGES	POTENTIALS	ROLE IN THE ENERGY SYSTEM
SOURCES	**Geothermal**	Continuously available and not dependent on weather conditions Very low operation and maintenance (O&M) costs	Large, especially for shallow and low-temperature geothermal resources (Resource available at different temperatures and depths)	Can be used for centralised exploitation in large-scale district heating or cooling systems
	Solar thermal	Sustainable resource Very low O&M Very long lifespan	Almost everywhere	Can cover summer load in district heating systems Can provide cooling in summer Can be combined with seasonal storage
	Bioenergy	Abundant and sustainable source in some areas	Almost everywhere	Can be combined with solar thermal for district heating Can compete with uses in other sectors (transport or other purposes)
	Free cooling	Abundant Very low O&M costs	Large	Can reduce electricity consumption and allow the chilled water to bypass chillers
	Waste heat	Use of a resource that would otherwise be lost Advantageous cost	Industrial and commercial areas	Can reduce energy consumption for the alternative sources of heating or cooling
ENABLING TECHNOLOGIES	**Heat pumps**	Capacity to use renewable energy from air, water or ground and waste heat from buildings and processes to deliver heating and cooling	Everywhere	Can act as the conversion technology between electricity and heating sector Can upgrade low-temperature heat sources to higher-temperature levels or to produce cold
	Thermal storage	Costs 100 times less in investment terms per unit of storage capacity compared to electricity storage Economy of scale	Everywhere where room is available and geological conditions are favourable	Integration of variable renewable energy production

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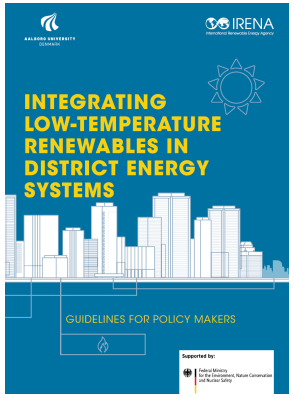
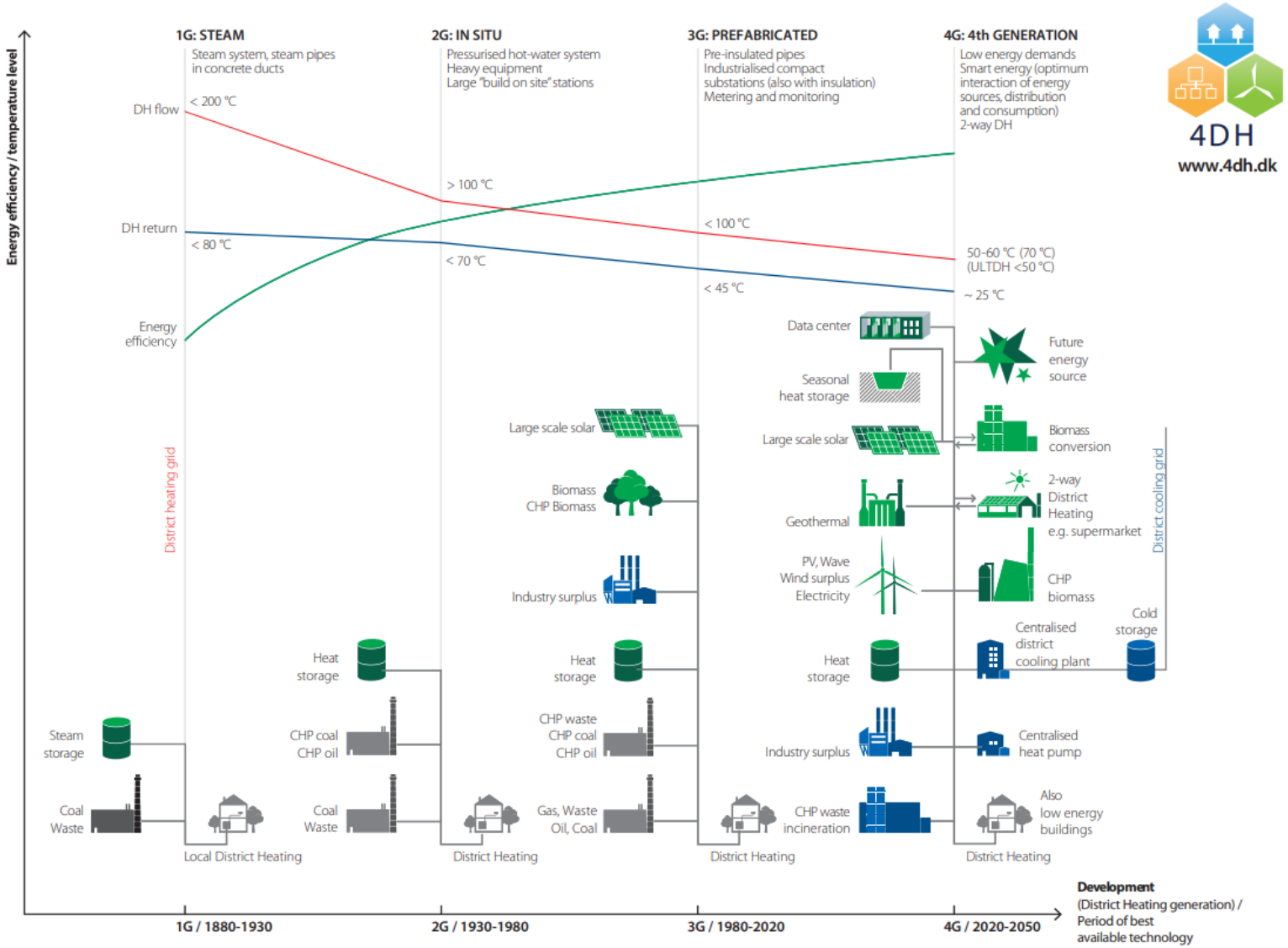
Elaborate technical scenarios based on the demand for heating and cooling and mapping of resources



- Improve the collection of data on heating and cooling demand by making actual measurements at the building level or using existing tools to make demand estimates through top-down or bottom-up modelling.
- Assess the available heat resources for utilization in the heating and cooling of buildings by using existing tools such as geographical information systems or by developing heat atlases. The information generated by the use of these tools could be used to support planning and investment in district energy systems.
- Ensure that the scenarios advanced for heating and cooling development are in line with long-term targets.

The developments of District Heating



4DH
www.4dh.dk

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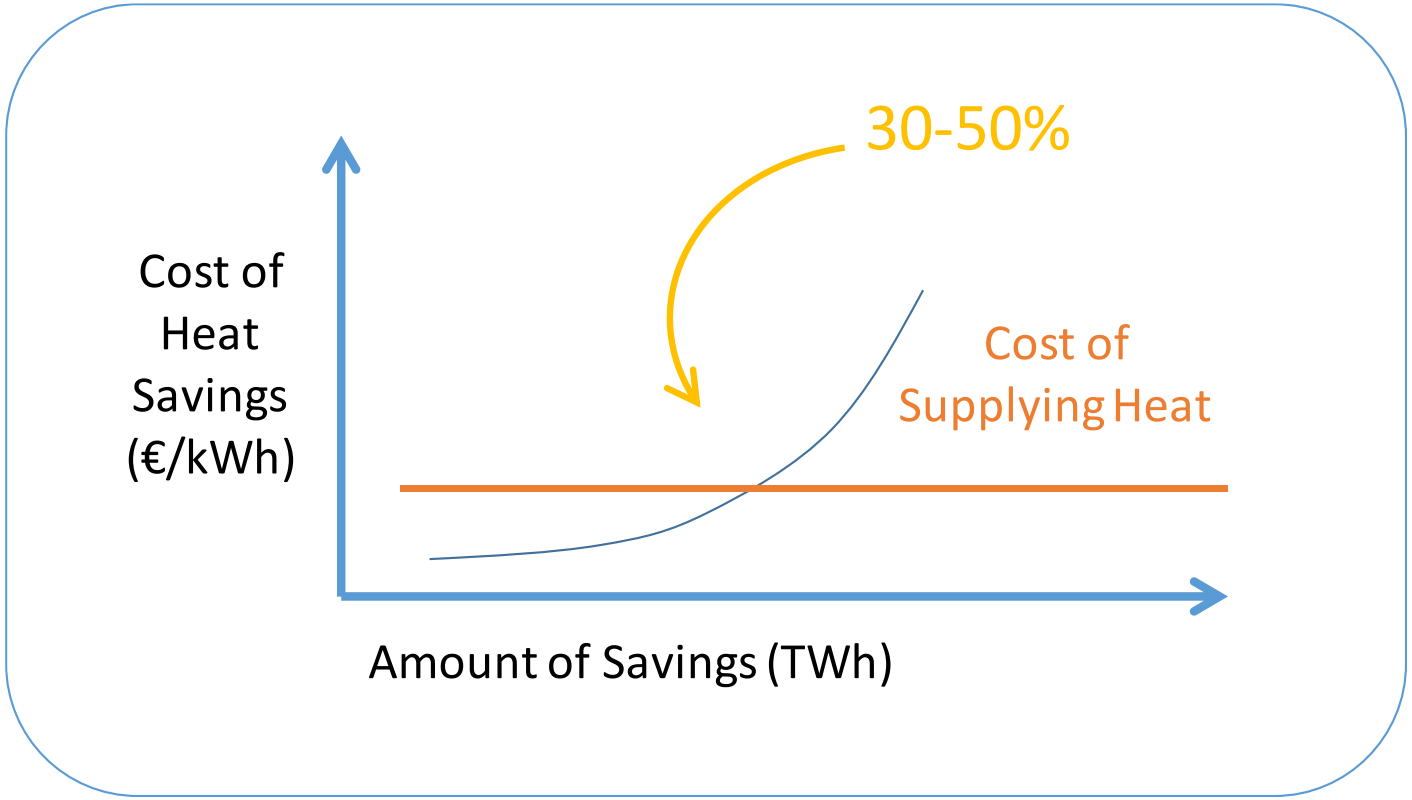
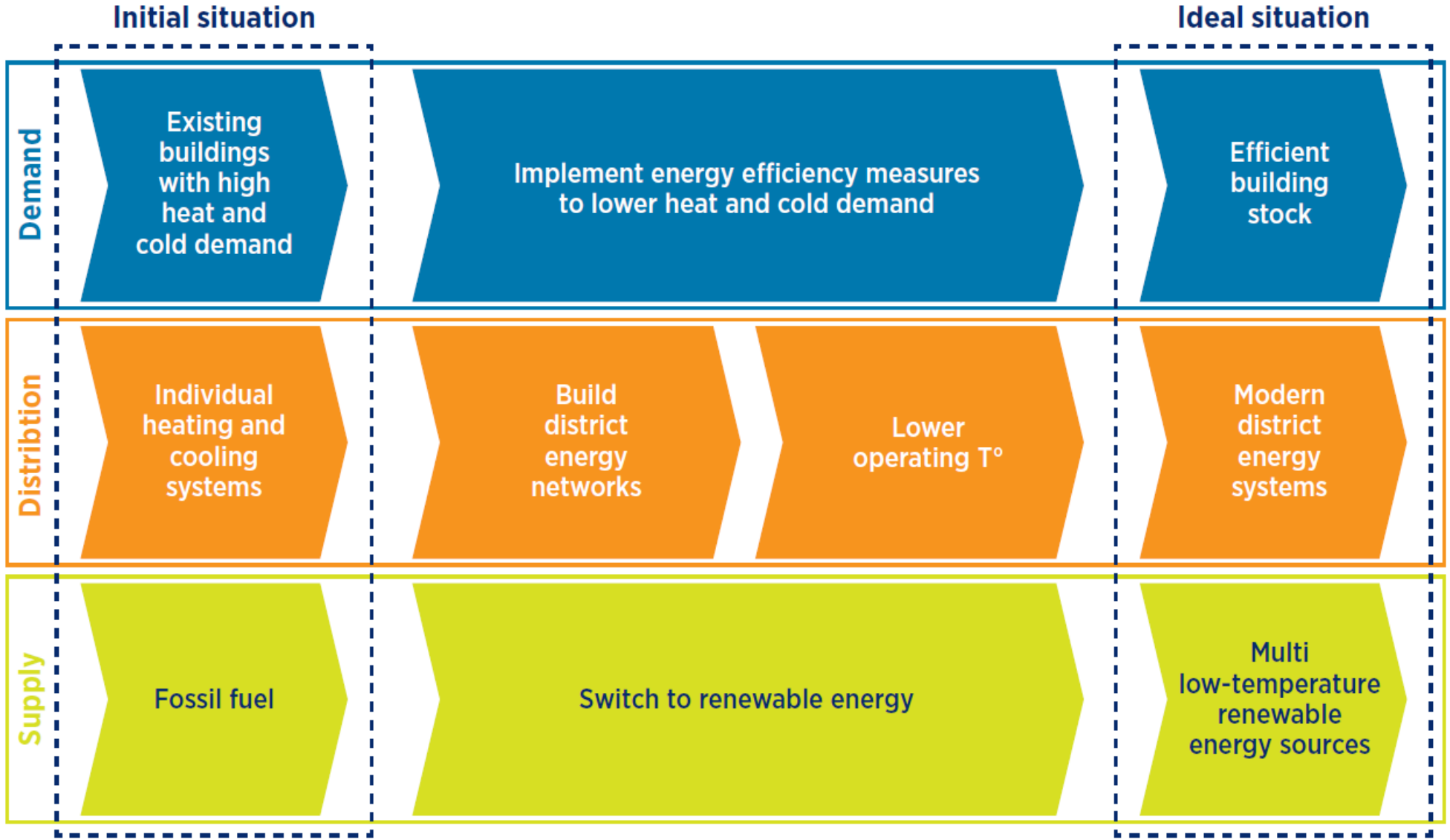
Energy efficiency is required on both the demand and supply side of the heat sector





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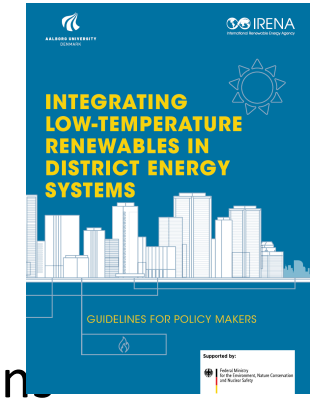
Integrated district heating strategies and plans.



- Integrate changes of supply, modernisation of the network and building renovation plans to achieve an optimum performance level (both technical and socio economic) and avoid lock-in effects and disconnections
- Align the development of district energy and energy efficiency in buildings and create synergies between them. For example, design neighbourhood schemes in which energy efficiency measures are implemented at the demand and supply sides simultaneously. Encourage more energy-efficient practices by moving to consumption-based billing for all consumers.
- Implement measures to decrease the operating temperatures both for systems already in operation and new district heating networks in existing neighbourhoods. This can be done
  - i) at the building level by introducing control systems, redesigning heating equipment, retrofitting with energy efficient building envelopes, redesigning domestic hot water preparation systems and substations, etc.; and
  - ii) at the network level by insulating pipes, incorporating temperatureboosting technologies, instituting measures to lower return temperatures, and avoiding higher flow rates that could damage the network, etc.

Photograph 4. **Thermal heat storage (44 000 m³) at Avedøre Kraftværket in Copenhagen (Denmark)**

Photograph 7. **Solar district cooling plant, Scottsdale, Arizona (United States) (left) and part of the Fernheizwerk collector field, Graz (Austria) (right)**

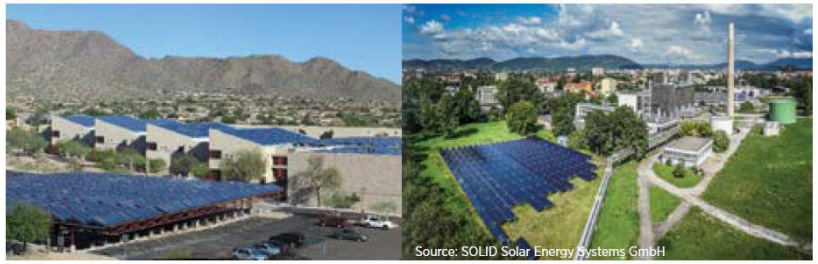
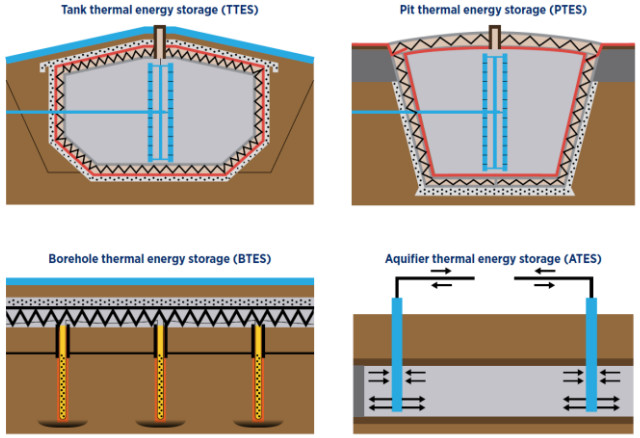


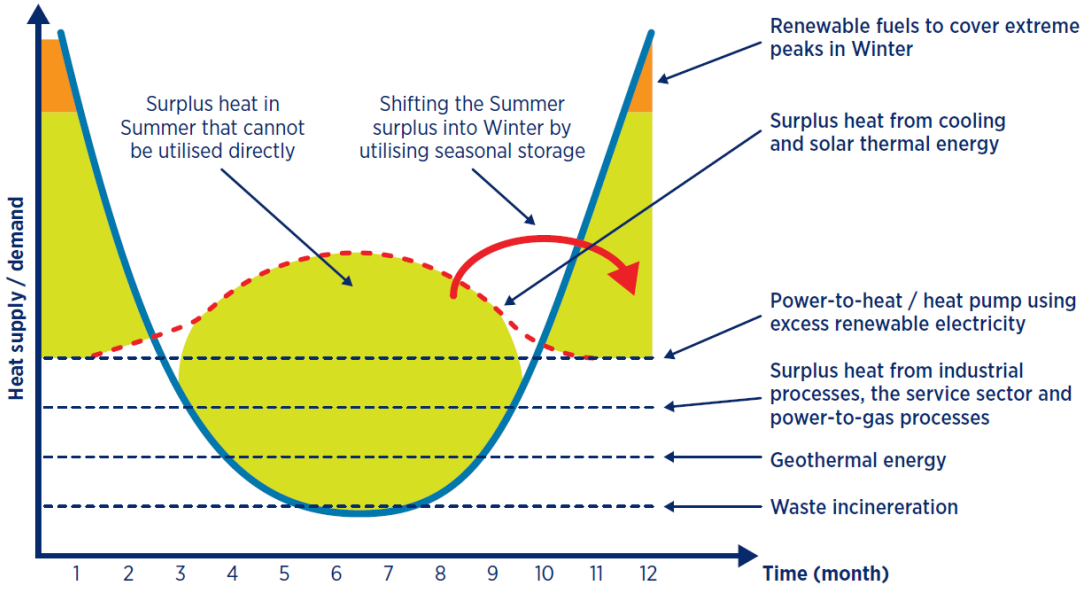
Figure 18. **Seasonal thermal storage concepts**



SOURCE	MAIN CHALLENGES	POSSIBLE SOLUTIONS
Geothermal	High investment cost Risk of drilling failure Risk of decreasing productivity over time Risk of scaling and corrosion	Establishing geothermal resource risk and well-productivity guarantee schemes Conducting extensive geo-scientific studies Monitoring reservoirs and managing resources (especially of injection) Maintaining temperature of geothermal fluid above the saturation temperature of the dissolved substances during heat exchange, regularly maintaining heat exchangers and other equipment, treating of geothermal fluids using chemical methods (*e.g.*, anti-scalants) to reduce the rate of precipitation and scaling
Solar thermal	Offset between seasonal availability and demands High investment costs Constraint temperature Space constraint	Ensuring use in systems that have a DHW demand Using solar thermal to provide cooling when the supply and demand for heating are mismatched Incorporating thermal storage to take care of surplus solar thermal Using alternative spaces, *e.g.*, rooftops, sewage basins, former landfill sites, etc.
Waste heat	Sustainability of the resource Fluctuating conditions of supply	Developing contractual agreements to assure of supply Incorporating thermal storage in the network Combining connections to deliver high-temperature to the supply line and lower temperature to the return line
Free cooling	Preservation of water quality and aquatic life Risk of fouling and corrosion	Filtering Antifouling processes

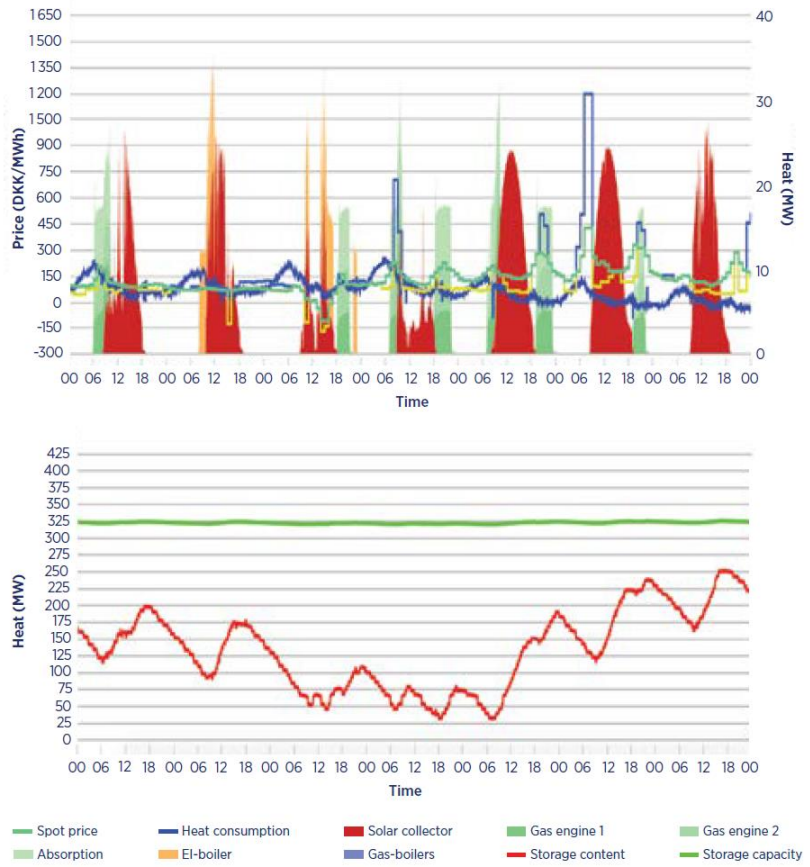
Complex supply – cheaper heat

Principle production structure



Concrete case

Figure 24. **Example of daily heat production of a hybrid district heating system using thermal storage**



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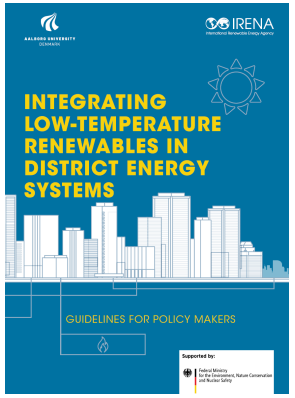
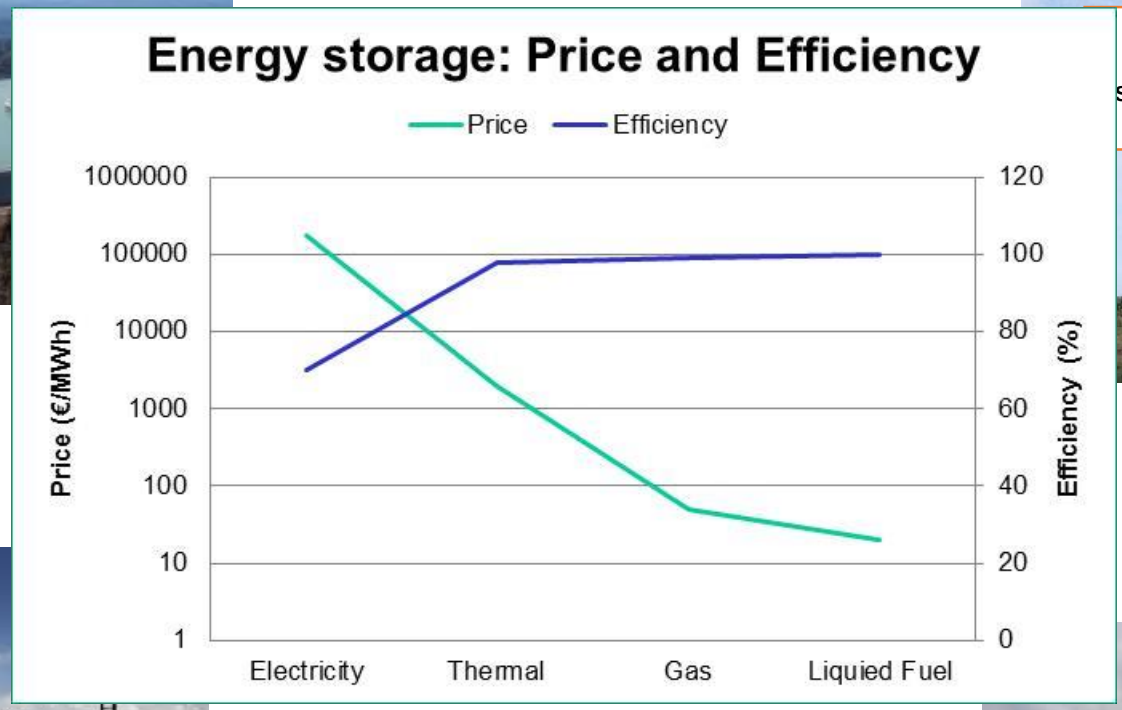
Promote the utilisation of locally available renewable energy sources for heating and cooling by addressing intrinsic challenges.



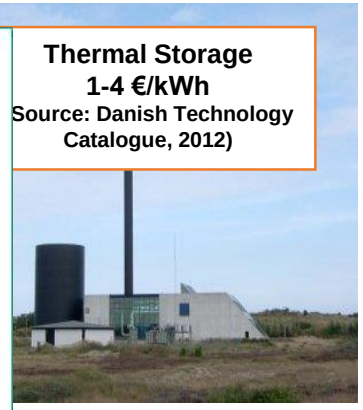
- Build capacity to develop sound renewable energy projects and address technical challenges for integrating and operating low-temperature sources in new or existing district energy systems.
- Ensure adherence to best practices for the operation of local renewable energy sources. These best practices result in the most cost-efficient and sustainable utilisation of resources, *e.g.*, reinjection for geothermal energy or seasonal thermal storage for solar thermal.

Energy Storage

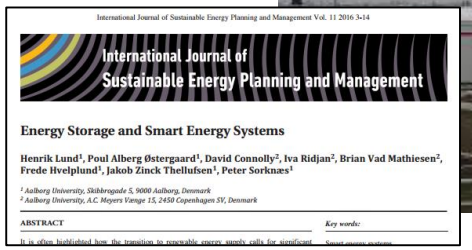
Pump Hydro Storage
175 €/kWh
(Source: Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits. Electric Power Research Institute, 2010)



Thermal Storage
1-4 €/kWh
Source: Danish Technology Catalogue, 2012)



Natural Gas Underground Storage
0.05 €/kWh
(Source: Current State Of and Issues Concerning Underground Natural Gas Storage. Federal Energy Regulatory Commission, 2004)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Energy Storage and Smart Energy Systems

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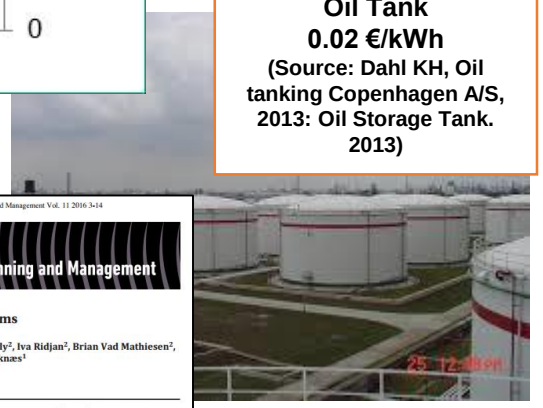
ABSTRACT

Key words:

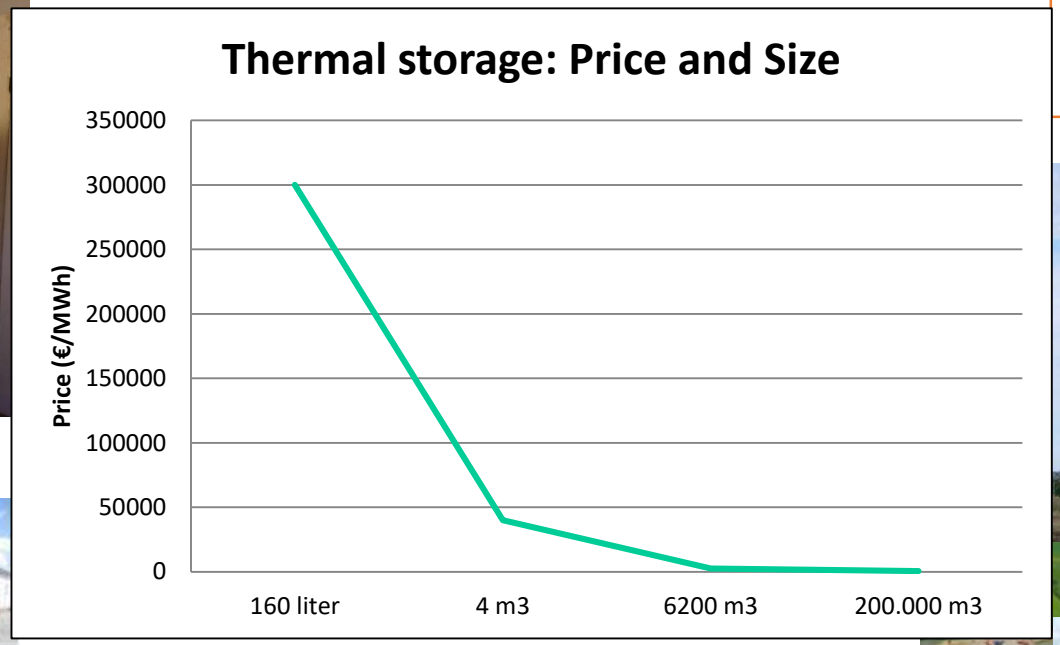


Oil Tank
0.02 €/kWh
(Source: Dahl KH, Oil tanking Copenhagen A/S, 2013: Oil Storage Tank. 2013)

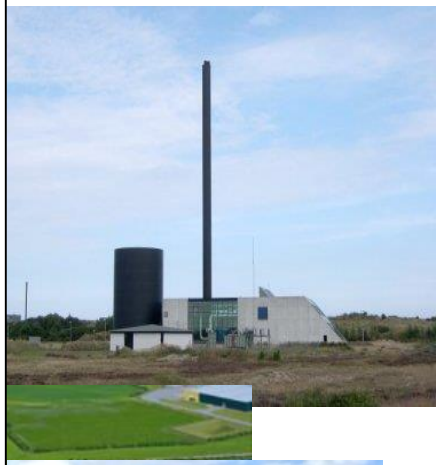
Thermal Storage

0.16 m3 Thermal Storage
300.000 €/MWh
(Private house: 160 liter
for 15000 DKK)

4 m3 Thermal Storage
40,000 €/MWh
(Private outdoor: 4000 m3
for 50,000 DKK)



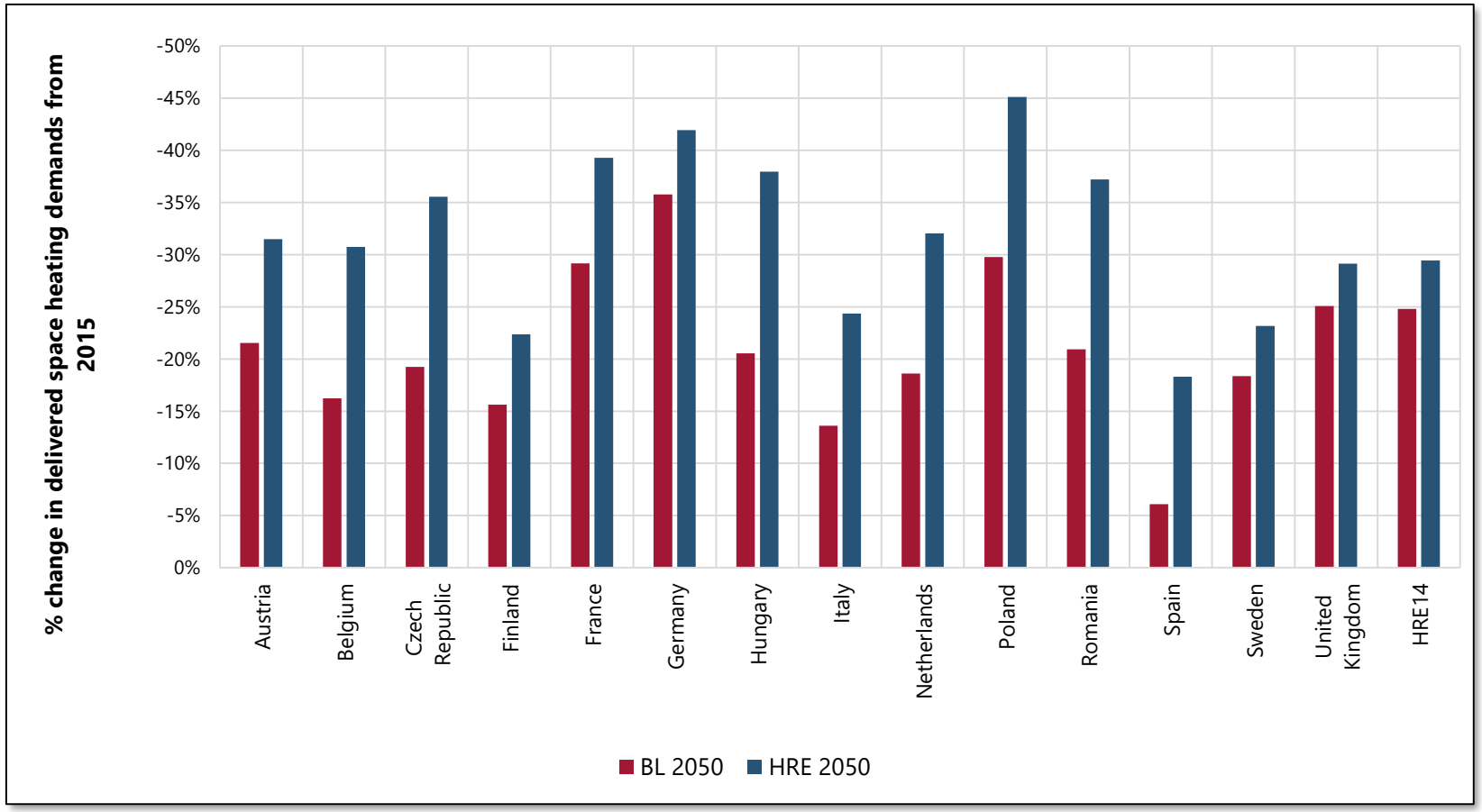
6200 m3 Thermal Storage
2500 €/MWh
(Skagen: 6200 m3
for 5.4 mio. DKK)



200,000 m3 Thermal Storage
500 €/MWh
(Vojens: 200,000 m3
for 30 mio. DKK)

Recommended development of thermal demands

- Current policy: 25% reduction in space heating
- HRE: 30% reduction in space heating
- Current policy: annual refurbishment rate between 0,7% and 1,0%
- HRE: annual refurbishment rate at 1,5% to 2%, AND deeper renovations when they occur



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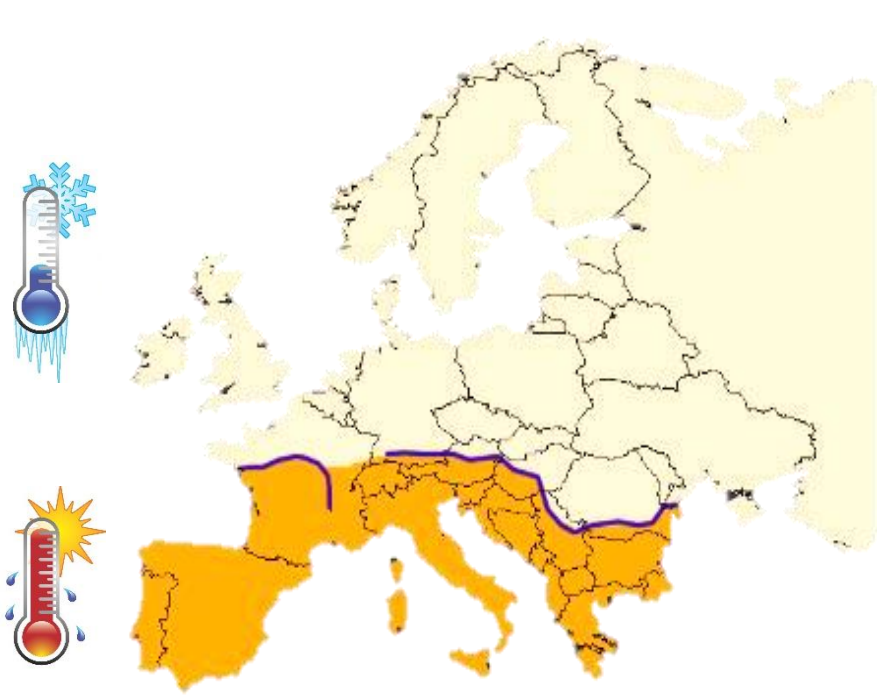
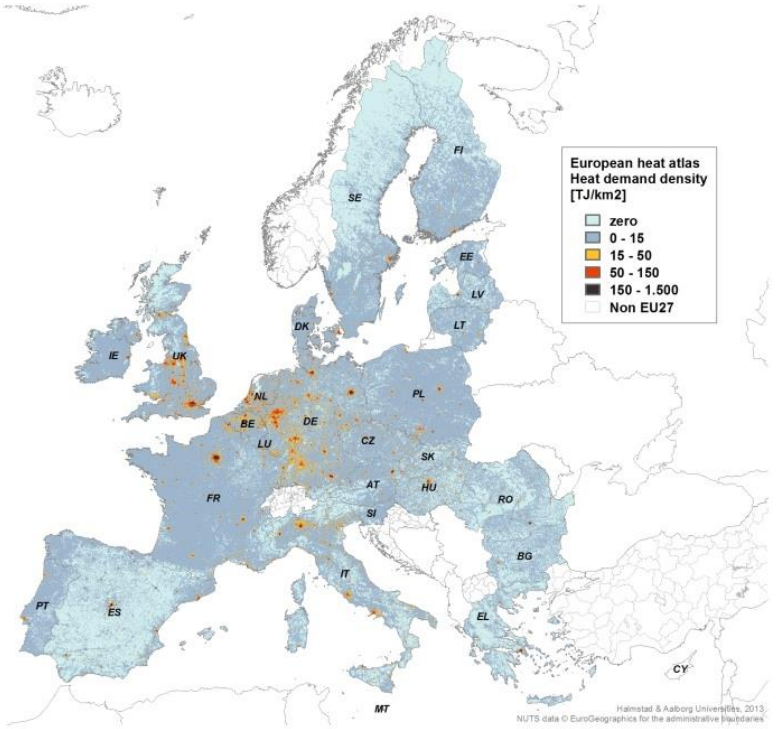
50% of the heat demand in Europe can be supplied with district heating





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Heat Roadmap Europe Methodology

Data profiling and mapping

FORECAST
FORecasting Energy Consumption Analysis and Simulation Tool

Peta

The JRC-EU-TIMES model

EnergyPLAN

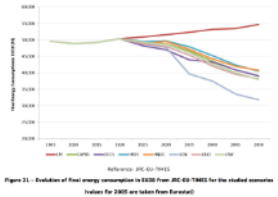
Building Demand Savings Potential	District Heating Potential	Energy System Potential
Costs of Making Savings	District Heating Resources	Energy System Resources

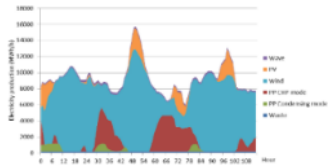
Energy System analyses

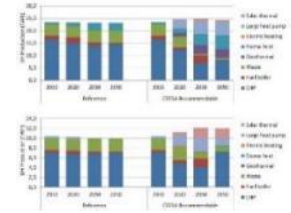
BAU (References)

Heat Roadmap Europe Alternatives

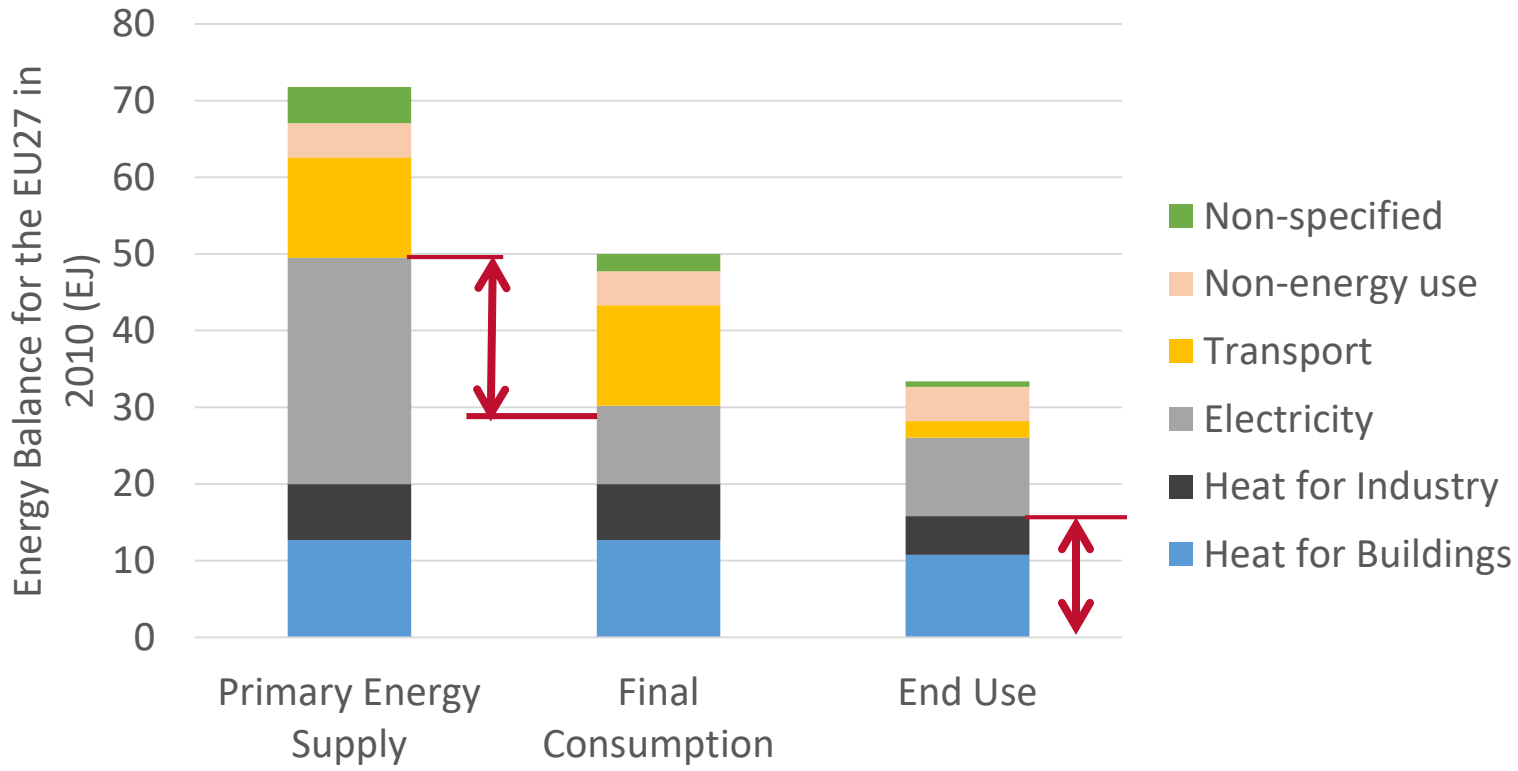
Results (PES, CO2, Costs)



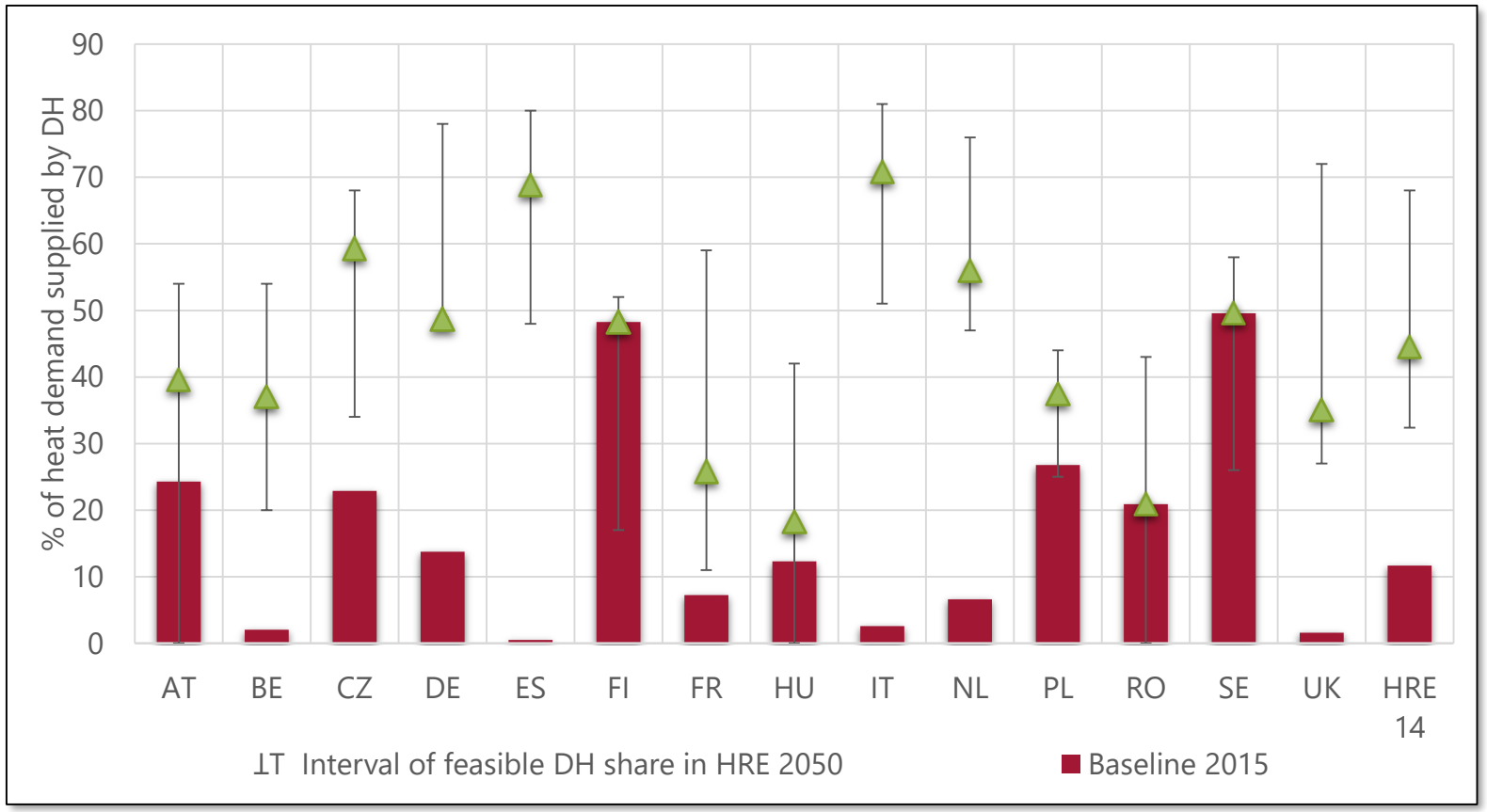


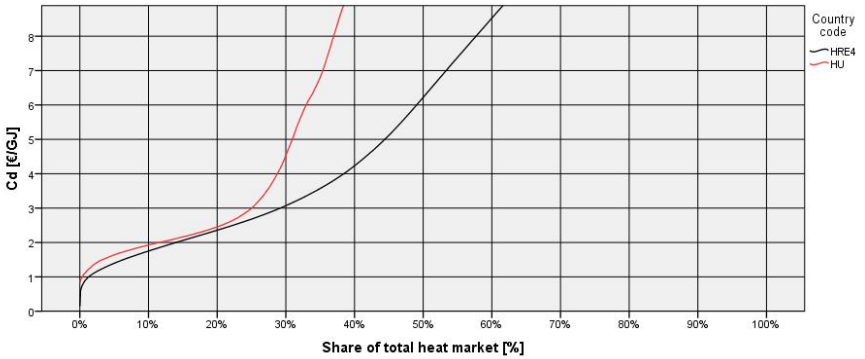


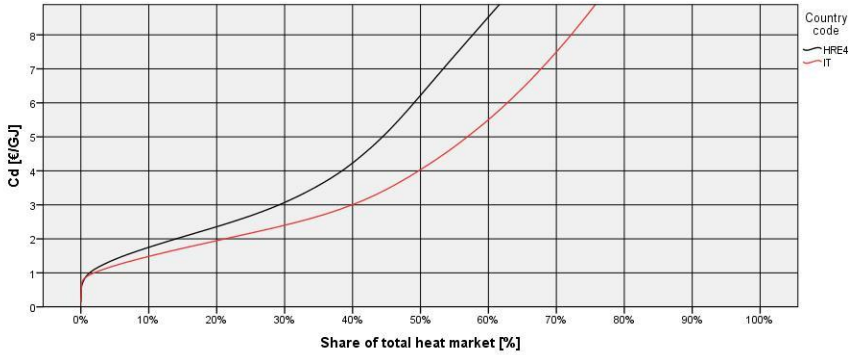
There is more excess heat in Europe than all of the heat demand in buildings



Minimum Recommended DH levels of the total heat market pr. country







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Why isn’t it happening?

- Heating is complex
- Heating and cooling is local
- Heating is long term
- Heat savings and district heating have large investment costs
- Heating and cooling is cultural, has ownership challenges and profit margins

- Scope and purpose of strategic heating and cooling planning
- Identification and co-ordination of stakeholders

- Mapping demand for heating and cooling
- Identifying and assessing geothermal, solar thermal and other local heat sources
- Establishing scenarios for heating/cooling supply

- Ownership
- Pricing
- Regulations
- Financing and risk mitigation
- Business models

- Assessing compatibility with the existing building stock
- Assessing compatibility with the existing networks
- Addressing technical challenges for low-temperature sources

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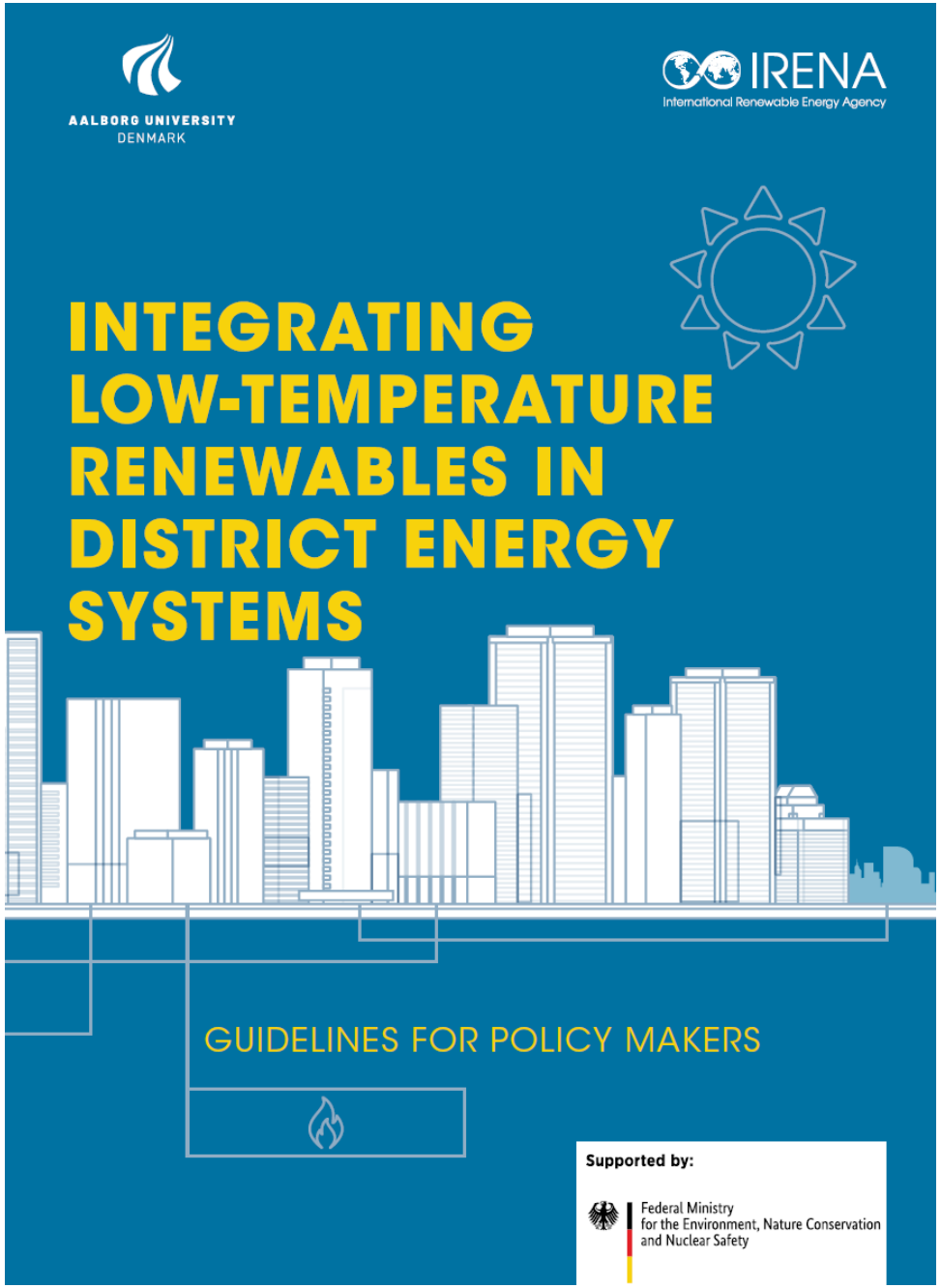
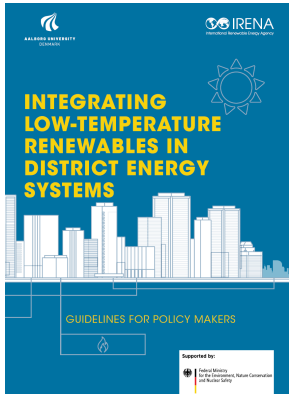
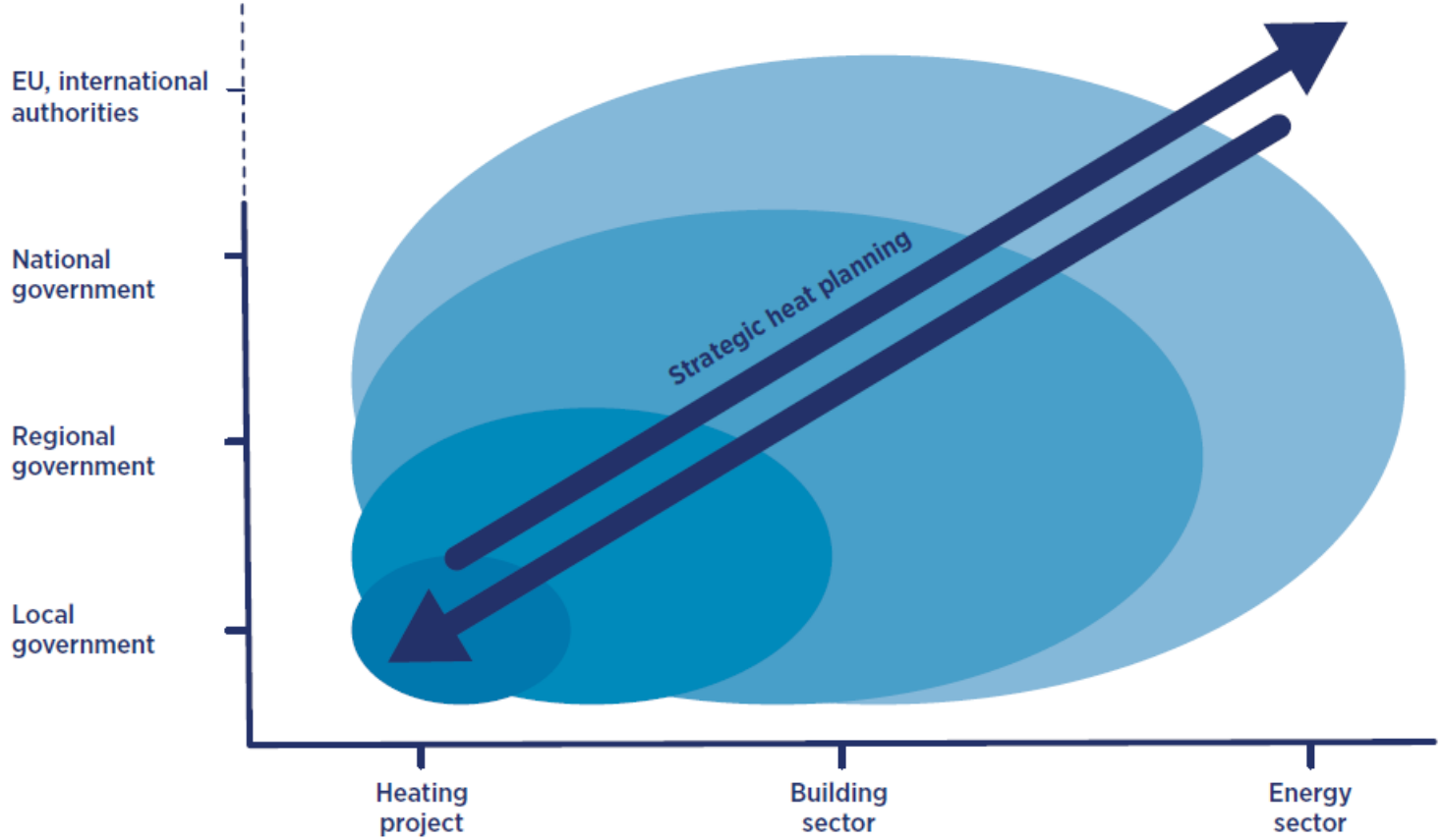


Strategic heating and cooling plans



Local/strategic heat planning in the context of national and international regulation and alignment with multiple interests and needs



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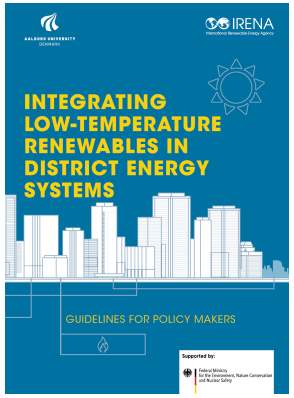
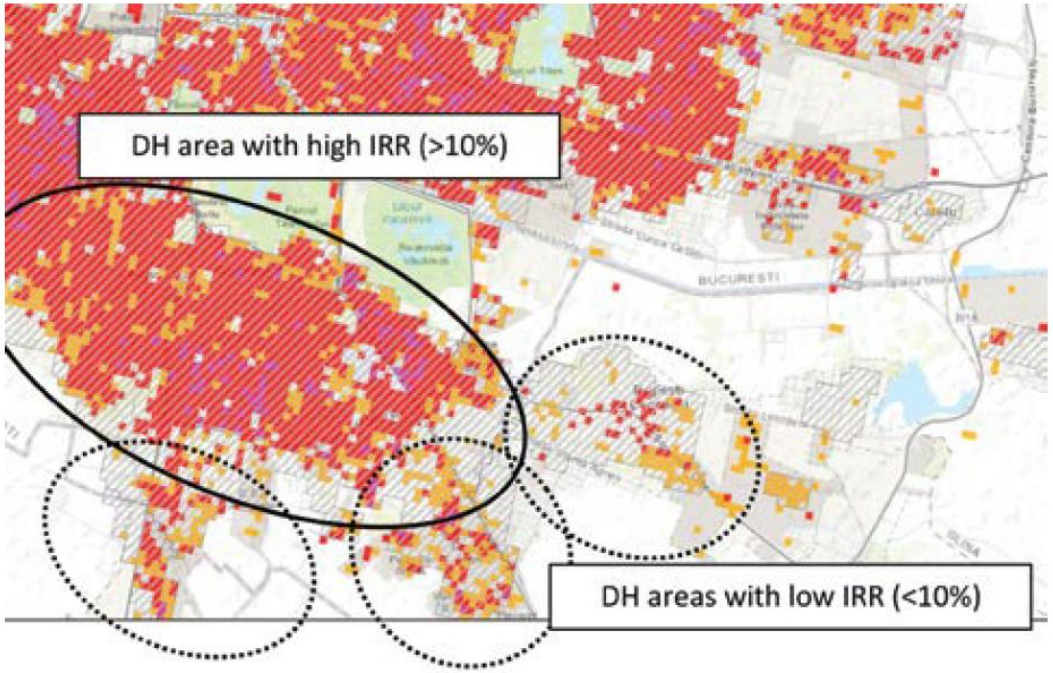
Ensure enabling regulatory conditions, supportive financing options and business models are put in place.



- Consider district energy grids as public infrastructure and ensure a level playing field through fiscal levers, legislation and price regulation, but also consider externalities such as greenhouse gas emissions or air pollutants
- Overcome uncertainty associated with demand for heating and cooling to attract investment by first connecting high-demand consumers – while making sure the full potential can be exploited.
- In addition to public finance, including grants, explore the involvement of the private sector and innovative practices such as partnerships with energy service companies (ESCOs) or crowdfunding.

Figure 34. **Example of developing district heating for areas with high and low IRRs**



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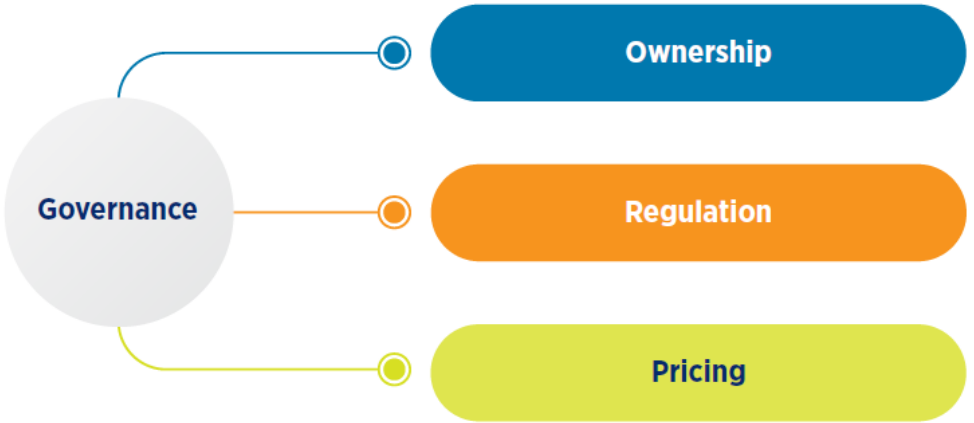
Ensure enabling regulatory conditions, supportive financing options and business models are put in place.

- Develop schemes to de-risk renewable-based applications. For example, promote support schemes for geothermal energy which are tailored to the market maturity and that reduce investors' risk of drilling unproductive wells and/or declining well productivity.
- Set up a comprehensive and transparent governance scheme through ownership, regulation and pricing that promotes district heating and cooling systems. The systems should be based on renewables and waste heat sources and align with societal goals.

Table 2. **Model of matrix for mapping the public regulatory framework for heat planning**

	PROJECT REGULATION	HEAT AND BUILDING REGULATION	ENERGY SYSTEM REGULATION
LOCAL REGULATION	☑	☑	
REGIONAL REGULATION	☑	☑	
NATIONAL REGULATION	☑	☑	☑
SUPRANATIONAL REGULATION	☑	☑	☑



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