Heat Roadmap Europe 2050

A low-carbon heating and cooling strategy

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Aalborg University

Methods and results of the Heat Roadmap Europe studies: Energy efficiency and renewable energy

September 25th 2017
"**EU4Energy Kyiv Policy Forum**
Kiev, Ukraine

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 695989.

WHO ARE WE? – SUSTAINABLE ENERGY PLANNING RESEARCH GROUP

- Smart Energy Systems
- Local/National/EU focus
- Strategic energy planning
- EnergyPLAN tool development
- Transport and renewable fuels
- International GIS mapping
- Public regulation, local implementation, ownership and market design

www.energyplan.eu

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WHAT AND WHO ARE 4DH?

- Strategic Research Centre financed by the Danish Research Council and the partners
- 4DH is an **international research centre** which develops 4th generation district heating technologies and systems
- 4DH has **30 partners** from universities in Europe and China, district heating supply companies, municipalities, manufacturers and consulting companies
- 4DH is a 6 year project (2012-2017) funded by Innovation Fund Denmark.

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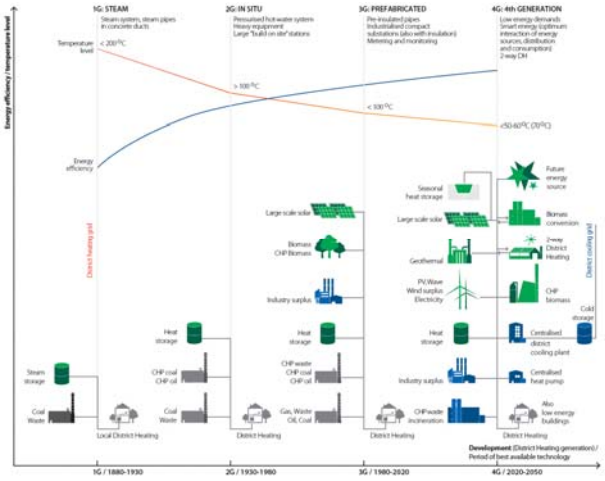
- Coherent concept
- Low energy demands
- Low distribution temperatures
- Recycle and use new, renewable sources of heat
- Interactions with integrated smart energy systems (mainly through thermal storage)
- Ensure strategic planning to transform to future sustainable energy systems



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- 2011: EU Energy Roadmap Released
- No growth in DH between 2010 and 2050

- 2016: EU has a long-term strategy dedicated to heating and cooling
- District heating is central in all of the documentation released to date

4DH
4th Generation District Heating Technologies and Systems

Heat Roadmap Europe 1, 2, 3, and 4

- Study 1 (2012): will district heating play a role in the decarbonisation of the European energy system?
- Study 2 (2013): what is the balance between heat savings and heat supply at an EU level?
- Study 3 (2015, STRATEGO WP2): low-carbon heating and cooling strategies for 5 member states
- Study 4 (2016-2019): low-carbon heating and cooling strategies for 14 member states

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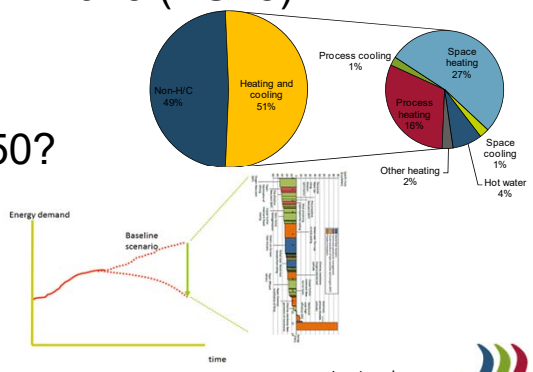
From 2015 to 2050?

- Total final energy in 2015 (EU28) H&C about 50%
- Demands and ressources in 2050?



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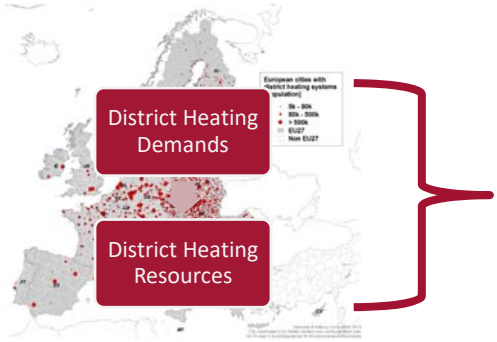
HRE Methodology

GIS Mapping
(could be another technology, resource, etc)

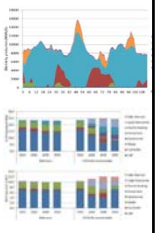
Energy System Modelling
(www.EnergyPLAN.eu)



BAU (References)

District Heating Alternatives

Results (PES, CO2, Costs)



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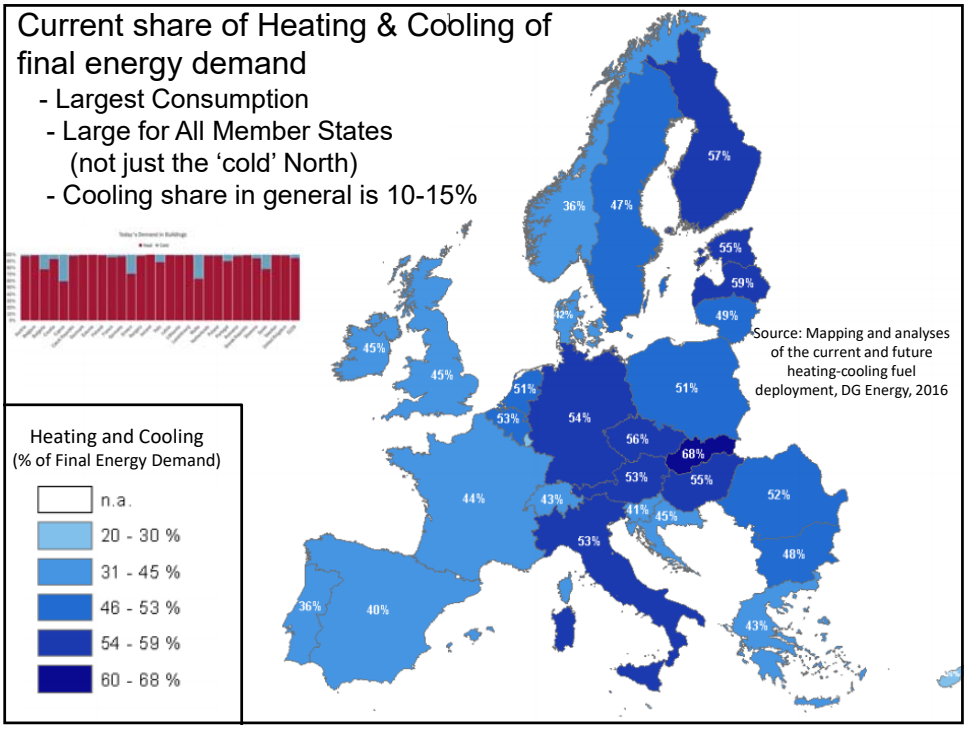
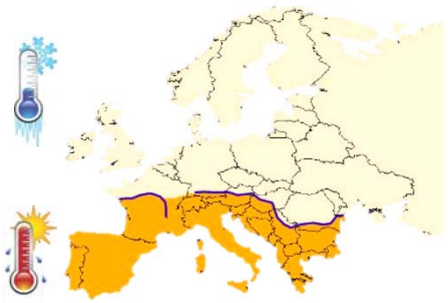
Current share of Heating & Cooling of final energy demand

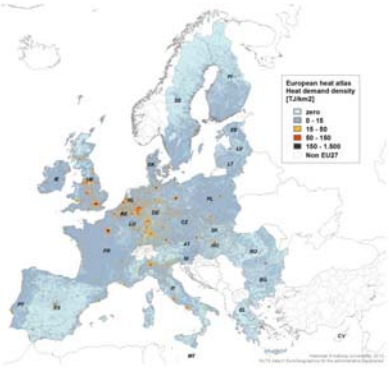
- Largest Consumption
- Large for All Member States (not just the 'cold' North)
- Cooling share in general is 10-15%



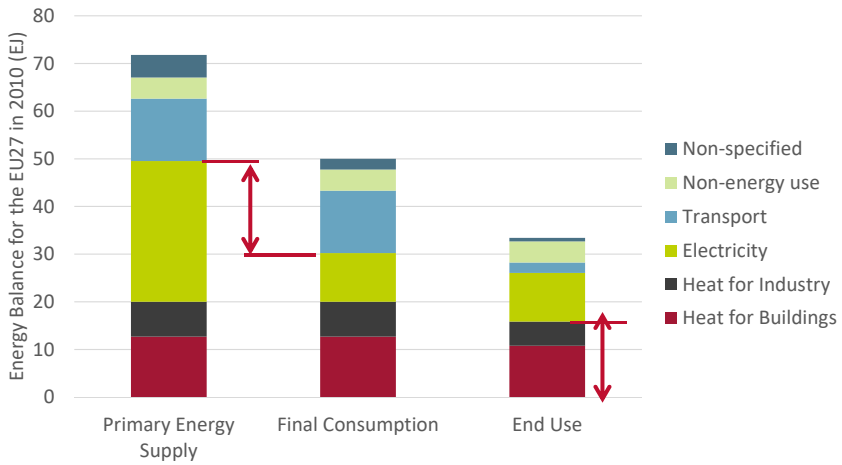
Source: Mapping and analyses of the current and future heating-cooling fuel deployment, DG Energy, 2016

Number 1: 50% of the heat demand in Europe can be supplied with district heating (www.HeatRoadmap.eu)

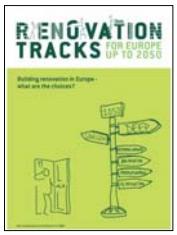


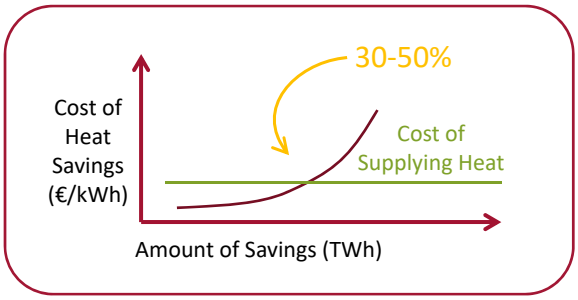


Number 2: there is more excess heat in Europe than all of the heat demand in buildings

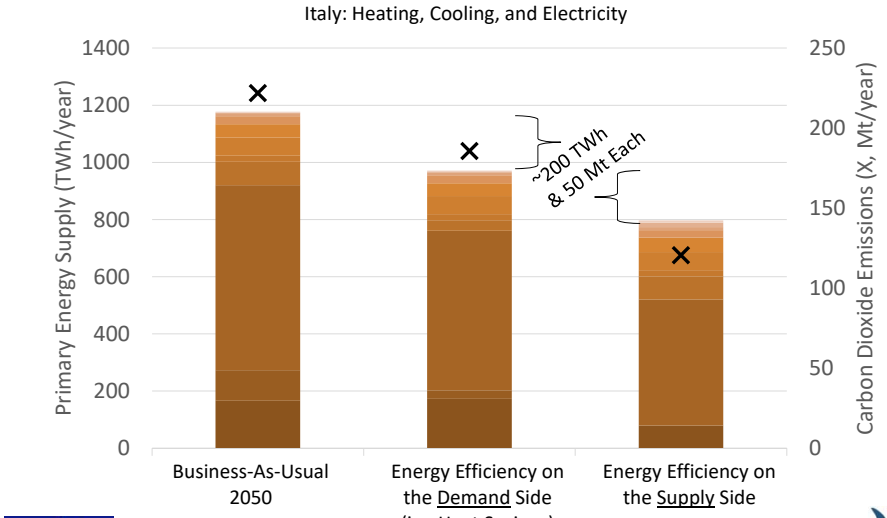


Number 3: Energy efficiency is required on both the demand and supply side of the heat sector





Number 4: Energy Efficiency on Both Sides Can Save Similar Levels of Energy & CO2



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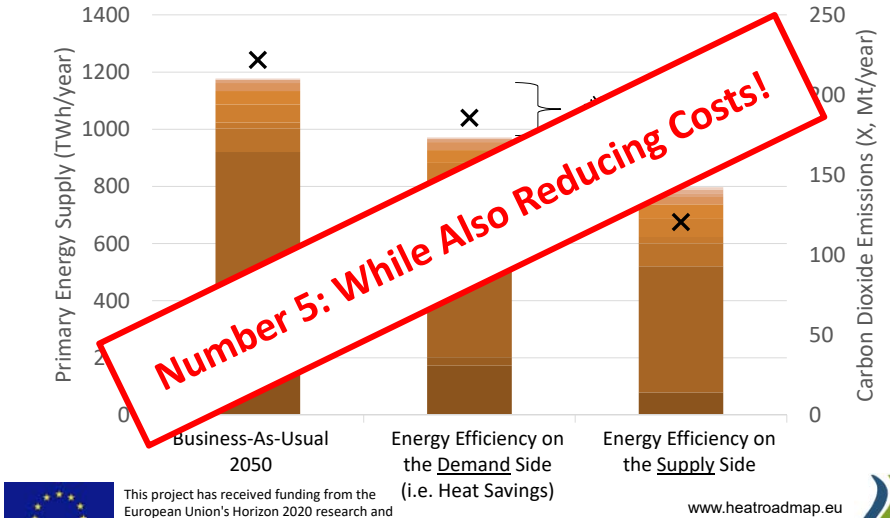
Number 5: Energy Efficiency on Both Sides Can Save Similar Levels of Energy & CO2



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Key Recommendations for the Heat Sector

Everywhere

- Heat Savings
- Balance Savings vs. Supply
- 30-50% Total Reduction

Urban Areas

- District Heating Networks
- High Heat Density Areas
- Supply ~50% of the Heat Demand

Rural Areas

- Primarily Electric Heat Pumps
- Smaller Shares of Solar Thermal & Biomass Boilers
- Remaining ~50% of the Heat Demand

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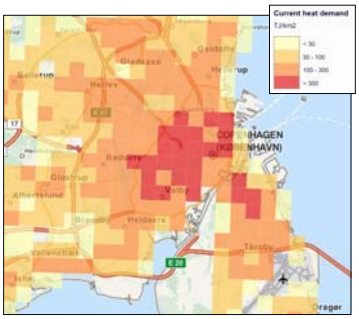
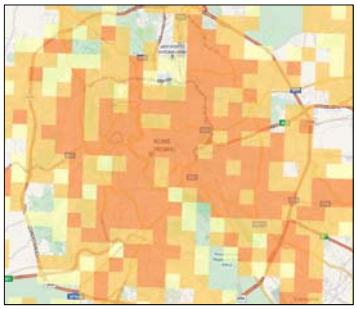
Today's Heat Demand from Peta3 (www.heatroadmap.eu)

London
←<5% DH

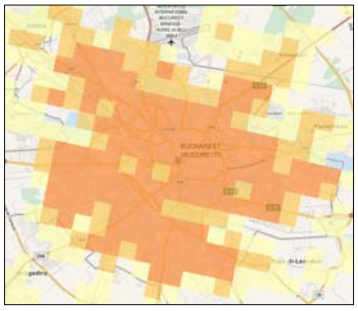
Copenhagen
>90% DH →





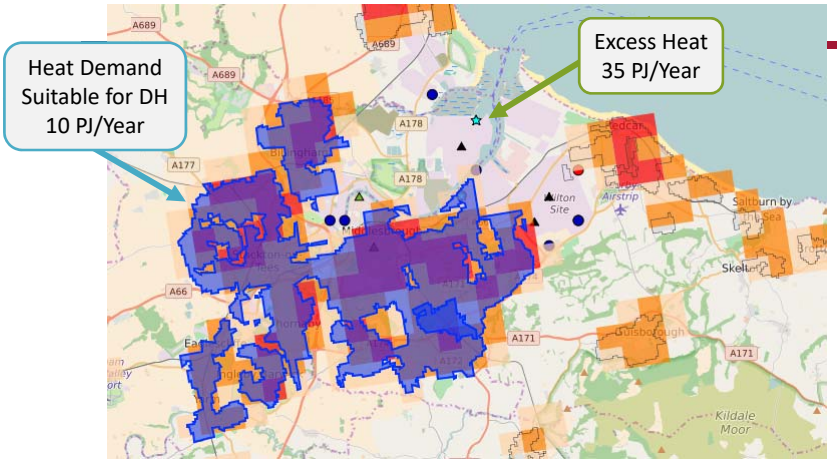
Roma
←<5% DH

Bucharest
~75% DH →



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

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



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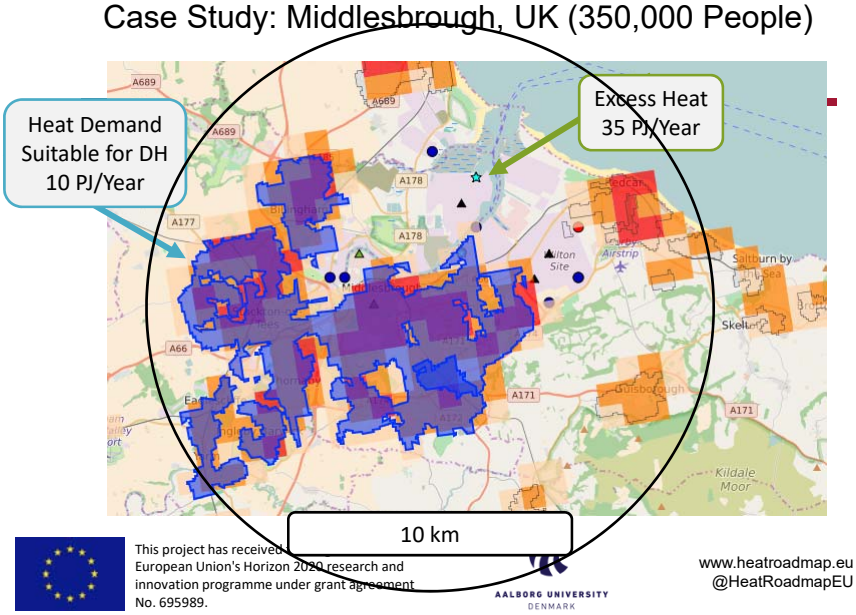

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From Research to Implementation

Impact at EU Level

(EC: European Commission)

Research: Internal & External to EC	Short-Term EC Communication	Long-Term EC Strategy
		
>5 journal articles published with over 100 citations in other peer-reviewed scientific articles since their release in 2014	*Paul Hodson, who is head of the Energy Efficiency Unit in DG Energy, referred to HRE/STRATEGO as "the most advanced on the EU's heating and cooling sector as a whole"*	*Referenced >20 times in the EU's first ever Heating and Cooling Strategy, which was launched in 2016*

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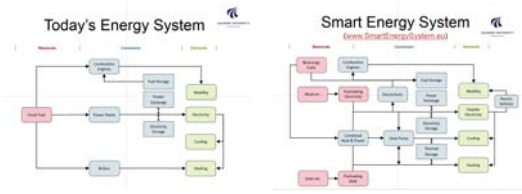
The aim in Heat Roadmap Europe 4

- Creating scientific **evidence** to support long-term energy strategies at local, national, and EU level
- By **quantifying** the impact of various future alternatives using energy savings, renewable energy and energy efficiency in the heating and cooling system as part of the energy system



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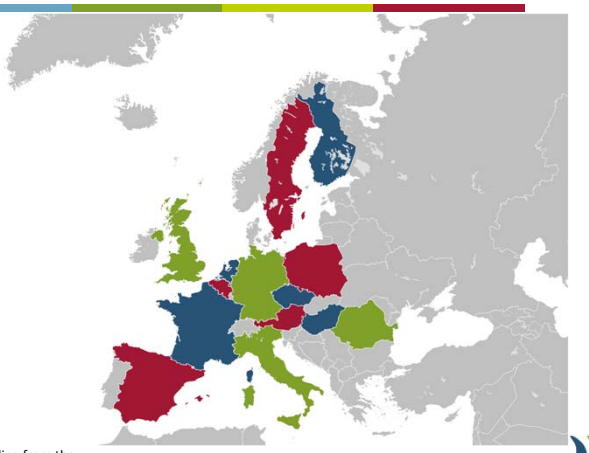
HRE4 Countries: 14 Largest EU Countries by Heat Demand = 90% of EU Heat

1. Germany
2. France
3. United Kingdom
4. Italy
5. Poland
6. Spain
7. Netherlands
8. Sweden
9. Belgium
10. Czech Republic
11. Romania
12. Austria
13. Finland
14. Hungary



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Project Participants

www.heatroadmap.eu/project-partners.php

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Heat synergies map in PETA4 example: Netherlands

- Heat demands: 296 PJ/y
- Excess heat: 560 PJ/y
- District heating share: 5%
- 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			1.75
NL121			0.25
NL131			0.92
NL132			0.55
NL213			0.48
NL224			0.08
NL225			0.09
NL226			1.40
NL230			0.99
NL310			0.12
NL322			1.16
NL323			12.27
NL325			0.05
NL326			1.05
NL332			0.05
NL337			0.09
NL339			5.06
NL33A			0.39
NL341	2.02	32.49	12.41
NL342	6.82	32.59	4.78
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**

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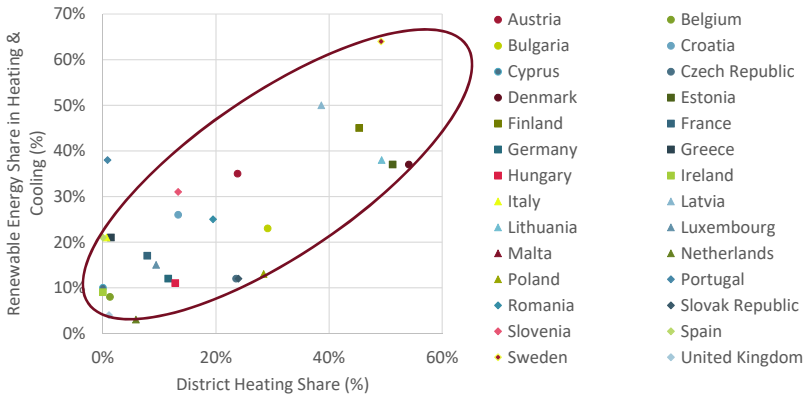
Proven Technology! Renewable Energy vs. District Heating



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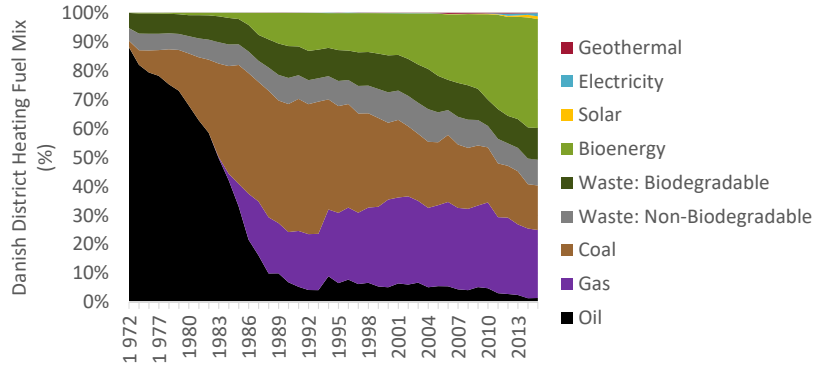
Resources for Danish District Heating1972-2015



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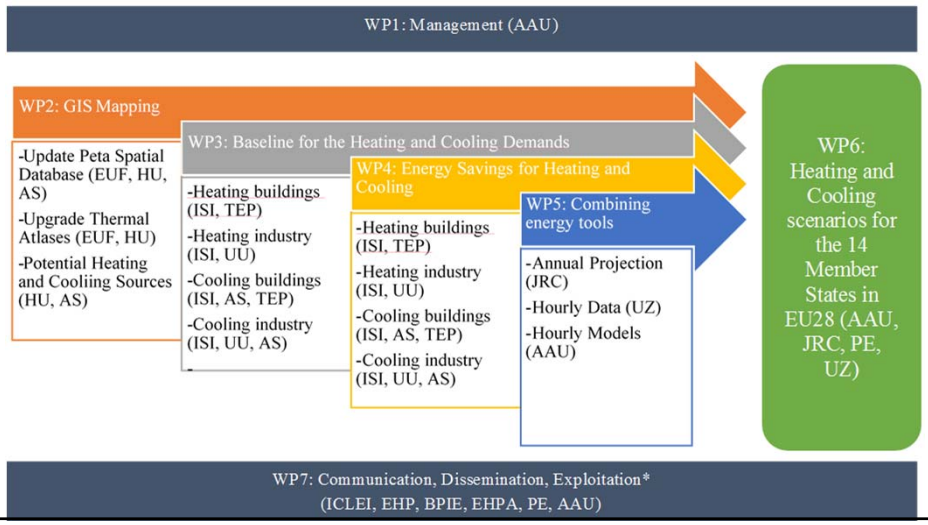
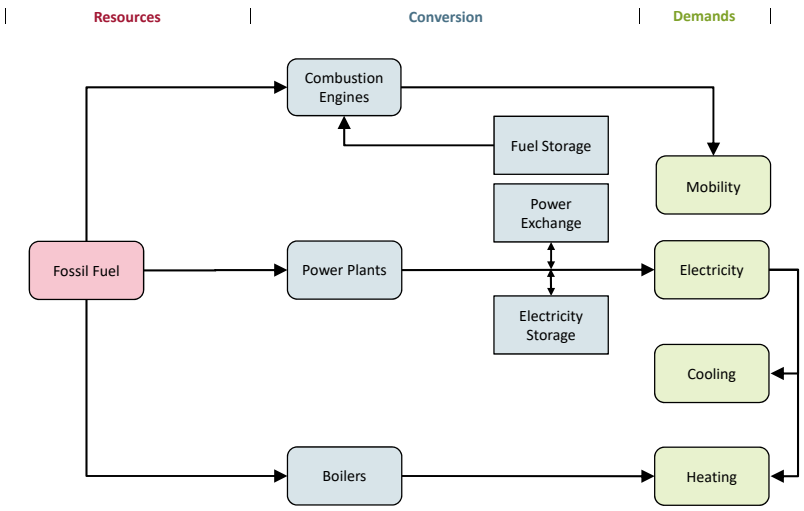
HRE4 Methodolgy

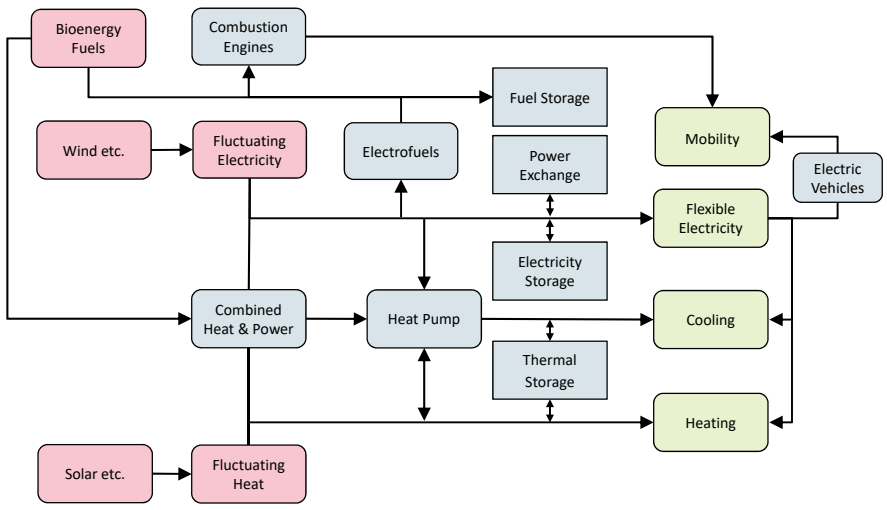


Today's Energy System



Future Smart Energy System

(www.SmartEnergySystem.eu)



Combining the Strengths of Different Energy Models

Heating & Cooling (Creating Data)

Location of Heating & Cooling and Renewable Enregy (WP2)

Profile of Heating & Cooling (WP3/4)

FORECAST
FORecasting Energy Consumption Analysis and Simulation Tool

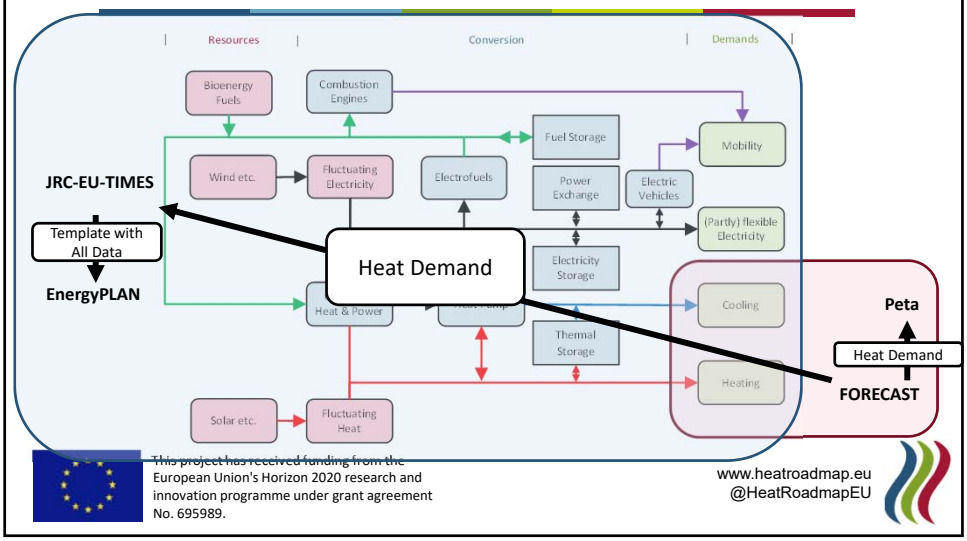
Energy System (Creating Scenarios)

Energy System Transition (WP5/6)

Energy System Operation (WP5/6)

Energy PLAN
Advanced energy system analysis computer model

Model Connections in HRE4



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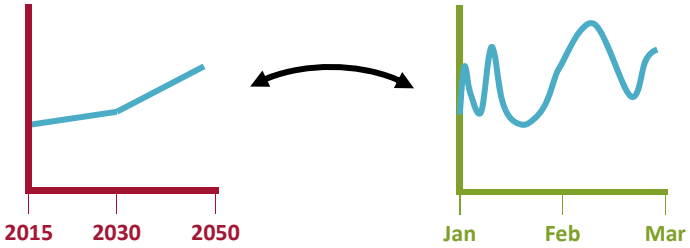
Connecting Energy Models Using the Strengths of Each One

JRC-EU-TIMES

Tells us what happens between now and 2050

EnergyPLAN

Explains what is going on in each hour of the year



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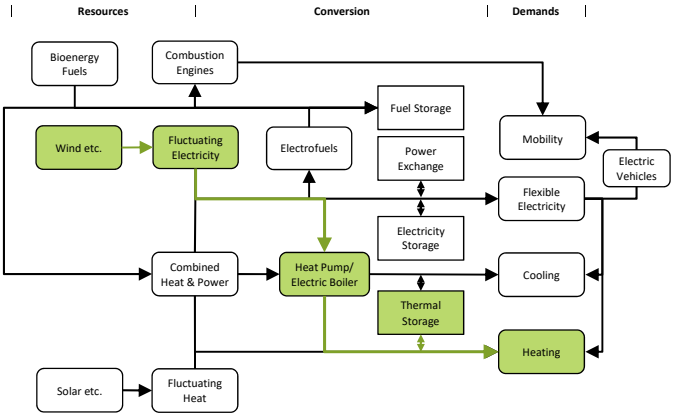
EnergyPLAN (www.EnergyPLAN.eu) Example of Hourly Operations in Smart Energy System (www.SmartEnergySystem.eu)



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Access to More Sustainable Resources: These Can Only Be Used with District Heating

- Excess heat from Power Plants
- Industrial Excess Heat
- Waste Incineration
- Bio-refinary Excess Heat
- Synthetic fuel Excess Heat (electrofuels)
- Large-Scale Solar Thermal
- Geothermal
- Large-Scale Heat Pumps (new study out)
- Large-Scale Electric Boilers
- Bioenergy for Urban Heating

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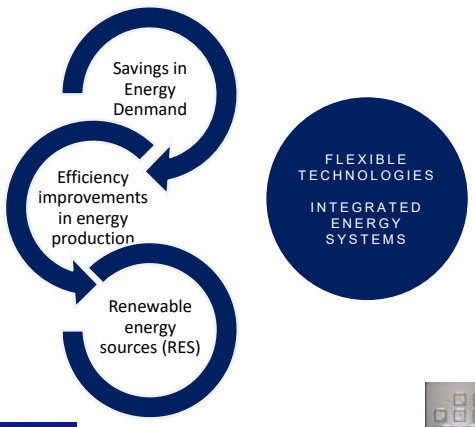
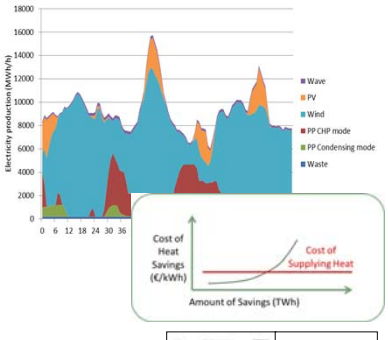
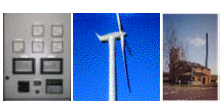
Renewable Energy Strategies for Sustainable Development







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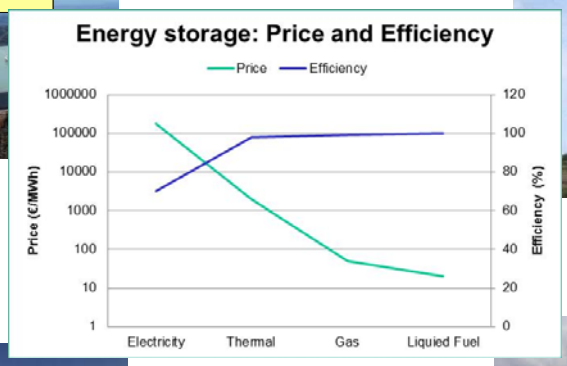
Energy Storage

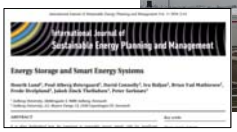
Pump Hydro Storage
175 €/kWh
(Source: Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits. Electric Power Research Institute, 2010)



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

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

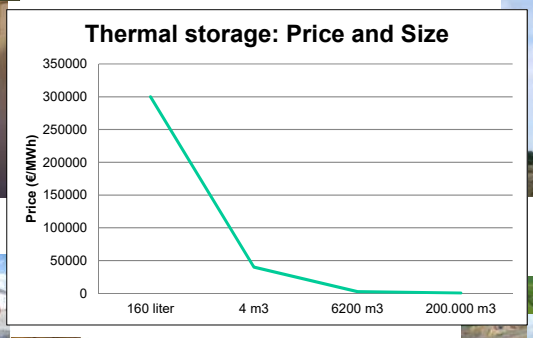
Natural Gas Underground Storage
0.05 €/kWh
(Source: Current State Of and Issues Concerning Underground Natural Gas Storage. Federal Energy Regulatory Commission, 2004)



No. 695989.

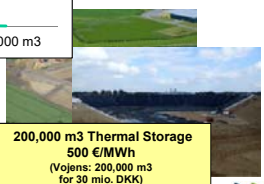
Thermal Storage

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



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

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



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

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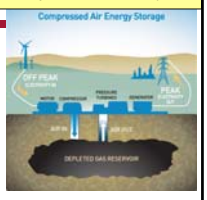
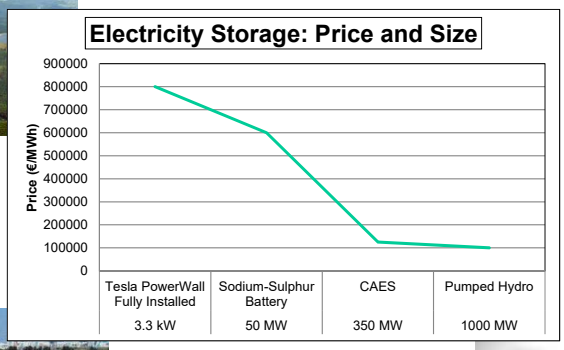
Electricity Storage

Pump Hydro Storage
100 €/kWh
(Source: Goldisthal Pumped Storage Station, Germany, www.store-project.eu)

Compressed Air Energy Storage
125 €/kWh
(Source: http://www.sciencedirect.com/science/article/pii/S0196890409000429)





Tesla PowerWall
800 €/kWh
(Source: Dahl KH, Oil tanking Copenhagen A/S, 2013: Oil Storage Tank. 2013)

Sodium-Sulphur Battery
600 €/kWh
(Source: Table 4: http://large.stanford.edu/courses/2012/ph240/doshay1/docs/EPRI.pdf)

SMART ENERGY SYSTEMS
- ARE CRUCIAL IN 100% RENEWABLE ENERGY SYSTEMS

SOLUTION

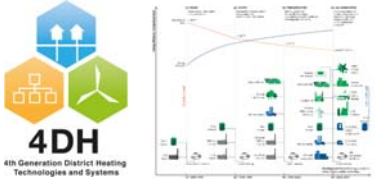
A cross-sectoral and coherent energy system solution

- **Smart Electricity Grids** to connect flexible electricity demands such as heat pumps and electric vehicles to the intermittent renewable resources such as wind and solar power.
- **Smart Thermal Grids** (District Heating and Cooling) to connect the

SMART ENERGY SYSTEM IS DEFINED AS AN APPROACH IN WHICH SMART ELECTRICITY, THERMAL AND GAS GRIDS ARE COMBINED AND COORDINATED TO IDENTIFY SYNERGIES BETWEEN THEM IN ORDER TO ACHIEVE AN OPTIMAL SOLUTION FOR EACH INDIVIDUAL SECTOR AS WELL AS FOR THE OVERALL ENERGY SYSTEM.

fuel storages can also be utilised.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 695989.



DH - rehabilitation implementation challenges for test cases identified by the DH-REHAB Eastern European partners

- End-user low income **(energy poverty)** making it difficult for them to pay for activities having an efficient DH-supply system (poverty) – also in a longer time perspective
- Tradition for seeing **heat supply as a social benefit**, which in shorter time perspective shall be delivered at the lowest cost possible meaning not having financial capacity for DH-maintenance/rehabilitation -
- No public **regulatory heat planning in place**, e.g. by local authorities, which can regulate heating supply in geographical areas and thereby secure the market for DH-supply
- No regulatory framework in place for making it **obligatory to be connected to DH**-supply in geographical areas
- **No public/end-user acceptance of/motivation for DH**-supply due to experience of bad technical performance and/or not cost-efficient DH-supply
- No public acceptance of/motivation for DH-supply due to **lack of transparent tariffs and/or end-user influence**
- **No regulatory framework in place for tariffs securing investments** in high level maintenance and operation of the DH-network and/or for converting from fossil fuel to RES
- No regulatory framework in place for regulating **exploitation of waste heat sources for DH**
- **Lack of information** on European level DH-rehabilitation best practice
- Lack of possibilities for **exchange on DH-rehabilitation** between the local DH-stakeholders
- Lack of **guidelines for achieving financing** for DH-rehabilitation projects – to be specified
- **Lack of capacity at the local level** for planning and implementing DH-rehabilitation
- **Poor insulation of building stock**
- No reliable/transparent **end-user consumption measurement**

APPLICATION IN

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www.heatroadmap.eu
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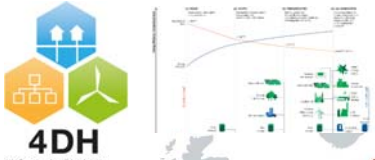
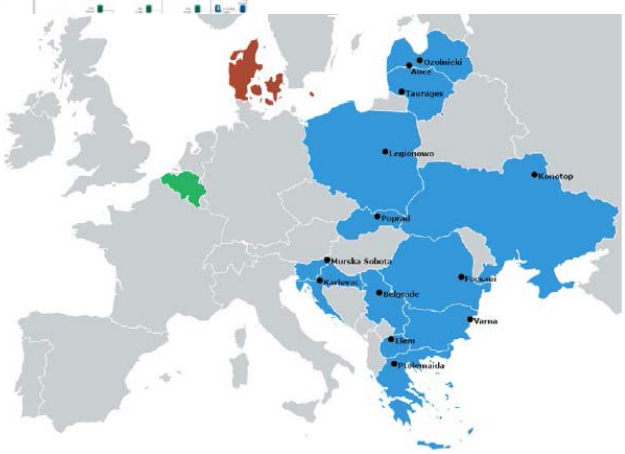


Title: DH-REHAB - District Heating REHABilitation H2020-EE-2016-2017 (EE-02-2017)



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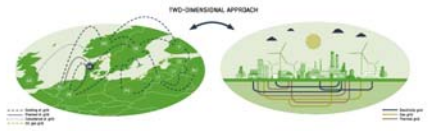

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4DH

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