CITIES
Centre for IT Intelligent Energy Systems

4DH
4th Generation District Heating Technologies and Systems

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www.heatroadmap.eu
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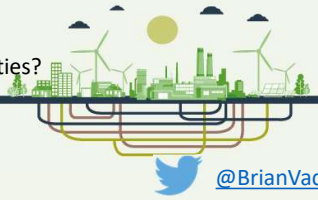
The Smart Energy System: Synergies in low-cost energy storages across sectors – studies from projects RE-INVEST, CITIES, Heat Roadmap Europe, 4DH Centre

Brian Vad Mathiesen; June 6 2018, European Commission, DG Energy

Expert workshop - Technology Pathways

- What will the energy system look like in 2050 and what does it mean for R&I priorities?



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

Innovation Fund Denmark

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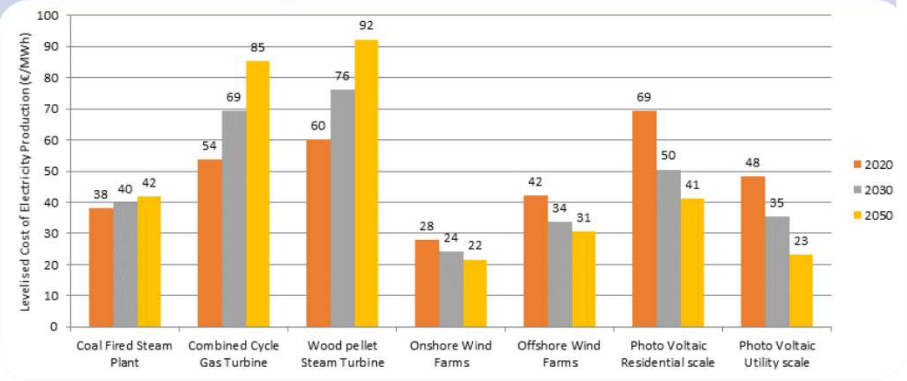
Energy System Challenges and opportunities	Questions and strategic decisions
- Lower and lower Renewable Energy investment costs (Electricity especially) - Batteries are falling in price - Electricity prices are falling (sign of system design failure) and cannot merit investments in new capacity - Power plants for back-up is closing down (lower operation hours)	- How should we use and balance (energy storage) more electricity from renewable energy? - How should we re-design the energy system and how much renewable energy is needed?

Energy PLAN
Advanced energy system analysis computer model

(sources: EnergyPLAN cost database)



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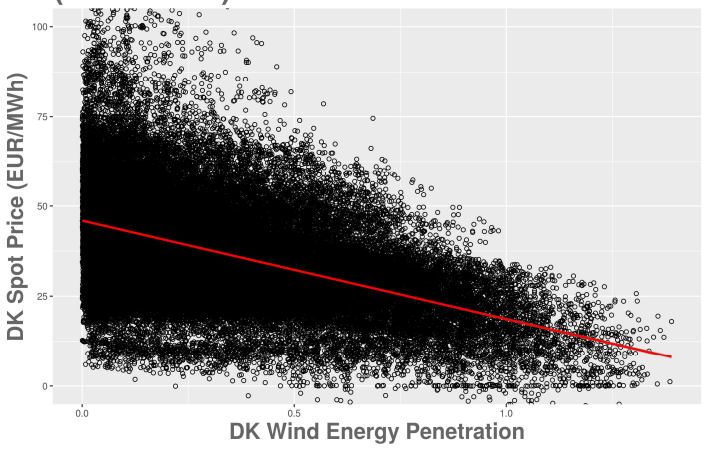
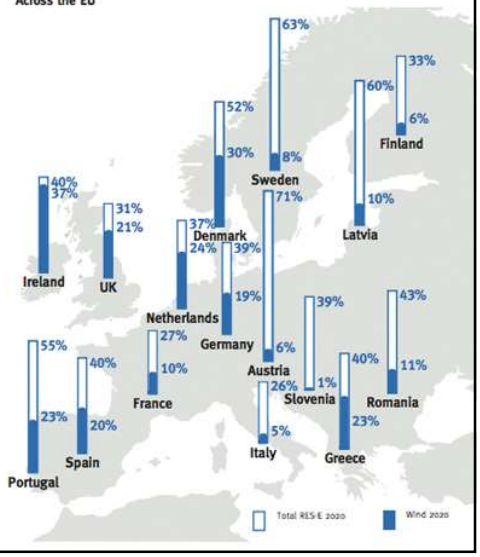
Danish Elspot Price by Danish Wind Power Penetration (2009-2016)



The European Union is a world leader in the deployment of renewable energy.

2020 Renewable Electricity Targets Across the EU



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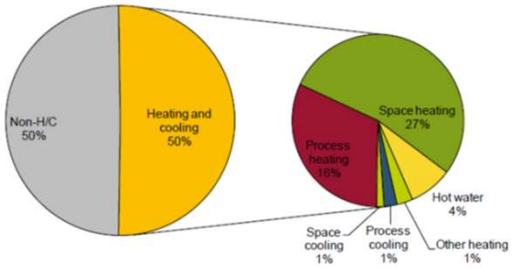
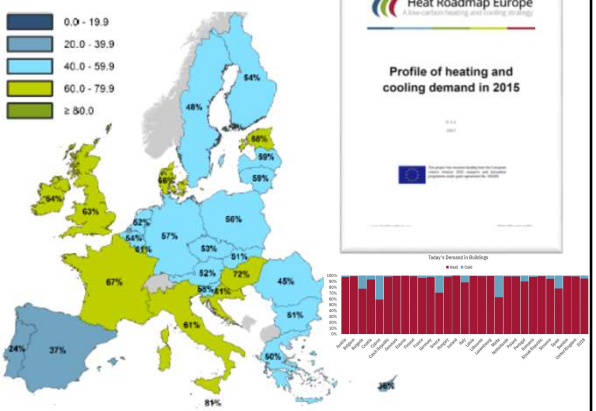
Heating vs. other sectors



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

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Examples of infrastructures supported

European Commission | **2017 PCI LIST**

173 PROJECTS

110 electricity and smart grids
53 gas projects
6 oil projects
4 cross-border CO_2 network projects

European Commission | **2017 PCI LIST**

SHIFT FROM GAS TO ELECTRICITY

2015		2017	
55%	electricity projects	61%	electricity projects
39%	gas projects	30%	gas projects

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Three focus areas for buildings

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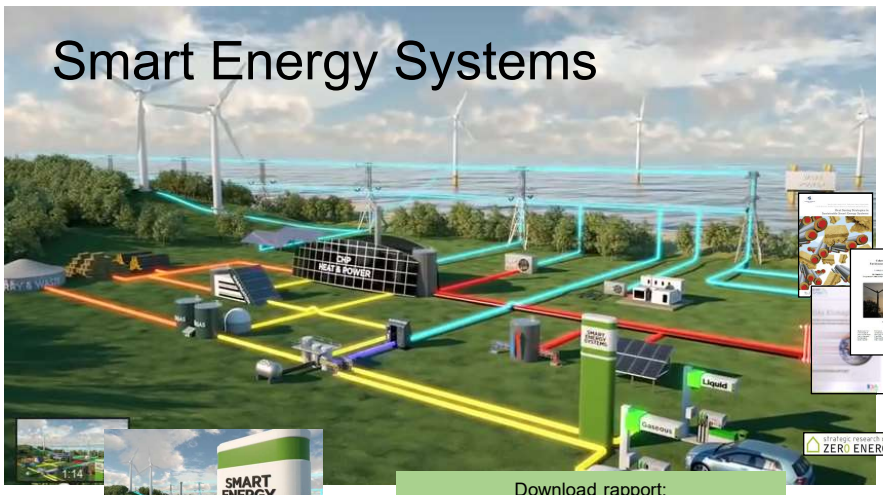

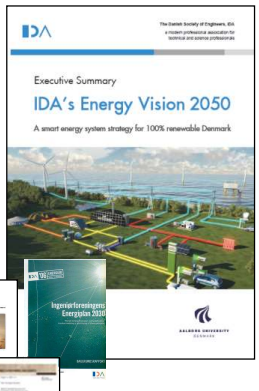

Download rapport:
www.EnergyPLAN.eu/IDA

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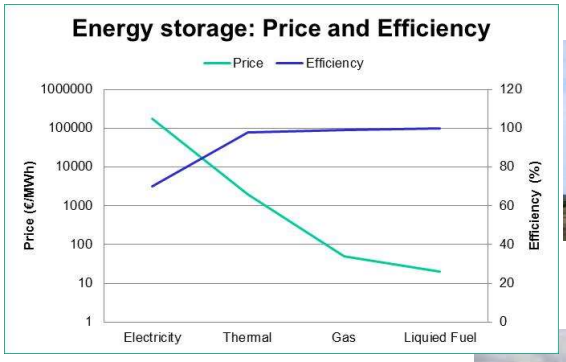
Pump Hydro Storage
175 €/kWh
(Source: Electricity Energy Storage Technology Options: A White Paper Primer on Applications, Costs, and Benefits. Electric Power Research Institute, 2010)



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)

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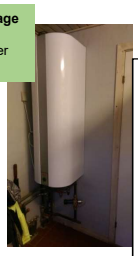
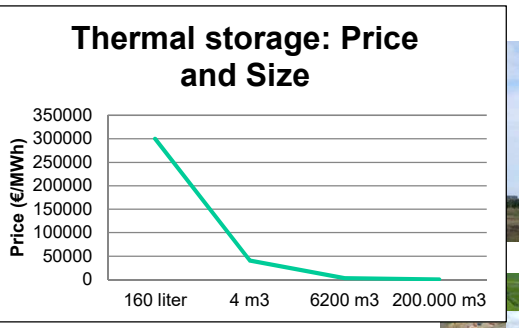
Heat energy storage

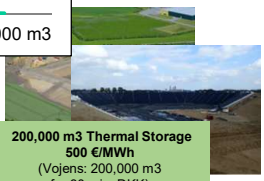
0.16 m3 Thermal Storage
300.000 €/MWh
(Private house: 160 liter for 15000 DKK)



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)

AALBORG UNIVERSITY
DENMARK

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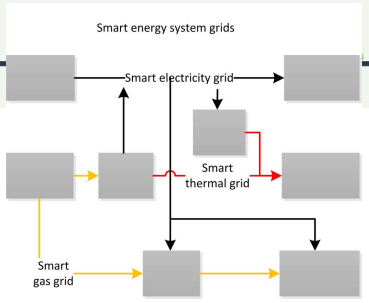
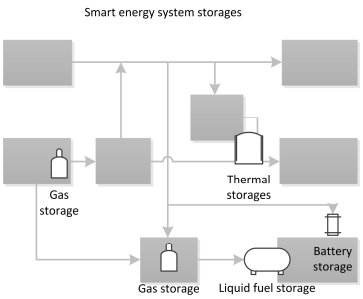
HOW TO USE STORAGES LONG TERM..

- Three crucial grids in Smart Energy Systems
  - Smart electricity grids
  - Smart thermal grids
  - Smart gas grids
- High capacity electrolyses (Power-to-gas)
- More district heating and district cooling
- Large heat pumps with high capacity (Power-to-heat)
- CHP, solar thermal, etc.
- Electricity storage in transport (batteries and electrofuels)
- Production of green gasses and synthetic fuels





WWW.SMARTENERGYSYSTEMS.EU

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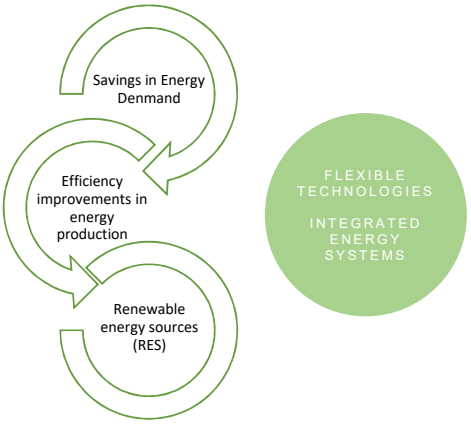
STATE-OF-THE-ART-KNOWLEDGE ON 100% RENEWABLE ENERGY IN 2050



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Heat Roadmap Europe Methodology

Data and mapping

Building Demand Savings Potential → Costs of Making Savings

District Heating Potential → District Heating Resources

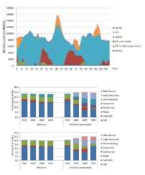
Energy System Potential → Energy System Resources

Energy System analyses

BAU (References)

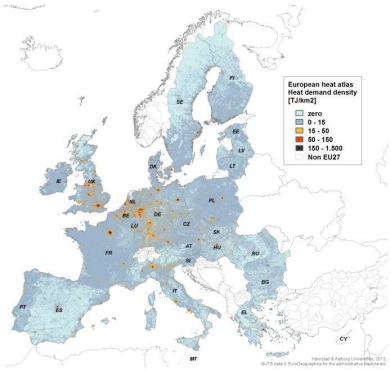
Heat Roadmap Europe Alternatives

Results (PES, CO2, Costs)



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

KEY ROLE FOR CITIES



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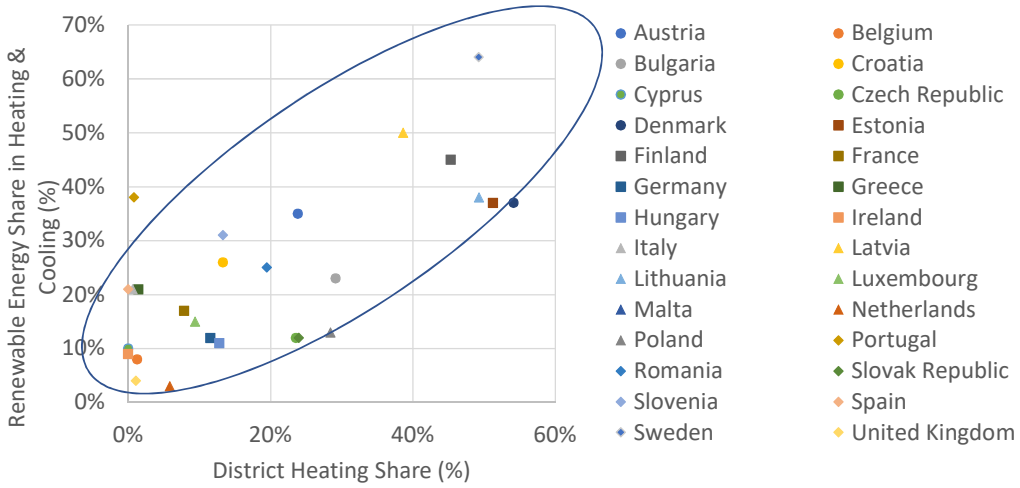
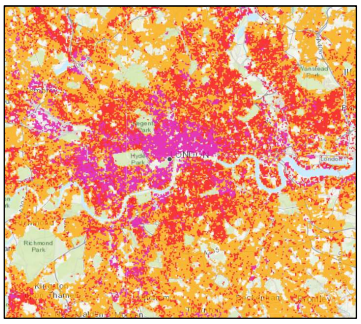
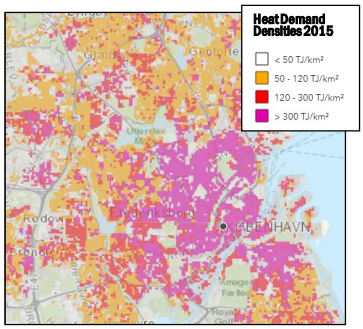
Proven Technology! Renewable Energy vs. District Heating



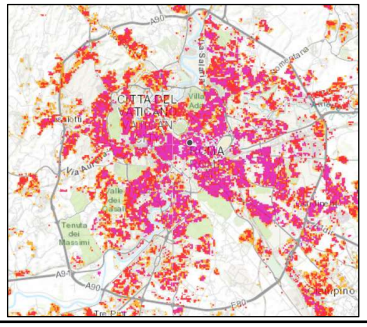
Today's Heat Demand from Peta 4.2 (www.heatroadmap.eu)



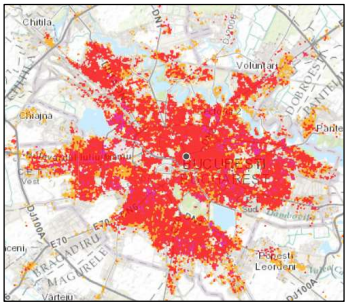
London
←<5% DH



Copenhagen
>90% DH →



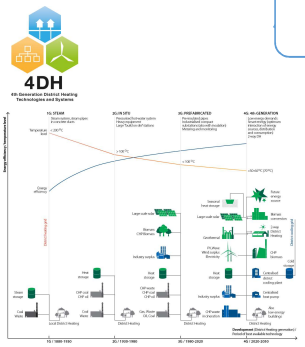
Roma
←<5% DH

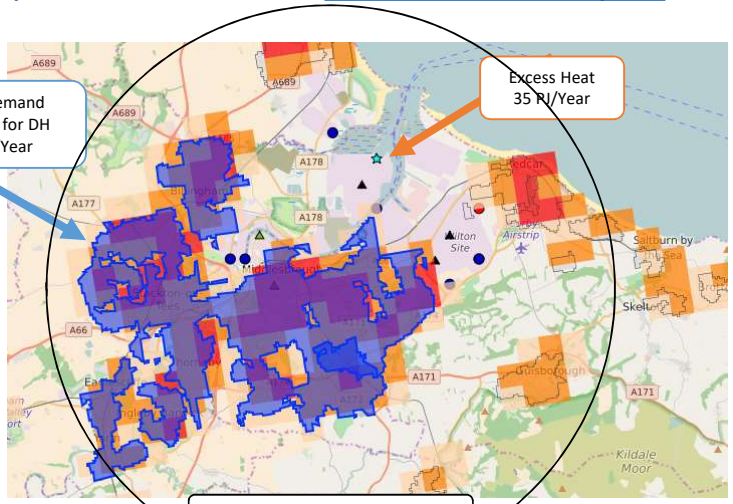


Bucharest
~75% DH →

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

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





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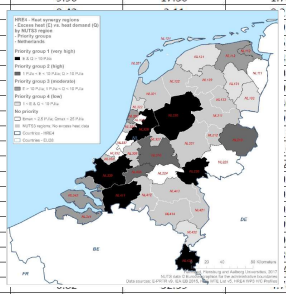
Heat synergies map in PETA4 example: Netherlands

- 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	9.90	17.30	1.75
NL121			5
NL131			2
NL132			5
NL213			8
NL224			8
NL225			9
NL226			0
NL230			9
NL310			2
NL322			6
NL323			27
NL325			5
NL326			5
NL332			5
NL337			9
NL339			6
NL33A			9
NL341			41
NL342			8
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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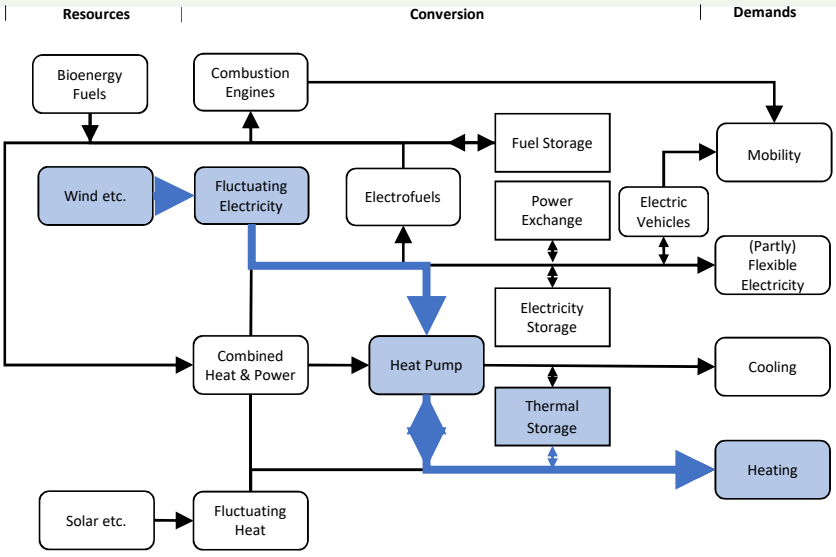
Smart Energy System: Thermal Storage



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We need two-dimensional approach - technically and in regards to markets