Heat Roadmap Europe 2050
A low-carbon heating and cooling strategy

4DH
4th Generation District Heating Technologies and Systems

reINVEST

Low carbon energy system planning in European regions

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Presentation outline

- Background
- Research aim and method
- Results
- Main discussion points

Background: SmartEnCity project "Towards Smart Zero CO_2 Cities across Europe"

- Aim to develop strategies for European cities that:
  - Reduce energy demand
  - Maximise renewable energy supply
  - Achieve low carbon
- 28M€ EU funding, 35 partners, 5.5 years (02/2016-07/2021)
- Will implement demonstration activities, i.e. retrofitting buildings, integrating infrastructures, developing sustainable mobility and the intelligent use of ICT
- Three lighthouse cities: **Vitoria-Gasteiz** (Spain), **Tartu** (Estonia) and **Sønderborg** (Denmark) - process **replicated** in two follower cities of Lecce (Italy), and Asenovgrad (Bulgaria)
- SmartEnCity city **Network** developed for replicating the approach elsewhere in Europe

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"Smart Zero CO_2 Cities" how?

I asked, what **studies** have been done that analyse the future decarbonisation of the entire energy system of a region (i.e. sub-national e.g. municipality or city but not sub-city e.g. a suburb)

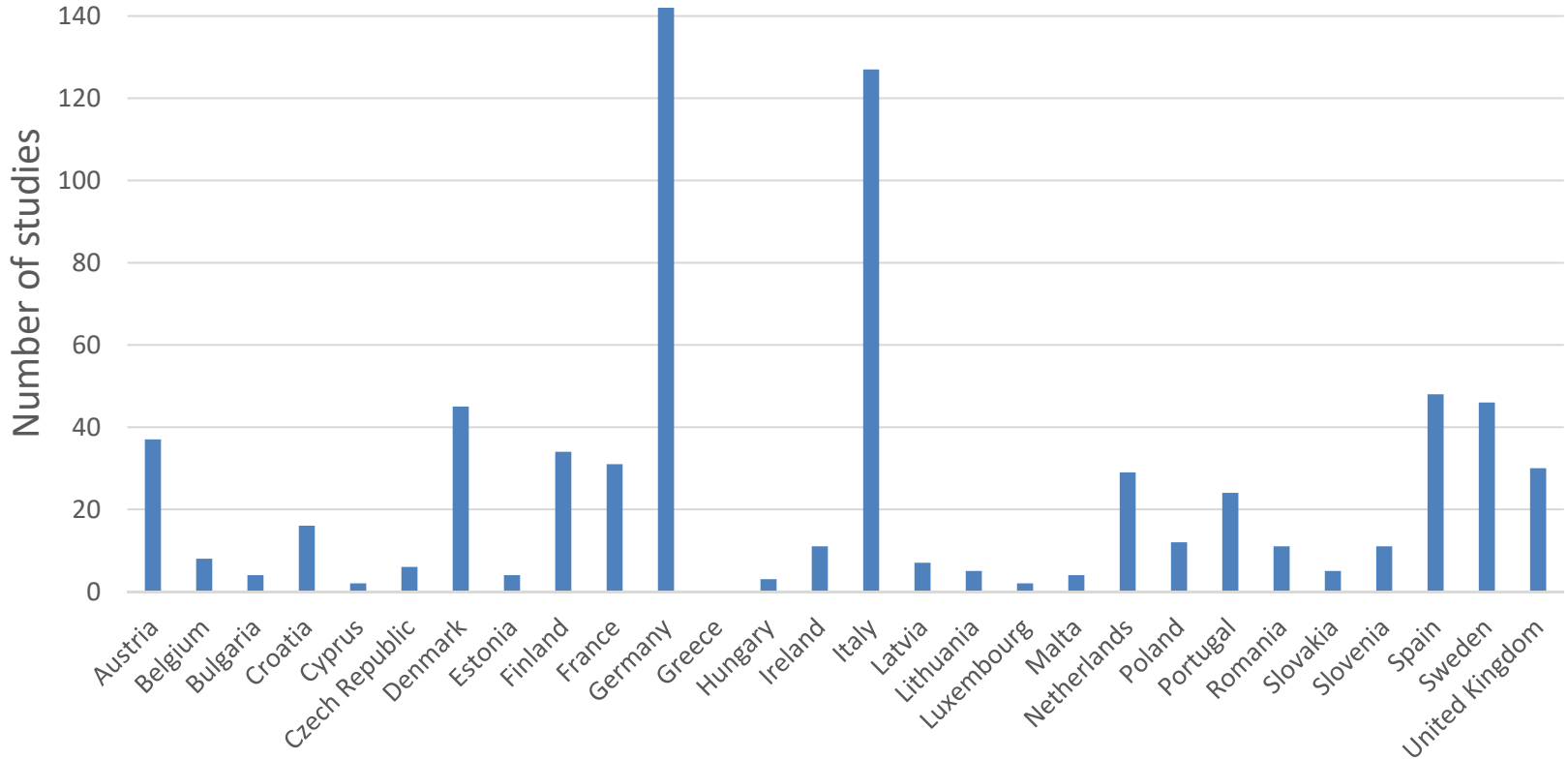
What are the main features of these studies? i.e. technologies & transition pathways, analysis methods

Method – keyword search

- Literature search done in Scopus and in English
  - Scopus is the largest abstract and citation database of peer-reviewed literature
- Studies were searched for all 28 EU countries
- The keywords searched within titles and abstracts were:

renewable OR sustainable OR mitigat* OR (fossil AND free OR independ*) OR (self AND sufficient)
AND
"energy system*" OR "energy scenario*" OR "energy plan*"
AND
urban OR cit* OR town OR municipal* OR region* OR province OR island OR village
AND
e.g. Austria OR Austrian OR Vienna

Results from first search

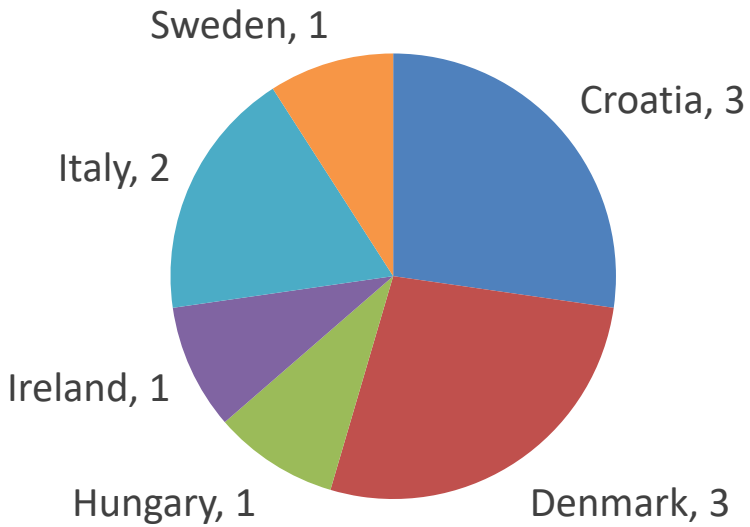


Method – limiting criteria

- Key criteria for identifying the final articles
  - The study must focus on reducing emissions in ALL energy sectors (transport, electricity, heat) because low carbon cities will need to achieve this
  - The region must be previously connected to the wider electricity grid (no disconnected islands)
  - The methodology must demonstrate carbon reductions in the entire energy system (transport, electricity, heat) using an analytical methodology, e.g. modelling

Results from further analysis

11 studies investigated CO_2 reductions in the entire energy system of a city or region



The regions and population sizes

Country	Region	Population
Sweden	Malardalen region	3,000,000
Italy	Bologna	380,000
	Bressanone-Brixen	147,000
Ireland	South West Region Ireland	642,355
Hungary	Pecs	20,000
Denmark	Aalborg	19,700
	Frederikshavn	25,000
	Sønderborg	75,000
Croatia	Island of Mljet	1,111
	Island of Hvar	11,000
	Dubrovnik	42,615

What features did I look at?

- Main technologies used to decarbonise
- Analysis methods and tools used

Main technologies used
Decarbonisation target

	Decarbon-isation target
Malardalen region (2007)	100%
Island of Mljet (2009)	100%
Aalborg (2010)	100%
Frederikshavn (2011)	80%
Island of Hvar (2013)	100%
South West Region Ireland (2014)	100%
Dubrovnik (2015)	100%
Bologna (2015)	80%
Pecs (2015)	25%
Bressanone-Brixen (2016)	15%
Sønderborg (2017)	60%

Main technologies used
Biomass

	Decarbon-isation target	Biomass
Malardalen region (2007)	100%	High demand
Island of Mljet (2009)	100%	
Aalborg (2010)	100%	
Frederikshavn (2011)	80%	
Island of Hvar (2013)	100%	
South West Region Ireland (2014)	100%	High demand
Dubrovnik (2015)	100%	
Bologna (2015)	80%	
Pecs (2015)	25%	
Bressanone-Brixen (2016)	15%	
Sønderborg (2017)	60%	

Main technologies used
External grid decarbonisation

	Decarbon-isation target	Biomass	External grid decarb.
Malardalen region (2007)	100%	High demand	
Island of Mljet (2009)	100%		
Aalborg (2010)	100%		
Frederikshavn (2011)	80%		
Island of Hvar (2013)	100%		
South West Region Ireland (2014)	100%	High demand	
Dubrovnik (2015)	100%		
Bologna (2015)	80%		High dependence
Pecs (2015)	25%		
Bressanone-Brixen (2016)	15%		
Sønderborg (2017)	60%		

Main technologies used
Local renewable electricity production

	Decarbon-isation target	Biomass	External grid decarb.	Local RE production
Malardalen region (2007)	100%	High demand		
Island of Mljet (2009)	100%			Wind, PV
Aalborg (2010)	100%			Wind
Frederikshavn (2011)	80%			Wind
Island of Hvar (2013)	100%			Wind, PV
South West Region Ireland (2014)	100%	High demand		
Dubrovnik (2015)	100%			Wind, PV, Hydro
Bologna (2015)	80%		High dependence	
Pecs (2015)	25%			PV
Bressanone-Brixen (2016)	15%			PV
Sønderborg (2017)	60%			Wind, PV

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Main technologies used
Electricity storage

	Decarbon-isation target	Biomass	External grid decarb.	Local RE production	Electricty storage
Malardalen region (2007)	100%	High demand			
Island of Mljet (2009)	100%			Wind, PV	Hydrogen
Aalborg (2010)	100%			Wind	Hydrogen
Frederikshavn (2011)	80%			Wind	
Island of Hvar (2013)	100%			Wind, PV	Pumped hydro
South West Region Ireland (2014)	100%	High demand			
Dubrovnik (2015)	100%			Wind, PV, Hydro	EV batteries
Bologna (2015)	80%		High dependence		
Pecs (2015)	25%			PV	
Bressanone-Brixen (2016)	15%			PV	
Sønderborg (2017)	60%			Wind, PV	

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Main technologies used
District heating

	Decarbon-isation target	Biomass	External grid decarb.	Local RE production	Electricty storage	District heating present
Malardalen region (2007)	100%	High demand				CHP
Island of Mljet (2009)	100%			Wind, PV	Hydrogen	
Aalborg (2010)	100%			Wind	Hydrogen	Geotherm., solar, storage
Frederikshavn (2011)	80%			Wind		Solar, industry, goethermal
Island of Hvar (2013)	100%			Wind, PV	Pumped hydro	
South West Region Ireland (2014)	100%	High demand				
Dubrovnik (2015)	100%			Wind, PV, Hydro	EV batteries	
Bologna (2015)	80%		High dependence			
Pecs (2015)	25%			PV		Geoth., solar
Bressanone-Brixen (2016)	15%			PV		Storage
Sønderborg (2017)	60%			Wind, PV		Solar, industry, goethermal

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Main technologies used
Multi-sector technology

	Decarbon-isation target	Biomass	External grid decarb.	Local RE production	Electricty storage	District heating present	Multi-sector technology
Malardalen region (2007)	100%	High demand				CHP	
Island of Mljet (2009)	100%			Wind, PV	Hydrogen		Electrolyser, fuel cell
Aalborg (2010)	100%			Wind	Hydrogen	Geotherm., solar, storage	HPs, EVs
Frederikshavn (2011)	80%			Wind		Solar, industry, goethermal	HPs, EVs
Island of Hvar (2013)	100%			Wind, PV	Pumped hydro		
South West Region Ireland (2014)	100%	High demand					
Dubrovnik (2015)	100%			Wind, PV, Hydro	EV batteries		Smart Evs
Bologna (2015)	80%		High dependence				
Pecs (2015)	25%			PV		Geoth., solar	HPs
Bressanone-Brixen (2016)	15%			PV		Storage	HPs
Sønderborg (2017)	60%			Wind, PV		Solar, industry, goethermal	HPs, Evs, electrolyser

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Main technologies used
Renewable electricity exporter

	Decarbon-isation target	Biomass	External grid decarb.	Local RE production	Electricty storage	District heating present	Multi-sector technology	RE exporter
Malardalen region (2007)	100%	High demand				CHP		
Island of Mljet (2009)	100%			Wind, PV	Hydrogen		Electrolyser, fuel cell	High
Aalborg (2010)	100%			Wind	Hydrogen	Geotherm., solar, storage	HPs, EVs	
Frederikshavn (2011)	80%			Wind		Solar, industry, goethermal	HPs, EVs	
Island of Hvar (2013)	100%			Wind, PV	Pumped hydro			
South West Region Ireland (2014)	100%	High demand						
Dubrovnik (2015)	100%			Wind, PV, Hydro	EV batteries		Smart Evs	
Bologna (2015)	80%		High dependence					
Pecs (2015)	25%			PV		Geoth., solar	HPs	
Bressanone-Brixen (2016)	15%			PV		Storage	HPs	
Sønderborg (2017)	60%			Wind, PV		Solar, industry, goethermal	HPs, Evs, electrolyser	High

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Analysis methods and tools used

	Decarbon-isation target	Biomass	External grid decarb.	Local RE production	Electricty storage	District heating present	Multi-sector technology	RE exporter	Approach used
Malardalen region (2007)	100%	High demand				CHP			Energy balance
Island of Mljet (2009)	100%			Wind, PV	Hydrogen		Electrolyser, fuel cell	High	Hourly, H2RES
Aalborg (2010)	100%			Wind	Hydrogen	Geotherm., solar, storage	HPs, EVs		Hourly, EnergyPLAN
Frederikshavn (2011)	80%			Wind		Solar, industry, goethermal	HPs, EVs		Hourly, EnergyPLAN
Island of Hvar (2013)	100%			Wind, PV	Pumped hydro				Hourly, EnergyPLAN
South West Region Ireland (2014)	100%	High demand							Hourly, EnergyPLAN
Dubrovnik (2015)	100%			Wind, PV, Hydro	EV batteries		Smart Evs		Hourly, EnergyPLAN
Bologna (2015)	80%		High dependence						Energy balance
Pecs (2015)	25%			PV		Geoth., solar	HPs		Hourly, EnergyPRO
Bressanone-Brixen (2016)	15%			PV		Storage	HPs		Hourly, EnergyPLAN
Sønderborg (2017)	60%			Wind, PV		Solar, industry, goethermal	HPs, Evs, electrolyser	High	Hourly, Sifre

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Conclusions

- Not many studies have done holistic analysis of cities becoming low carbon
- The concept of low carbon smart cities (based on ICT technologies) were rarely mentioned in the studies, sometimes mentioned with smart charging EVs
- Most studies are based on long term visions and not transition pathways
- If we discuss low carbon smart cities we need: 1) a clear definition about what this is, and 2) an understanding about how we achieve it

Thank you

Questions