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

Modelling Energy Systems in Heat Roadmap Europe

David Connolly, PhD
Associate Professor in Energy Planning
Aalborg University

www.dconnolly.net
www.heatroadmap.eu
@HeatRoadmapEU

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

Heat Roadmap Europe 4
Overall Aim

To identify how the EU can cost-effectively decarbonise its heating and cooling sectors…

…by quantifying the impact of various alternatives

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

- Belgium (BE)
- Czech Republic (CZ)
- Germany (DE)
- Spain (ES)
- France (FR)
- Italy (IT)
- Hungary (HU)
- Netherlands (NL)
- Austria (AT)
- Poland (PL)
- Romania (RO)
- Finland (FI)
- Sweden (SE)
- United Kingdom (UK)

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HRE Team


AALBORG UNIVERSITY
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Universiteit Utrecht
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ICLEI
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ehpa
european heat pump association
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Danfoss
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eceee
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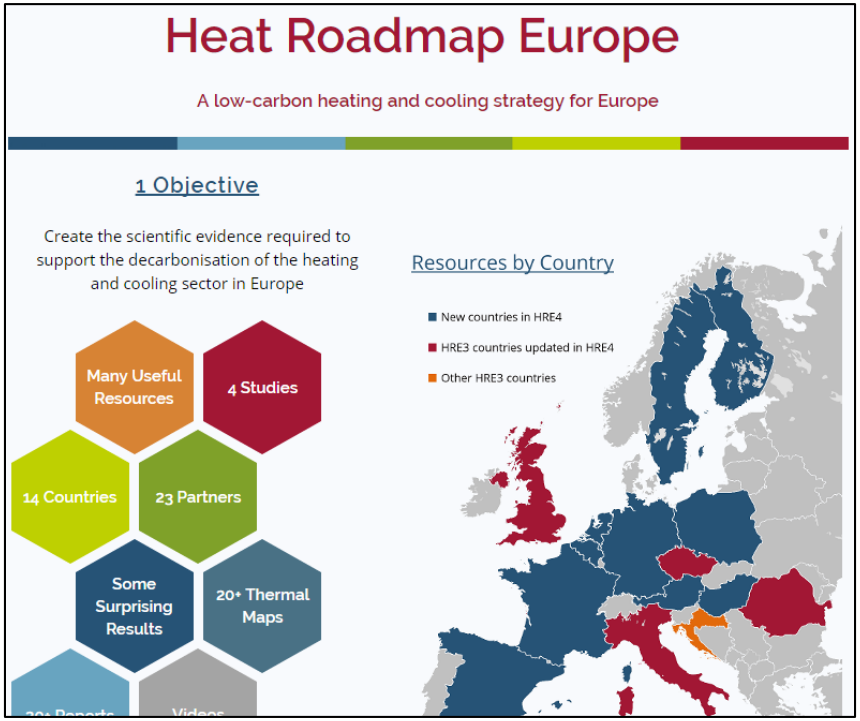

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  - Peta4 Version 1 Out Now!
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- Read about the HRE Team

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1. Underlying Data

2. Modelling Approach

3. Scenarios & Their Purpose

‘MODELLING METHODOLOGY’ IS MORE THAN JUST THE MODEL

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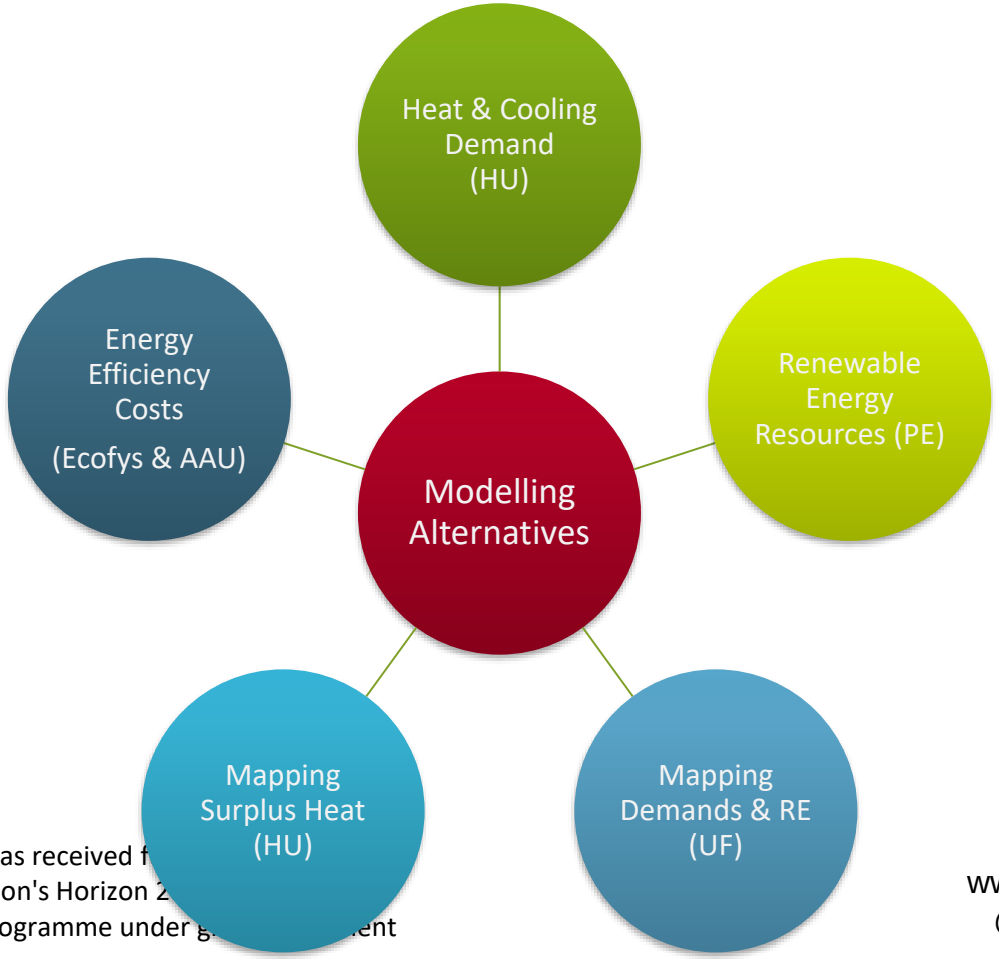
Building Background Data



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European Union's Horizon 2
innovation programme under g ent
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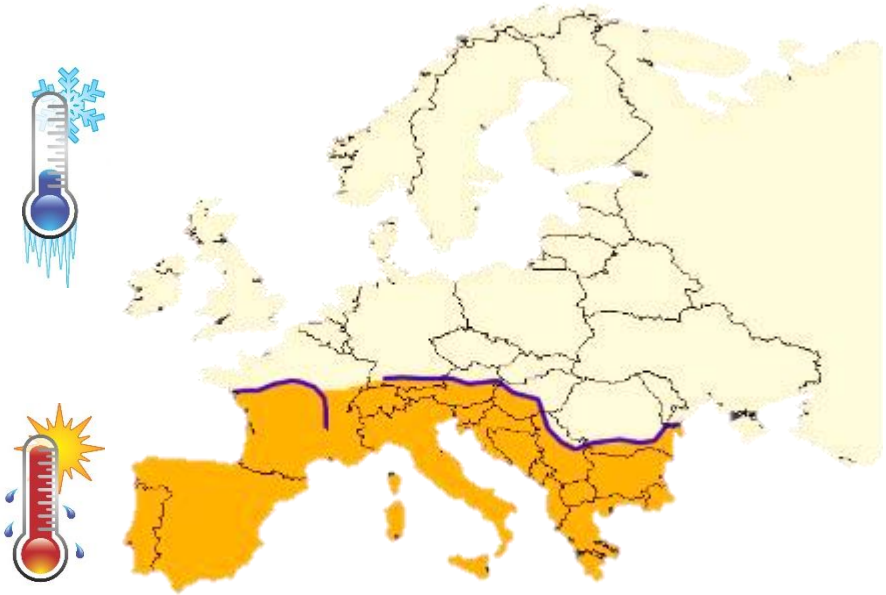
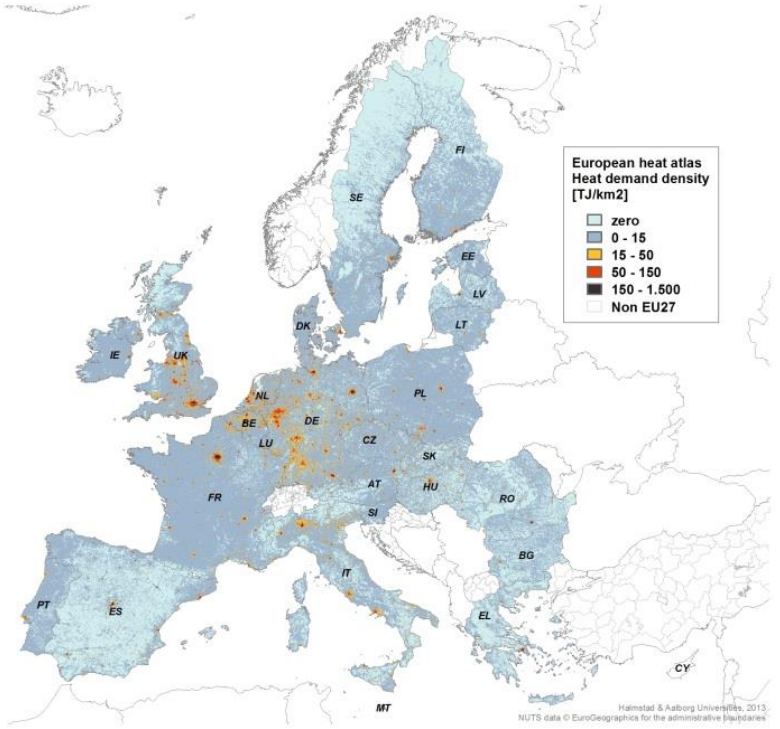
GIS: 50% of the heat demand in Europe can be supplied with district heating (www.HeatRoadmap.eu)





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HRE3 Has Nine Background Reports

1. Creating National Energy Models for 2010 and 2050
2. Creating Hourly Profiles to Model both Demand and Supply
3. Quantifying the Cost of Heat Savings in EU Member States
4. Quantifying the Heating and Cooling Demand in Europe
5. Mapping the Heating and Cooling Demand in Europe
6. Quantifying the Potential for District Heating and Cooling in EU Member States
7. Quantifying the Excess Heat Available for District Heating in Europe
8. Estimating the Renewable Energy Resources Available in EU Member States
9. Mapping the Renewable Heat Resources in Europe

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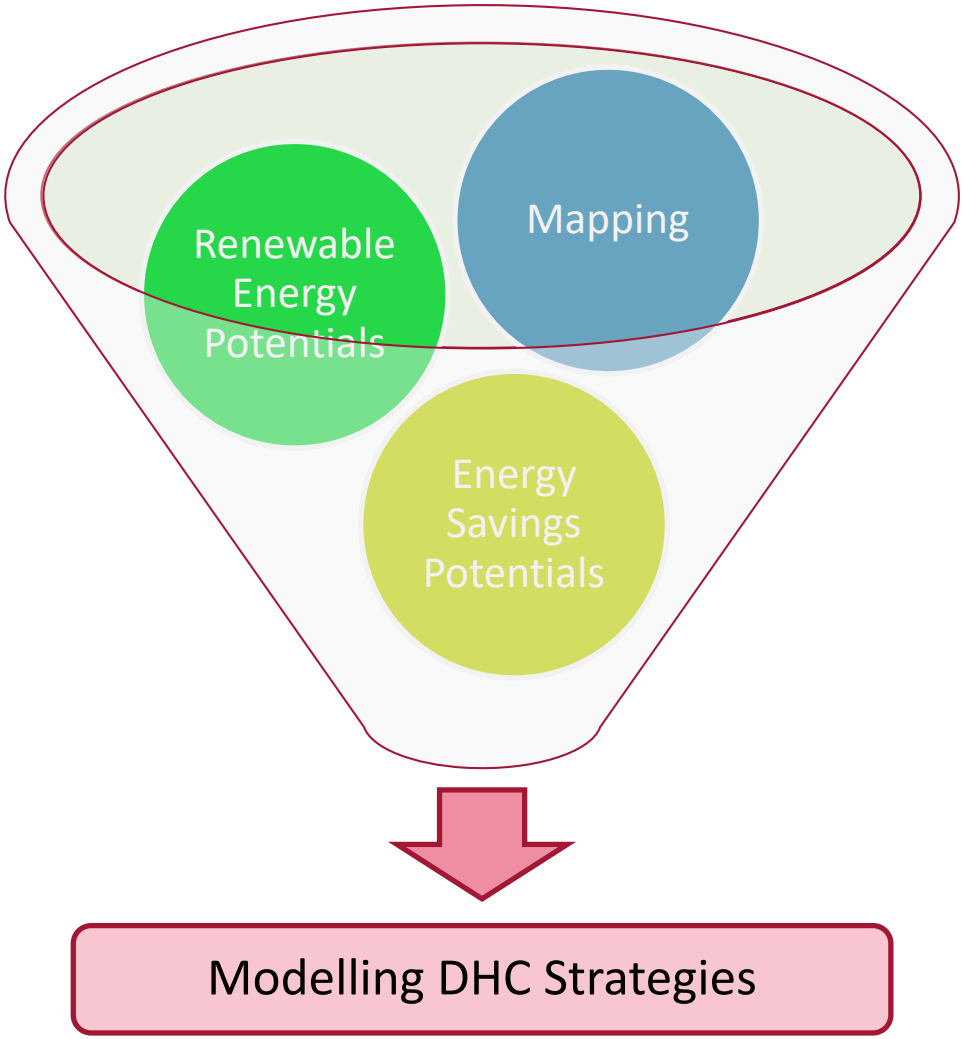
Modelling Is About Combining Data



1. Underlying Data – Essential Regardless of Model

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‘MODELLING METHODOLOGY’ IS MORE THAN JUST THE MODEL

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www.SmartEnergySystem.eu

APPROACH: SMART ENERGY SYSTEM

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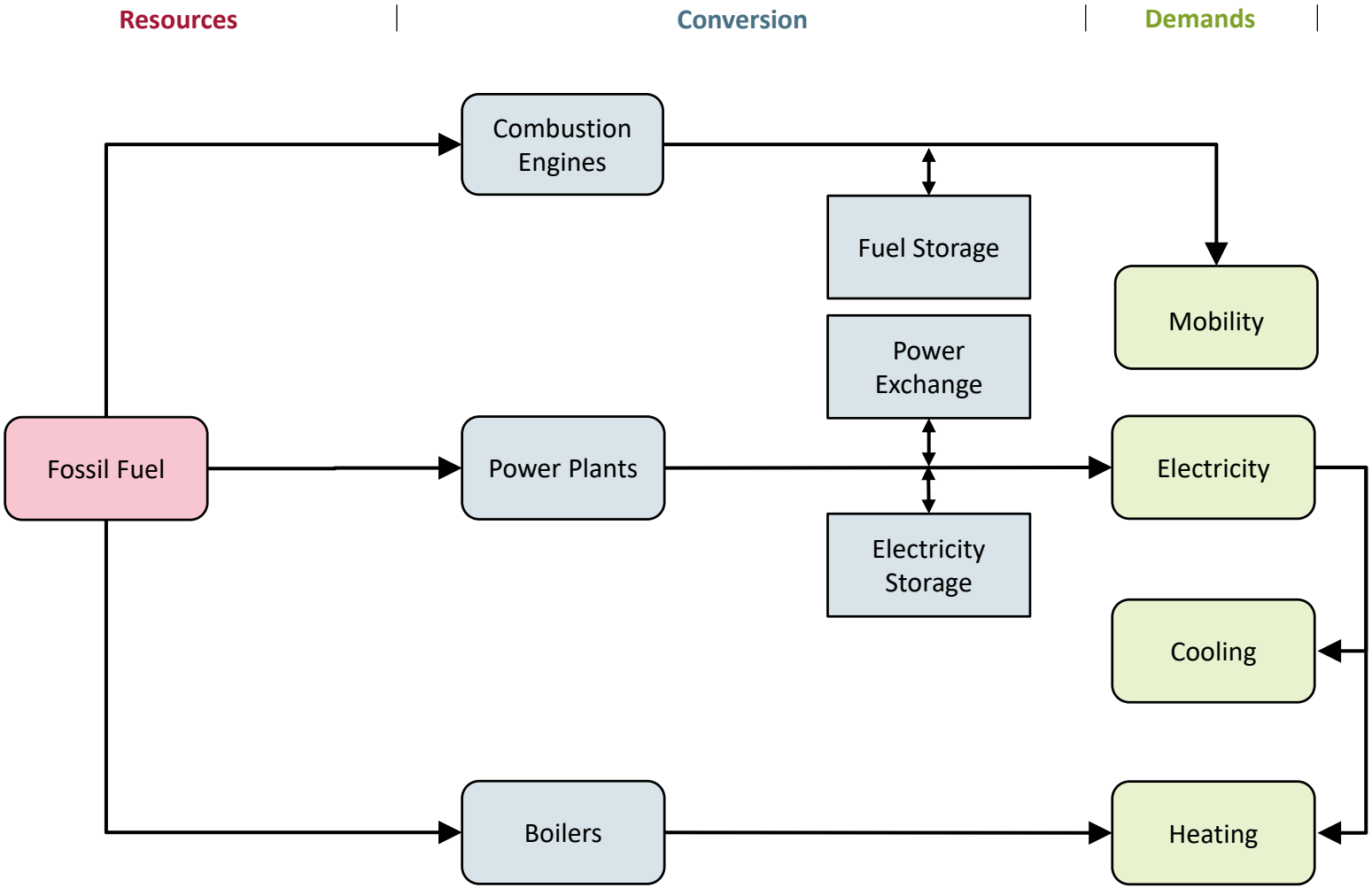
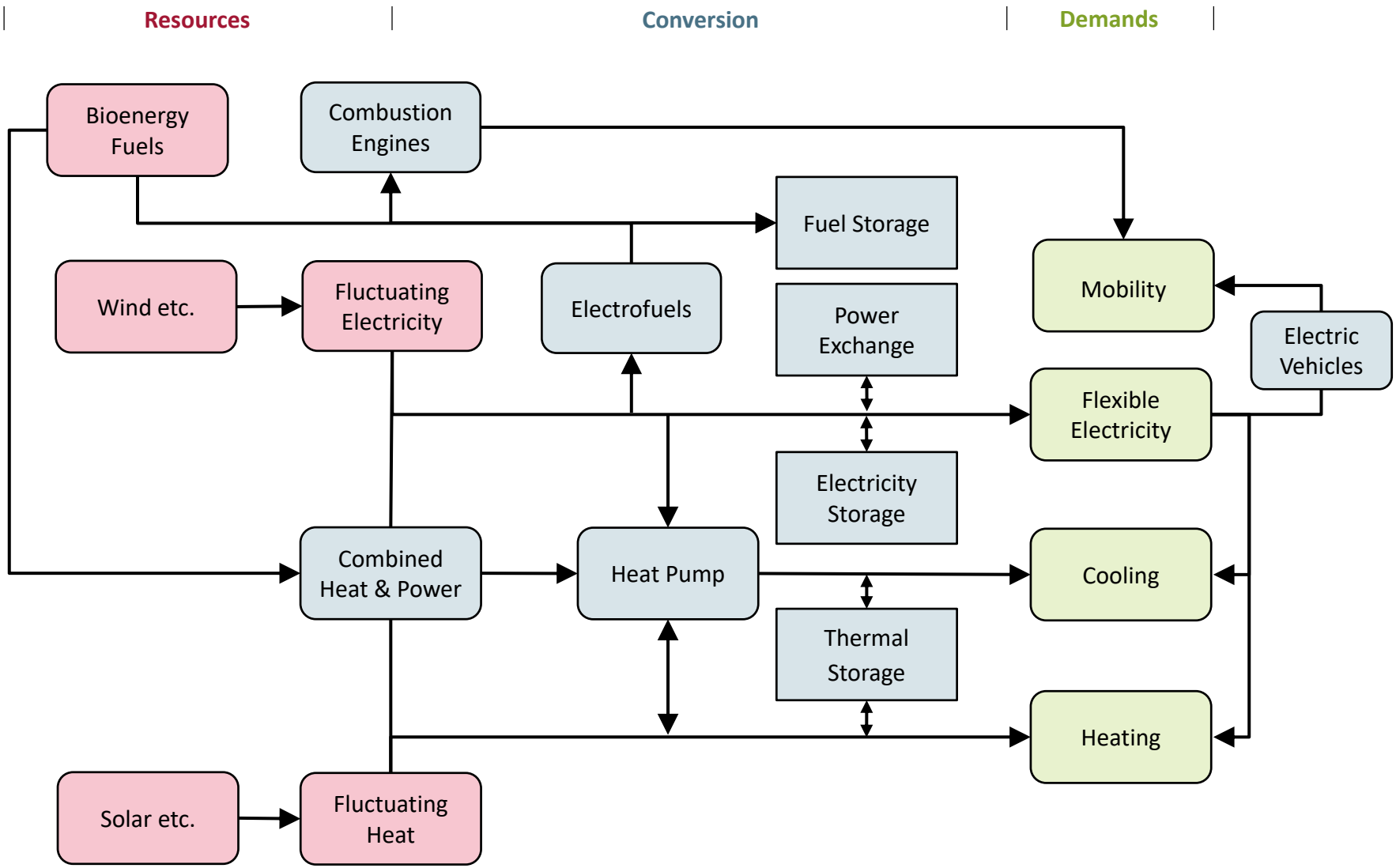
Today's Energy System



Smart Energy System



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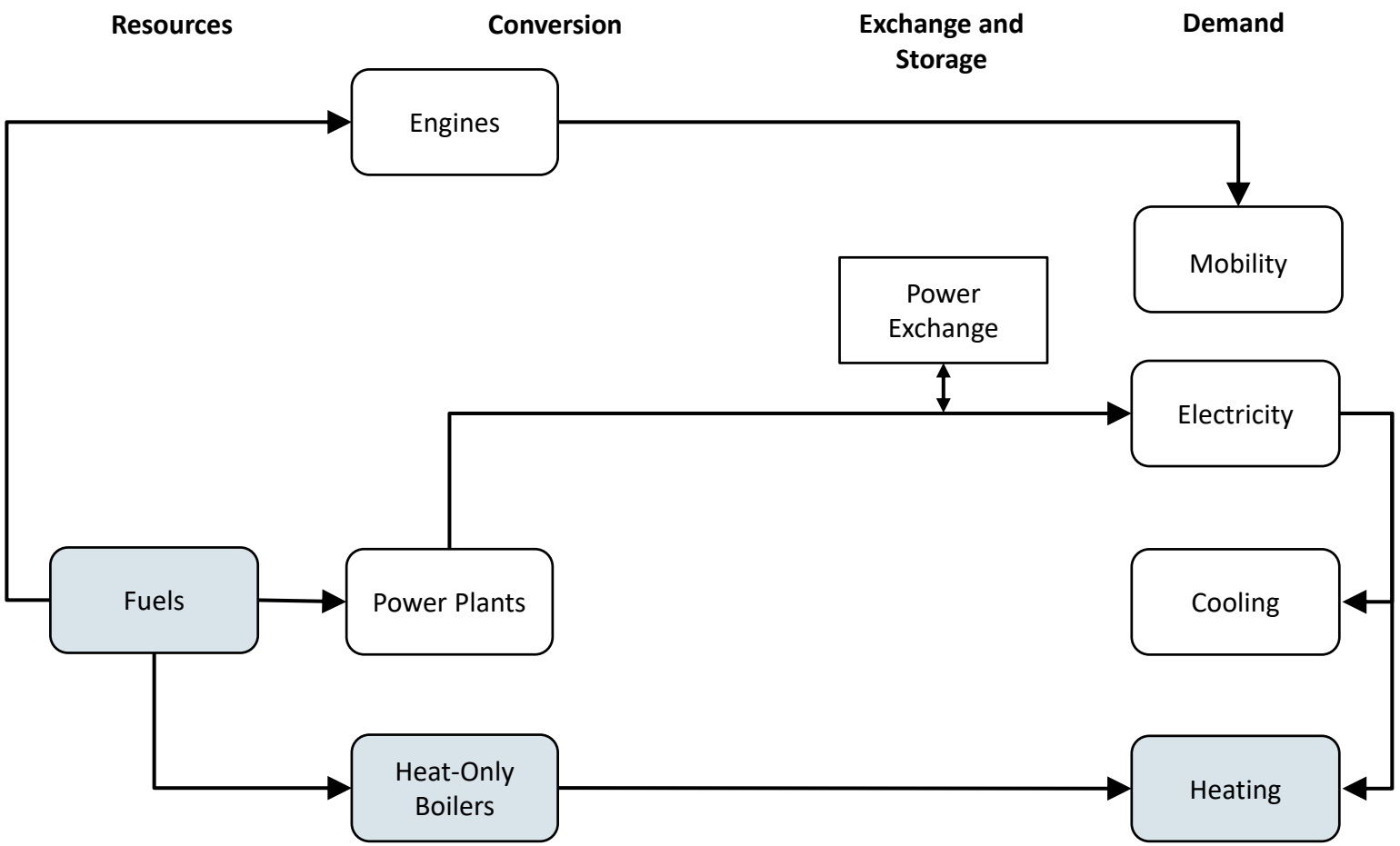
Energy PLAN
Advanced energy system analysis computer model

Today's Heat Sector



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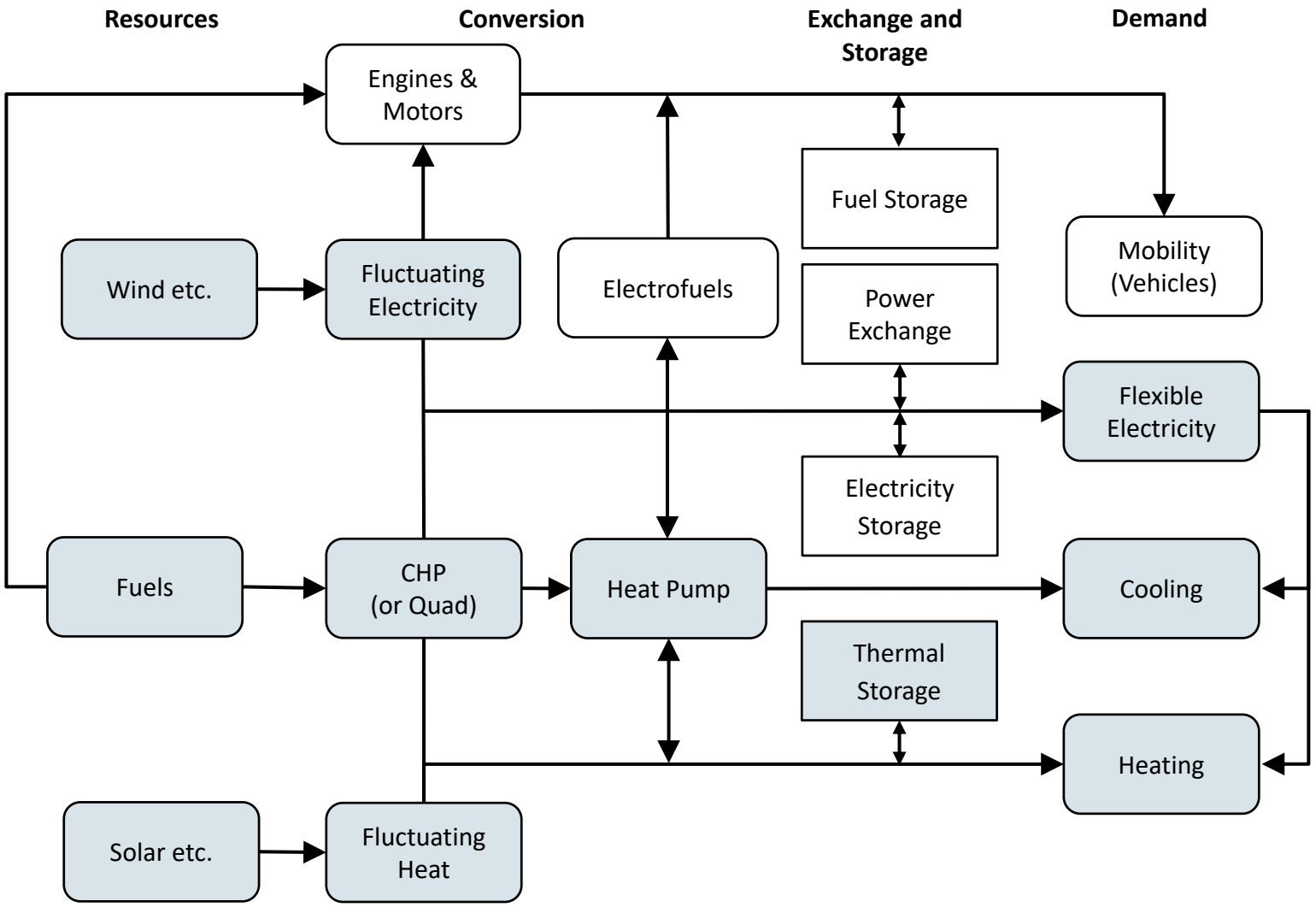
The New Heat Sector

Energy PLAN
Advanced energy system analysis computer model



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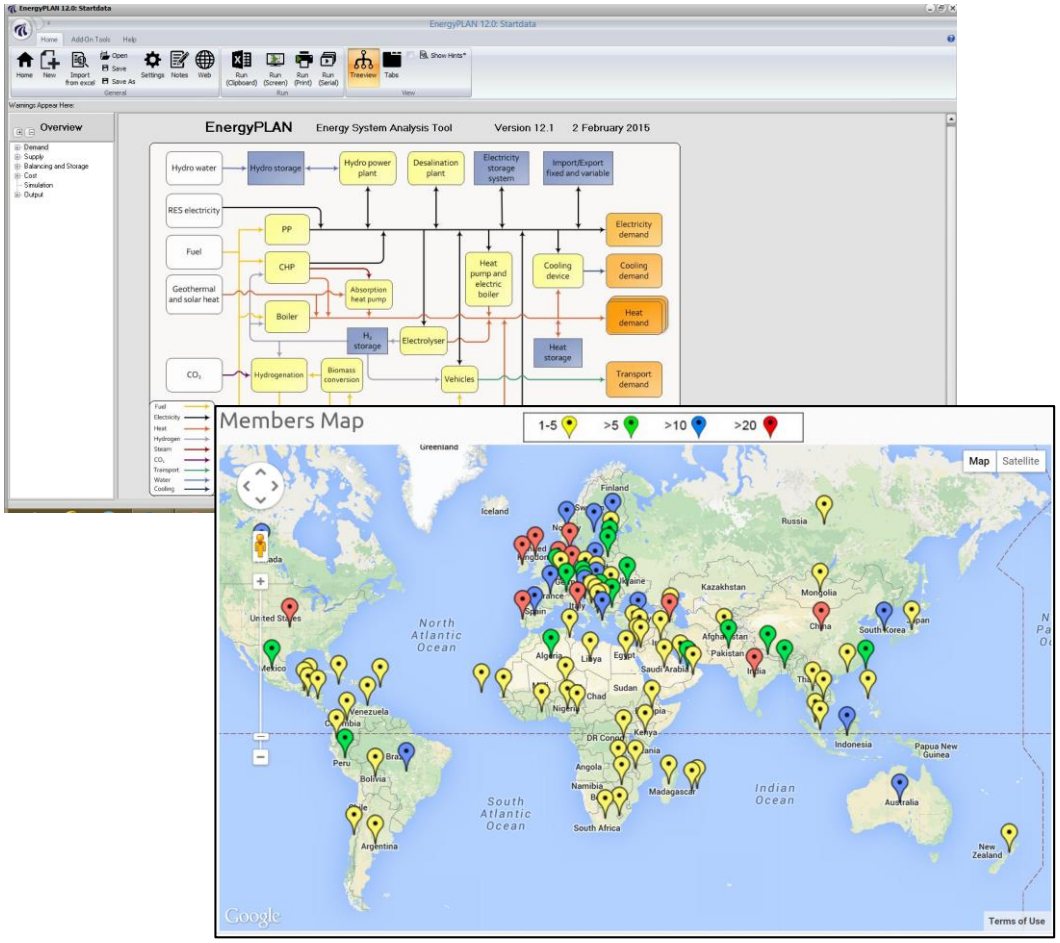
Energy PLAN
Advanced energy system analysis computer model

EnergyPLAN: Version 12

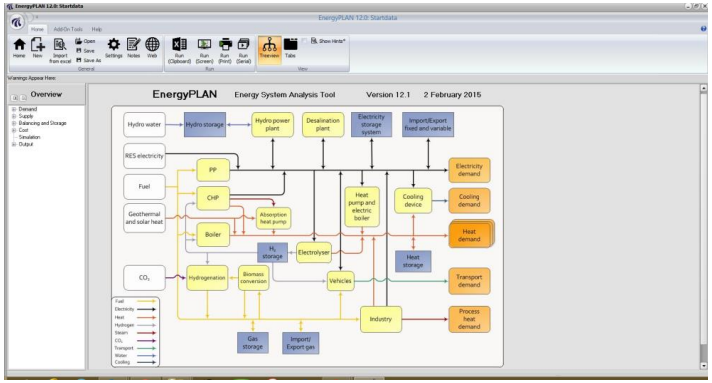
www.EnergyPLAN.eu

Hourly Modelling of Electricity, Heating, Cooling, Industry, and Transport



- Over 3000 Registered Users across more than 100 countries
- Lots of free training provided:
  - Exercises with solutions
  - FAQs
  - Forum
  - Quarterly online workshops
  - User Manual
- Can be used to model any national energy system
- Freeware software

Our Philosophy



- The future will require **radical technological change**: EnergyPLAN
- **All sectors** of the energy system will need to ne connected: EnergyPLAN
- Account for the **intermittency** of renewables such as wind: Hourly Analysis

Heat Storage Is 100 Times Cheaper… if you can see it!

- Electricity ~€150/kWh
- Thermal ~€1.5/kWh

International Journal of Sustainable Energy Planning and Management Vol. 11 2016 3-14

International journal of Sustainable Energy Planning and Management

Energy Storage and Smart Energy Systems

Henrik Lund, Poul Alberg Østergaard, David Connolly[2], Iva Ridjan[2], Brian Vad Mathiesen[2], Frede Hvelplund[1], Jakob Zinck Thellufsen, Peter Sorknæs[1]

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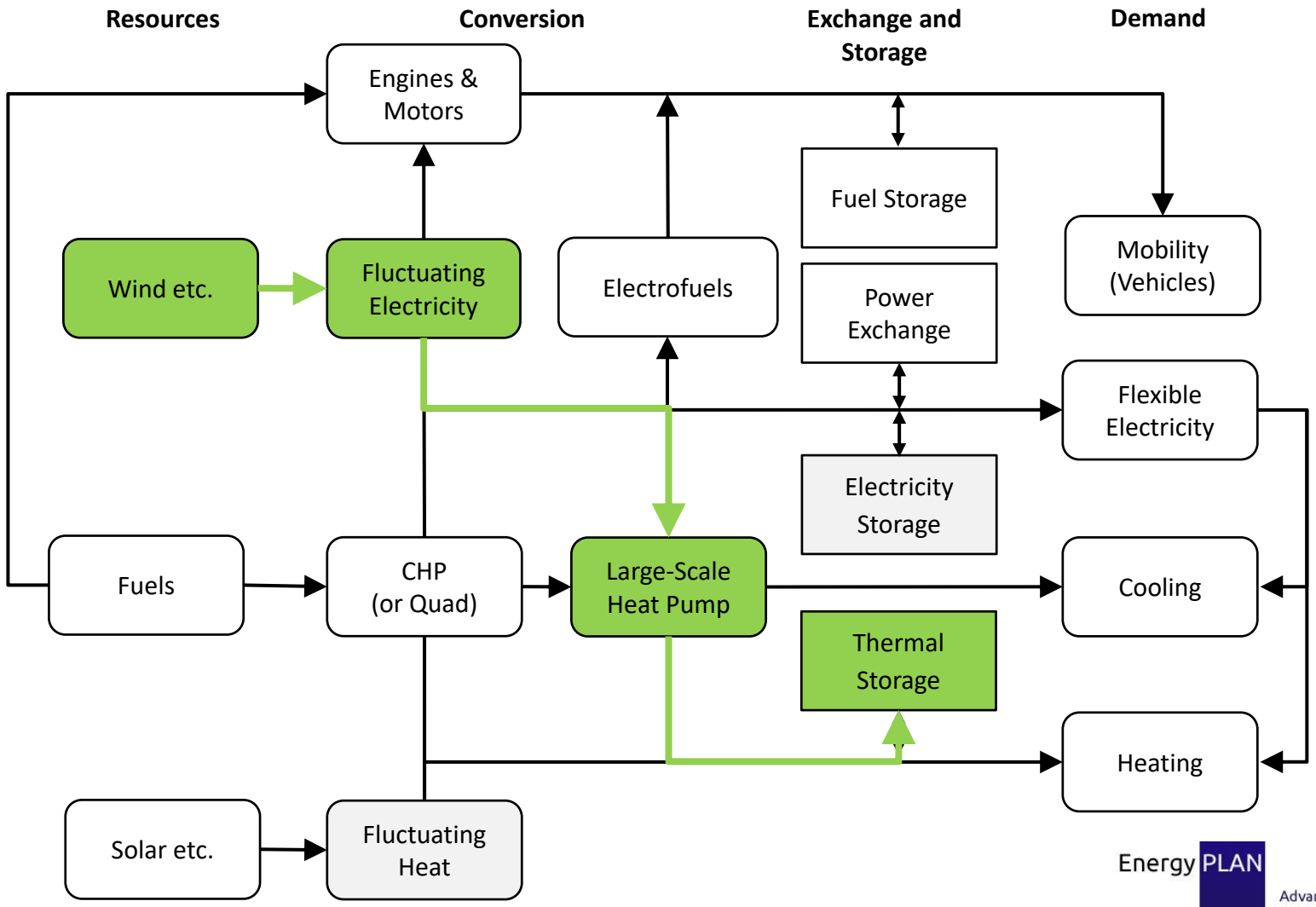
ABSTRACT

It is often highlighted how the transition to renewable energy supply calls for significant

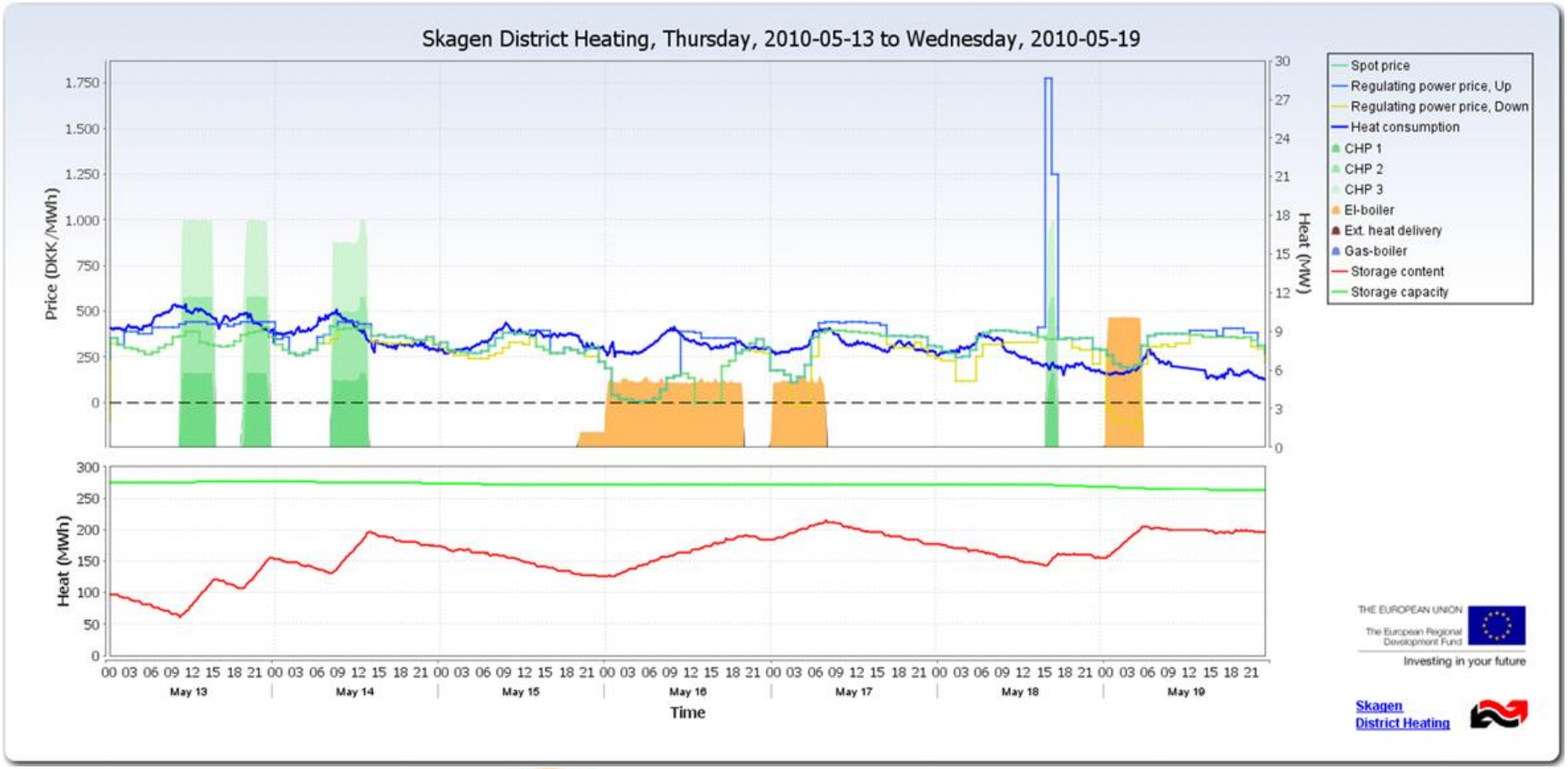
Key words:

Smart energy systems

Number 4: Thermal Storage (~€1/kWh) is much cheaper than Electricity Storage (~€150/kWh)



Denmark's Smart Energy System



EMD International A/S
www.emd.dk

1. Underlying Data – Essential Regardless of Model

2. Modelling Approach – Radical Change, Energy System, Hourly

3. Scenarios & Their Purpose

‘MODELLING METHODOLOGY’ IS MORE THAN JUST THE MODEL

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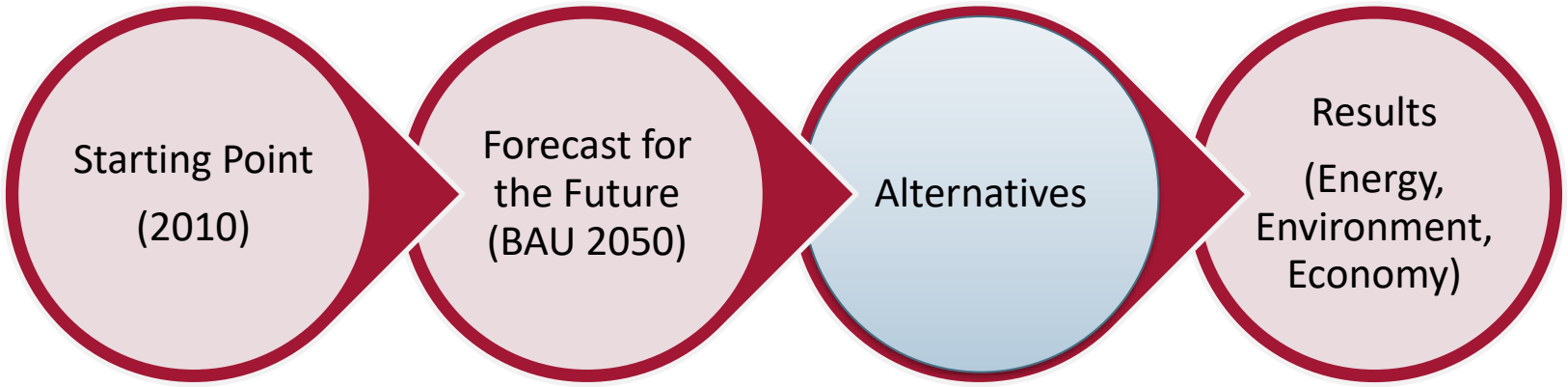
Modelling Steps



- Extra Heat Savings
- Extra District Heating
- Different Individual Heating Options

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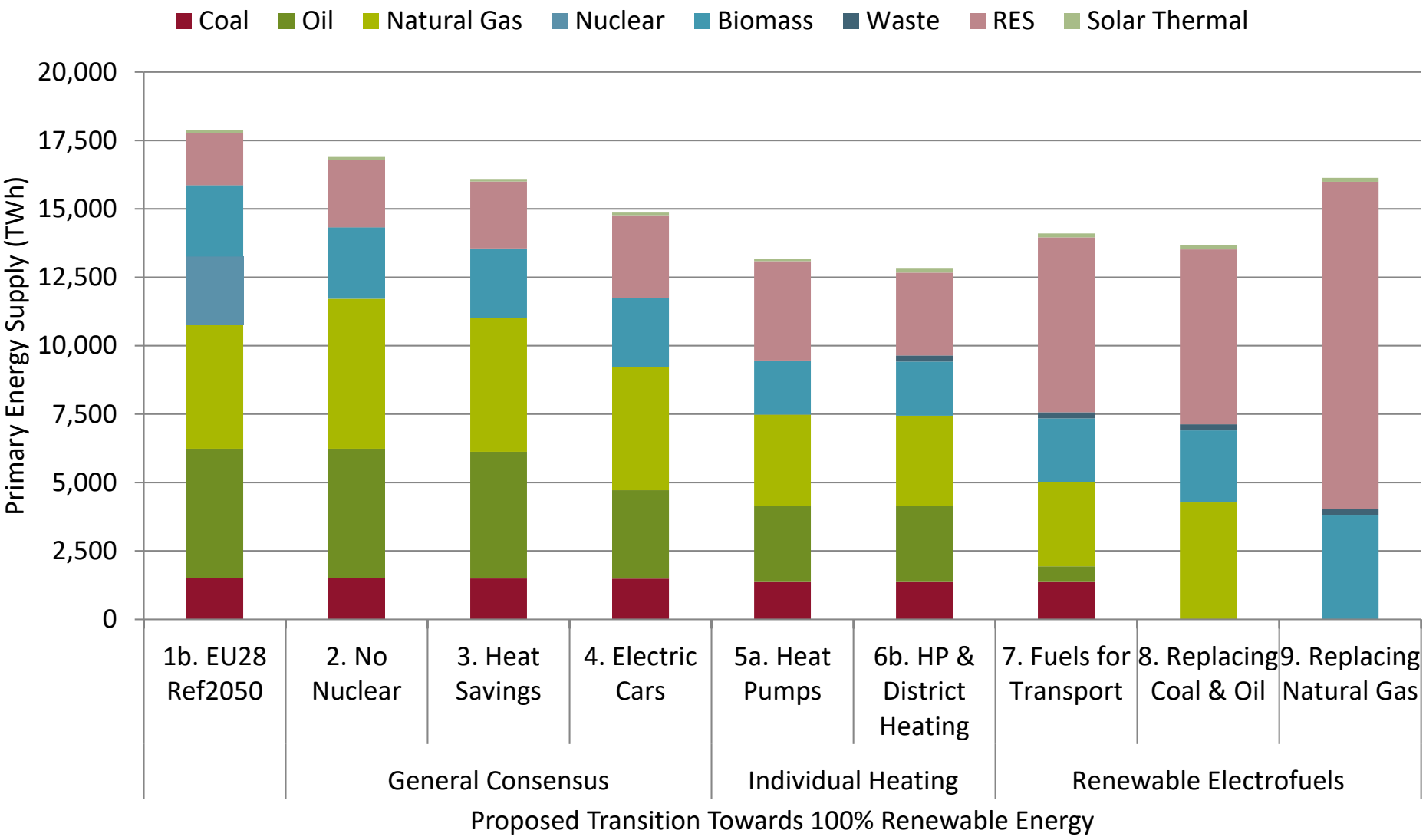
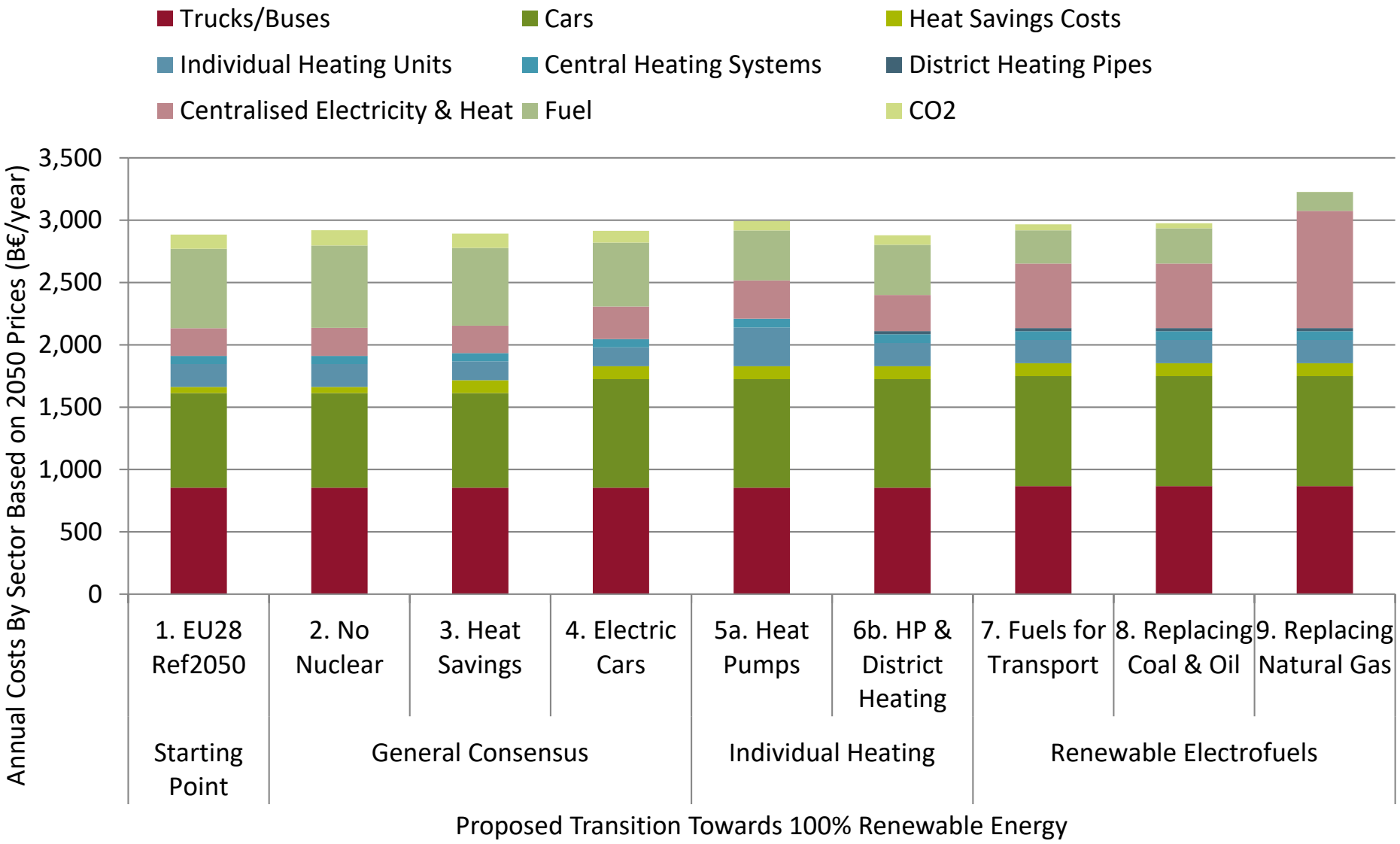
What Should We Measure?

- Energy (Primary Energy Supply)
- Environment (Carbon Emissions)
- Economy (Total Annual Energy System Costs)

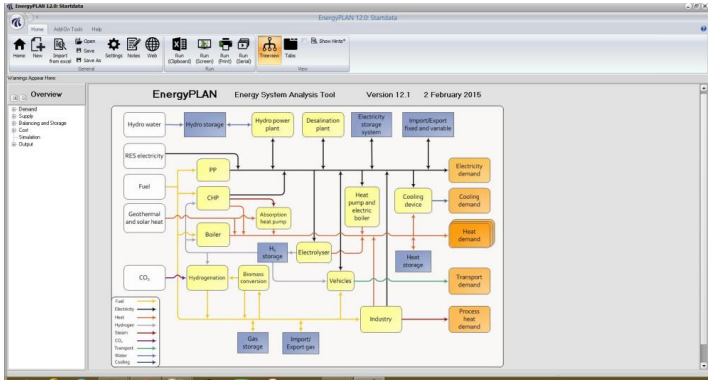
Smart Energy Europe: Energy Consumption



Smart Energy Europe: Annualised Costs



Our Philosophy



- The future will require **radical technological change**: EnergyPLAN
- **All sectors** of the energy system will need to ne connected: EnergyPLAN
- Account for the **intermittency** of renewables such as wind: Hourly Analysis
- Where will we **end up**, rather than where should we start: 2050 Analysis
- **Free from existing market regulations**: Socio-Economic Analysis

1. Underlying Data – Essential Regardless of Model

2. Modelling Approach – Radical Change, Energy System, Hourly

3. Scenarios & Their Purpose – Define What You See

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No ‘Best’ Energy Model

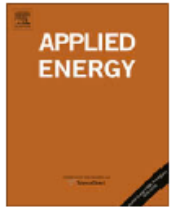
Each Look at the Same Thing from a Different Angle

Applied Energy 87 (2010) 1059–1082

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy



A review of computer tools for analysing the integration of renewable energy into various energy systems

D. Connolly [a,*], H. Lund [b], B.V. Mathiesen [b], M. Leahy [a]

[a] Department of Physics, University of Limerick, Ireland
[b] Department of Development and Planning, Aalborg University, Denmark

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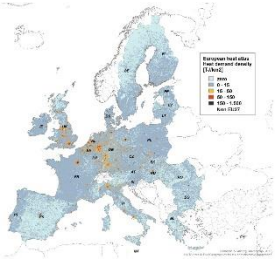
Energy Models in HRE4

Peta: Mapping Location of Heating and Cooling (WP2)

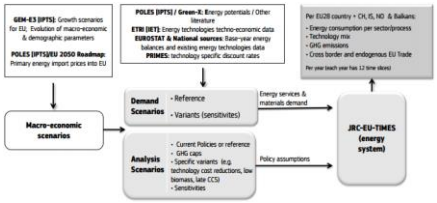


FORECAST - Heating and Cooling Transition (WP3/WP4)

FORECAST

FORecasting Energy Consumption Analysis and Simulation Tool

JRC-EU-TIMES – Annual Energy System Transition (WP5/WP6)

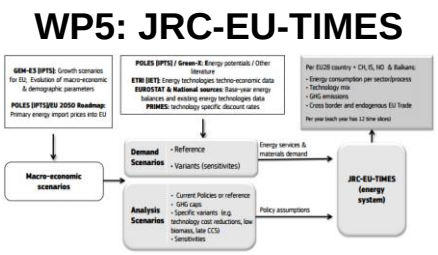


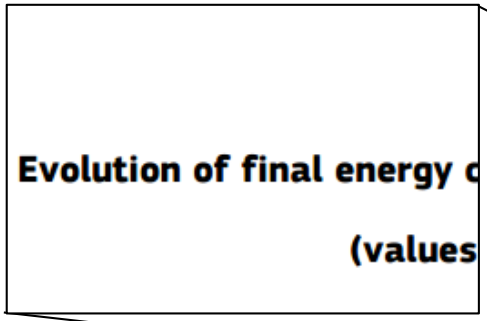
EnergyPLAN - Hourly Energy System Interactions (WP5/WP6)

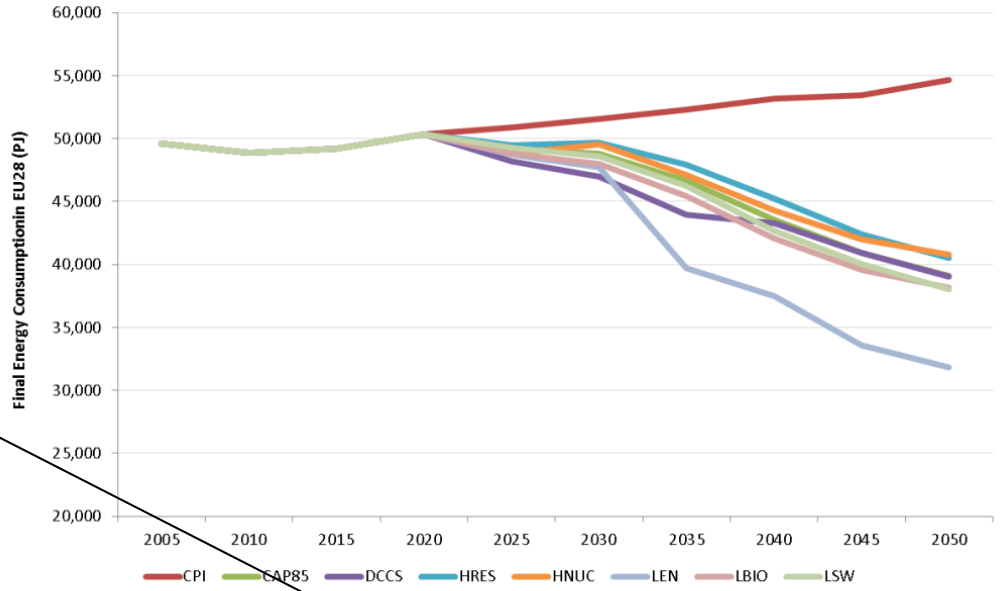
Energy PLAN

Advanced energy system analysis computer model

JRC-EU-TIMES: Transition 2015-2050







Reference: JRC-EU-TIMES

Figure 21 – Evolution of final energy consumption in EU28 from JRC-EU-TIMES for the studied scenarios (values for 2005 are taken from Eurostat)

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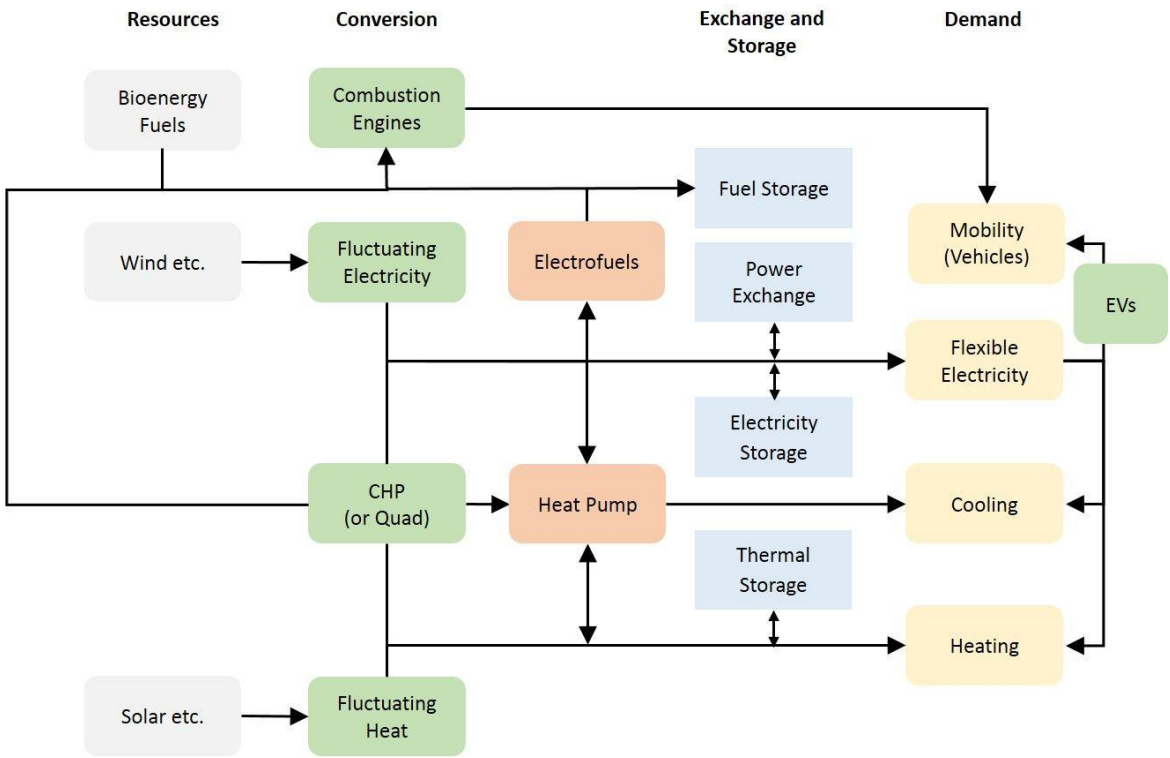
EnergyPLAN: Hourly Simulation Over 1 Year



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JRC-EU-TIMES + EnergyPLAN

- Transition of the Energy System
  - 2015-2050

- While Considering Hourly Interactions & Smart Energy System Over Single Years:
  - 2010
  - 2030
  - 2050

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