eurac research

Energy model Niederösterreich 2050

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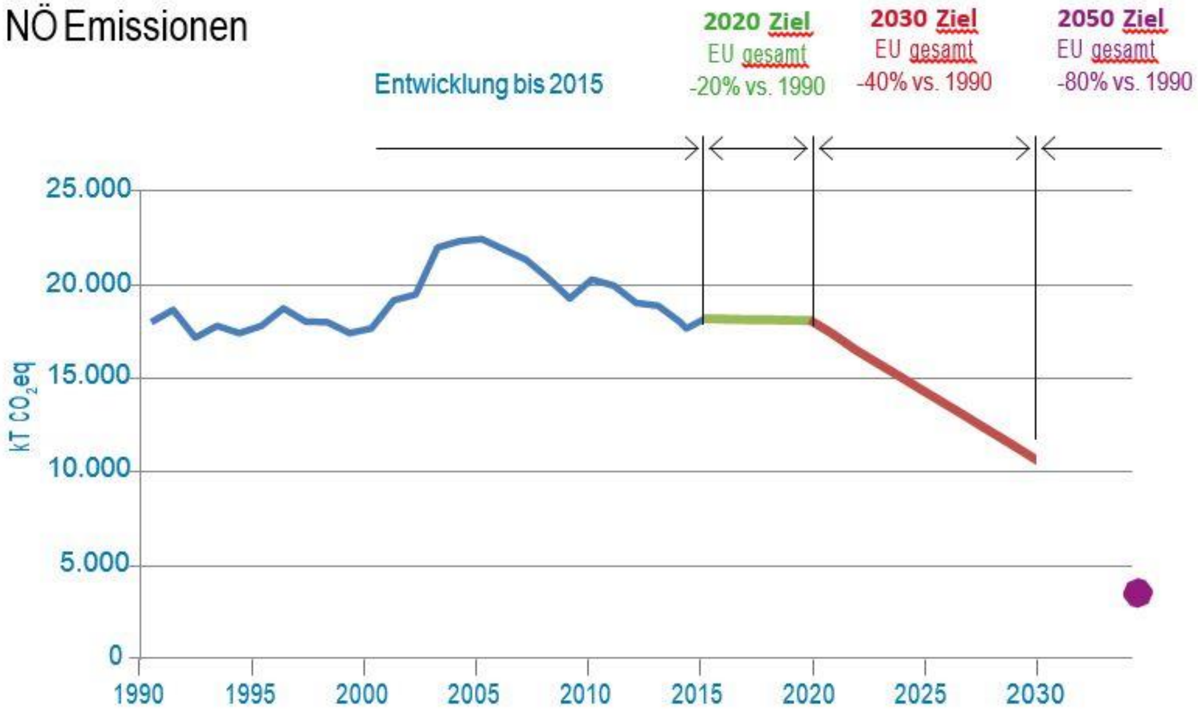
Niederösterreich 2050

Durnstein Niederösterreich | Source: Chris De Wit, www.goodfreephotos.com

NÖ Climate plan

Target

-80% emissions
at 2050 in respect
to value of 1990



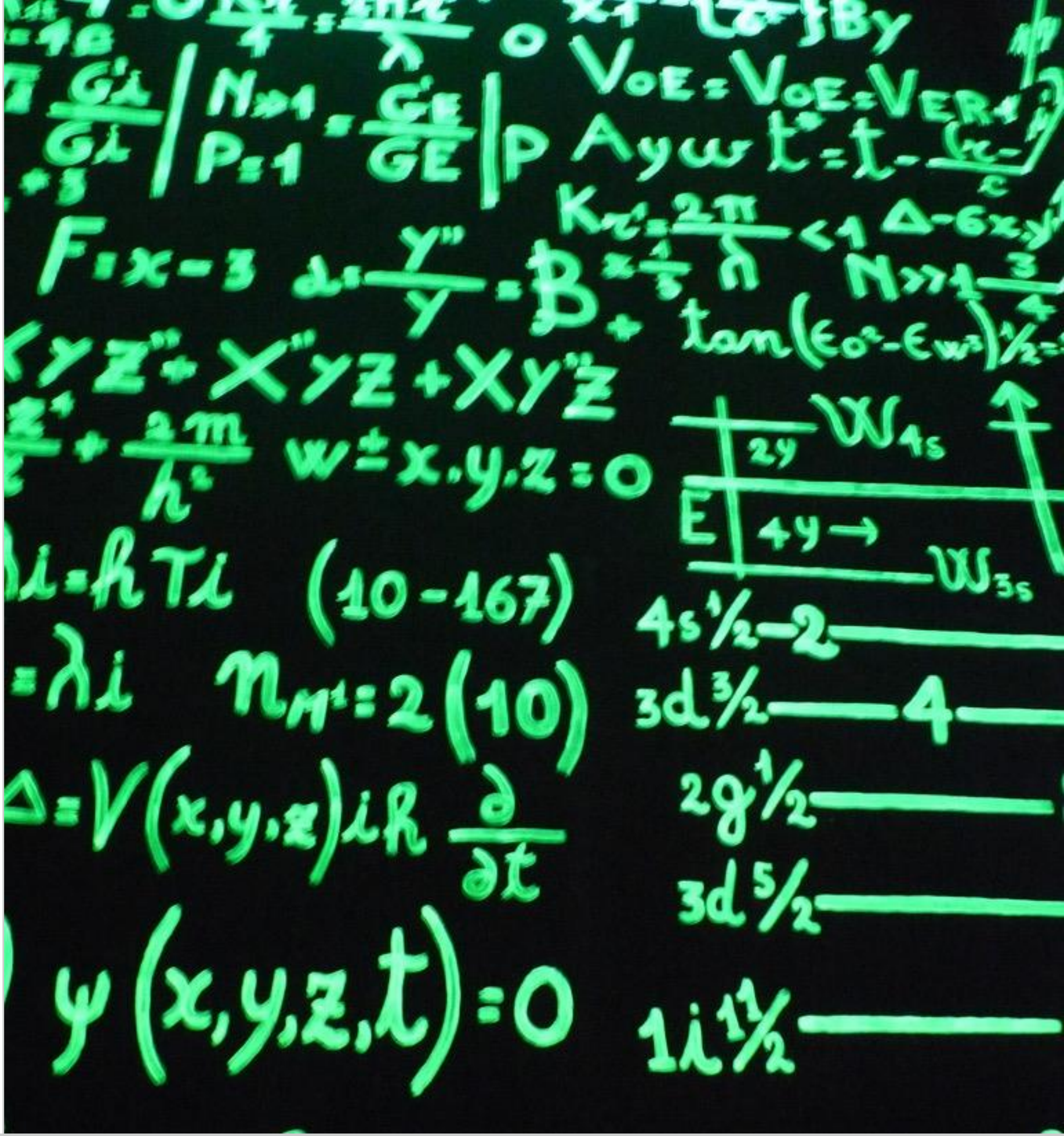
Source: Klima- und EnErgiEprogramm, November 2017

Questions

- Is it feasible to reach the target of the climate plan?
  If so, which features should the new energy system have?
- How much will the new energy system cost in comparison to the current one?
- How will the cost structure of the energy system change and which main effects will this have on the energy assets in the upcoming years?

What we are talking about

- A dynamic model that simulates over a reference year the hourly production and consumption of thermal and electric energy and considers also the transport sector
- Starting point is the actual energy system
- Scenarios of evolution of this system considering local boundaries are calculated
- Accuracy of the model depends of the accuracy the available data
- Various assumptions are necessary to perform the analysis. These can be gradually optimized and adapted.



What we are NOT talking about

- Seeing in the future
- The entry of radical new technologies has not been taken into consideration
- Important variations of the costs of the natural resources and technologies have not been taken into consideration

The starting point

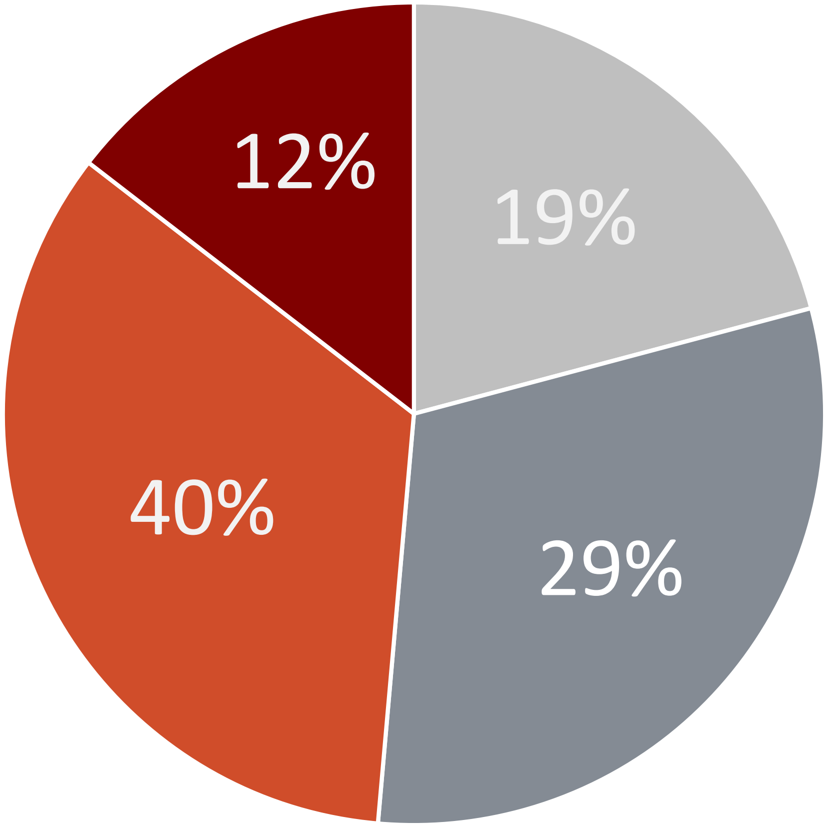
Laufkraftwerk Ybbs-Persenbeug, Niederösterreich | Source: ©VERBUND

Reference year: 2016

Variable	Source	Source year
Capacity, generation of different sources renewable and not	Niederösterreich, Energiebilanz 2016	2016
Overall annual electric and thermal energy consumption	Nutzenergieanalyse 2016	2016
Hourly profiles: District heating demand, electricity demand, wind power, PV, Hydro and biomass	Data provided by NÖ Landesregierung - RU3	2017
Energy efficiency curve in the building sector	EURAC research elaboration from different sources – details reported in annex 1	2014
Costs	EnergyPLAN database	2050

Appendix 1 contains a detailed list of hourly profiles and sources

Final energy consumption* in Niederösterreich: 2016



Heat
19.9 TWh

Transport
22.2 TWh

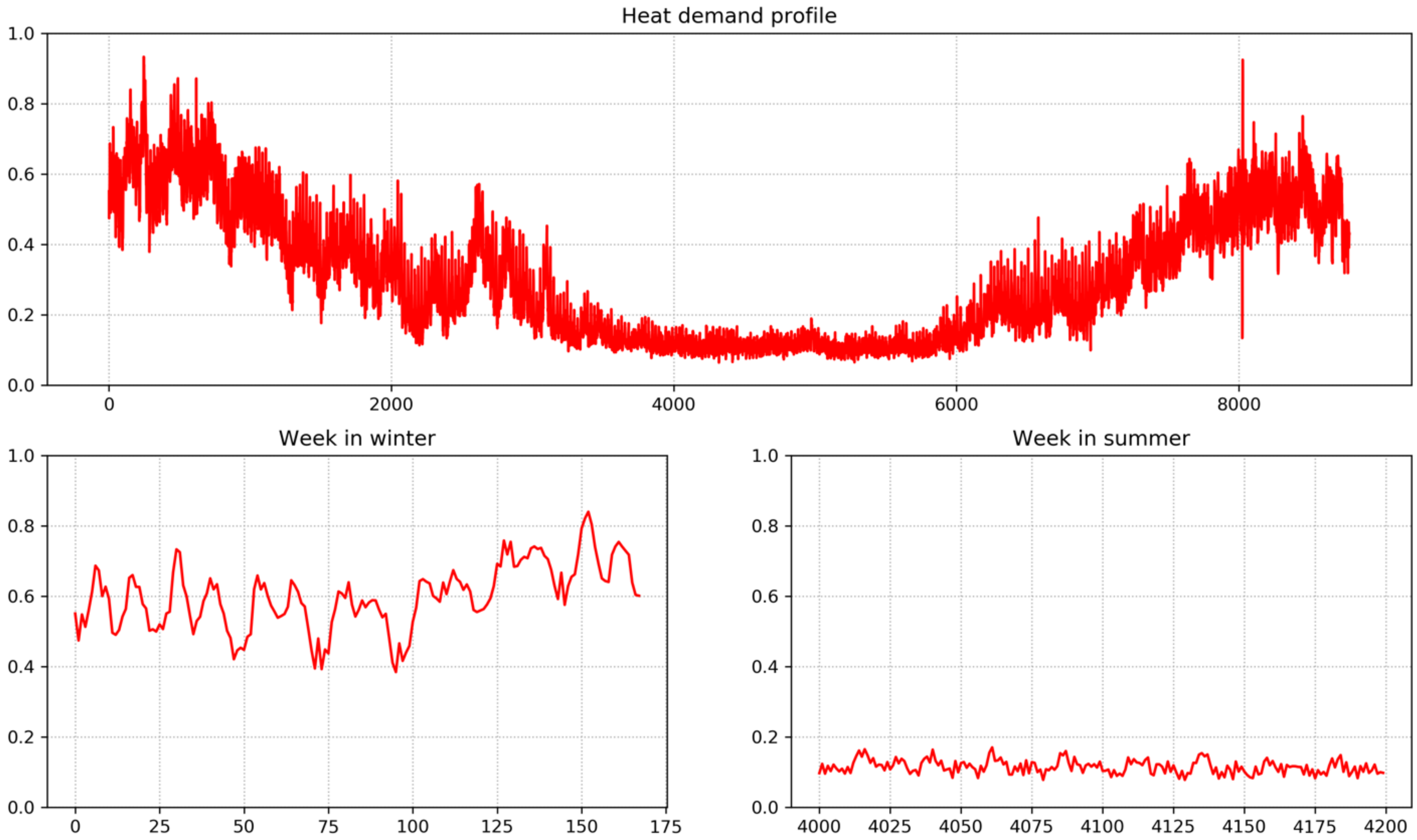
Electricity
13.6 TWh

Industrial heat
9.5 TWh

Total final energy consumption
65.1 TWh

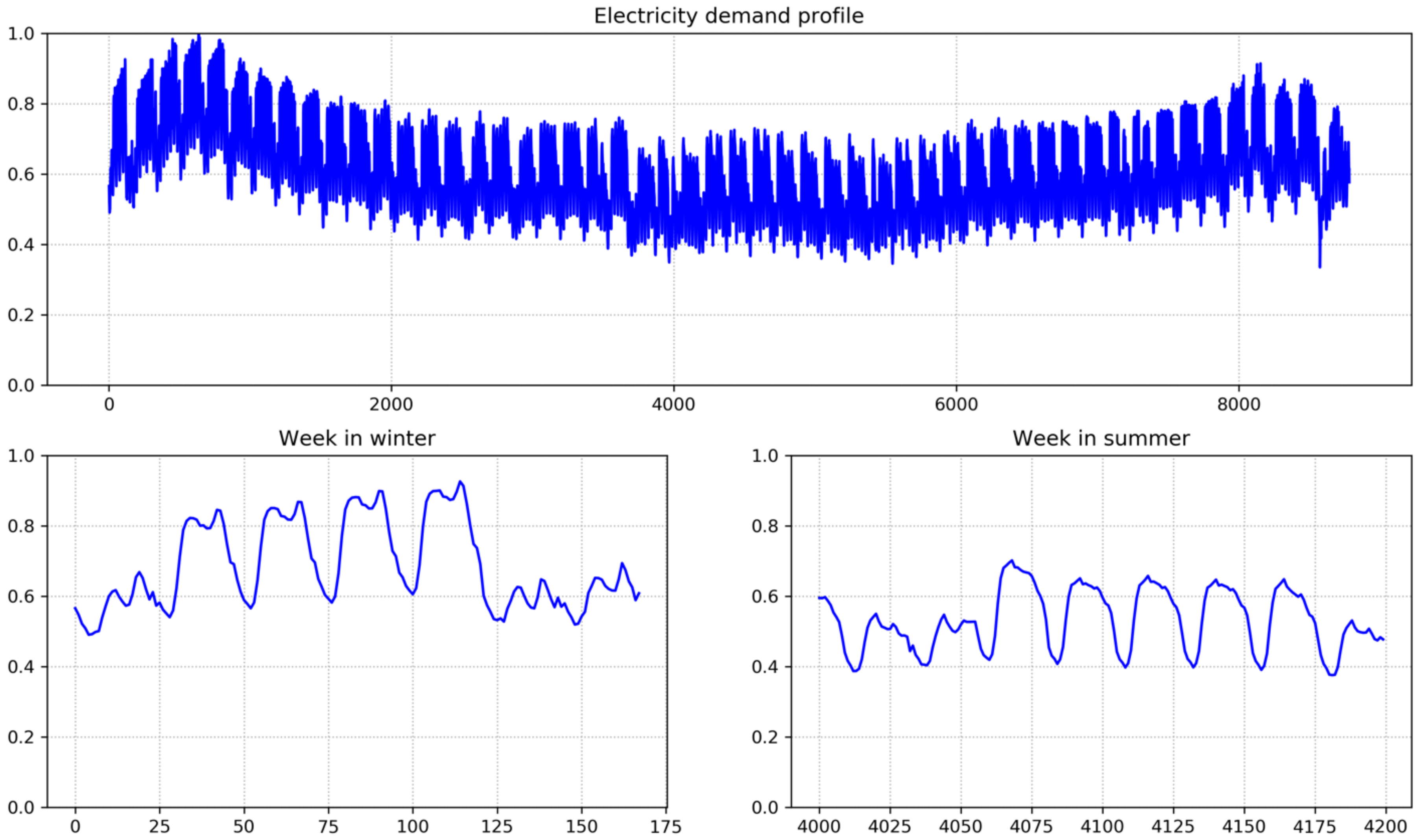
*Including distribution losses and consumption of the energy system itself for heat fuels and electricity

Heat demand profile



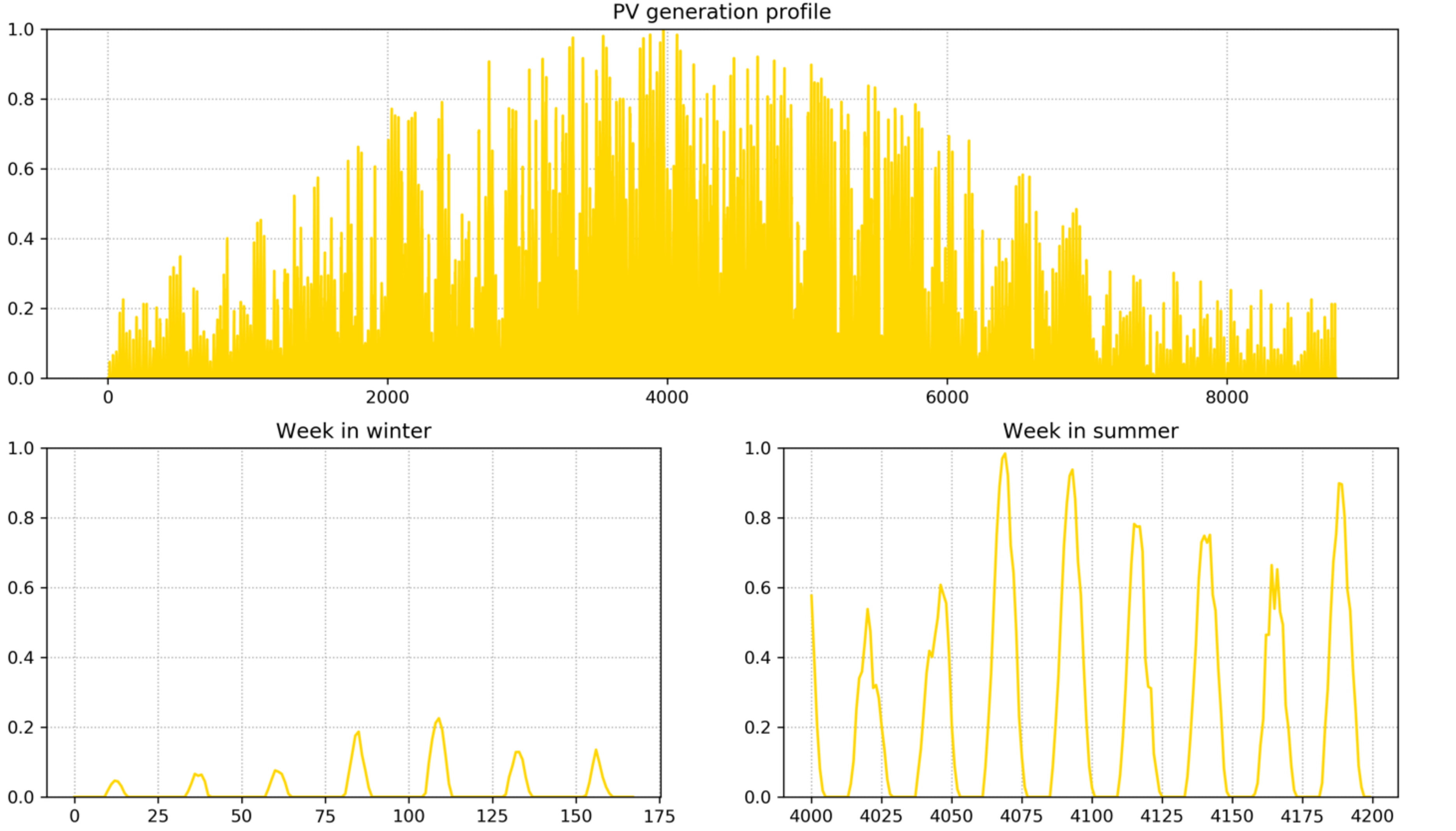
Year profile of the heat consumption from district heating, Niederösterreich 2017 | Source: NÖ Landesregierung –RU3

Electricity demand profile



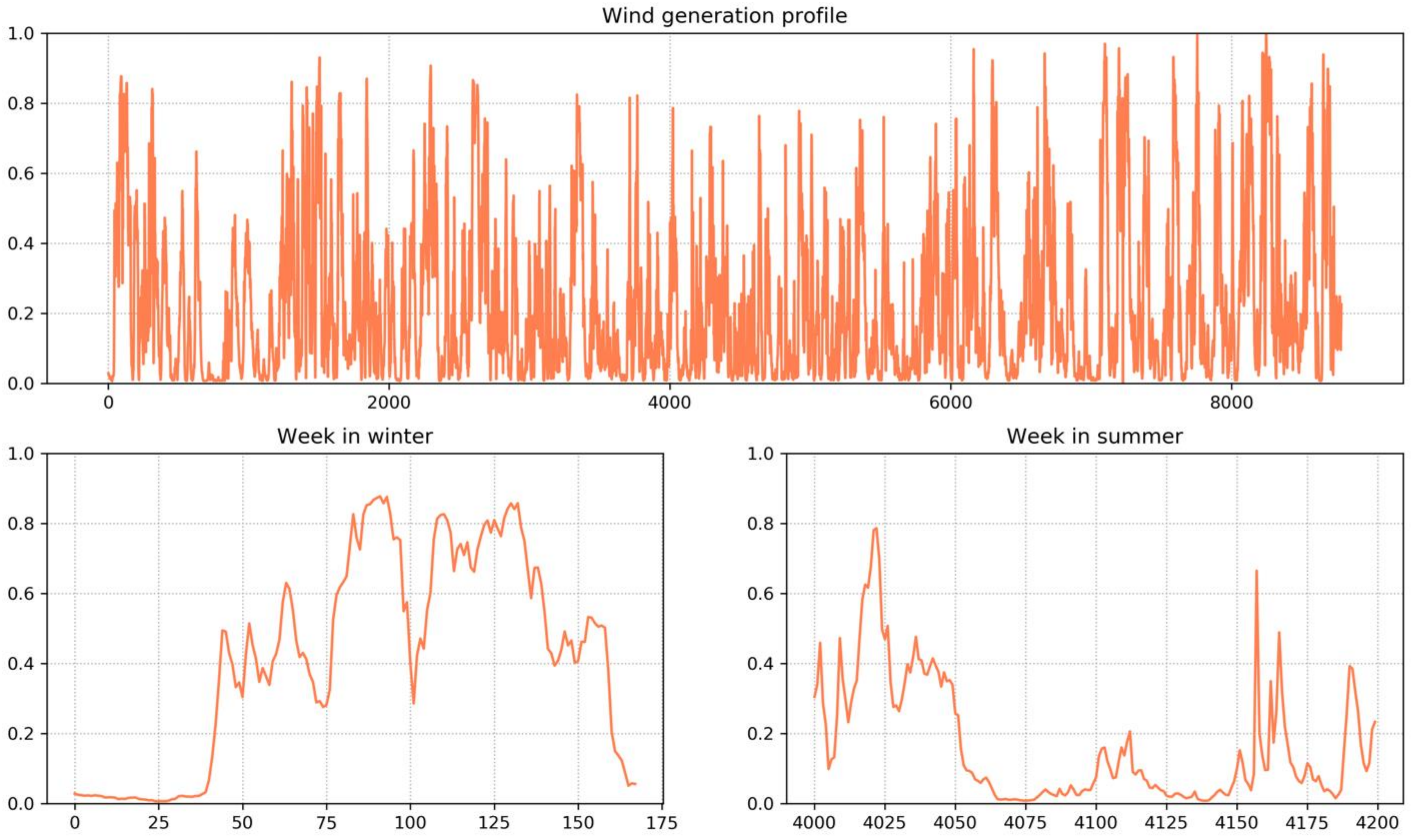
Year profile of the electricity consumption, Niederösterreich 2017 | Source: NÖ Landesregierung –RU3

Photovoltaic generation profile



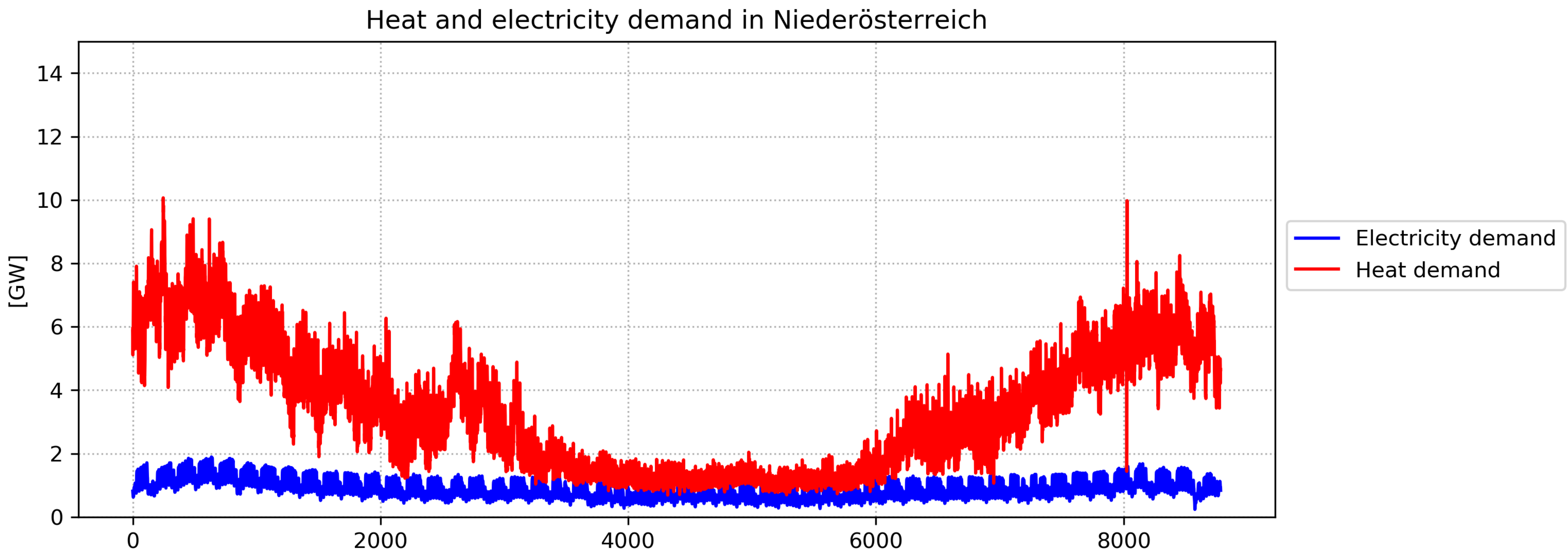
Profile of solar electricity generation, Niederösterreich 2017 | Source: NÖ Landesregierung –RU3

Wind generation profile



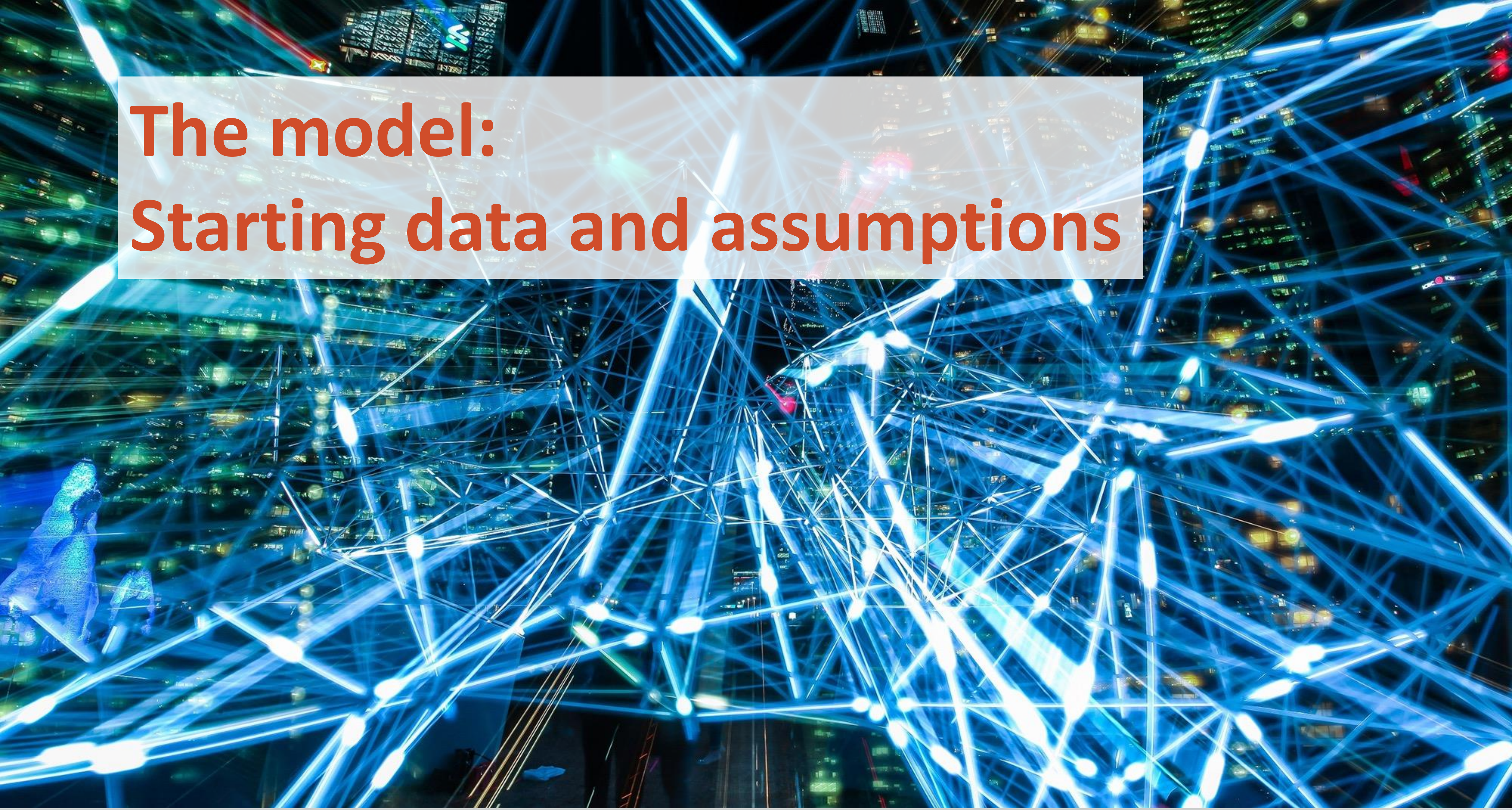
Profile of wind power generation, Niederösterreich 2017 | Source: NÖ Landesregierung –RU3

Comparison of heat and electricity demand profiles



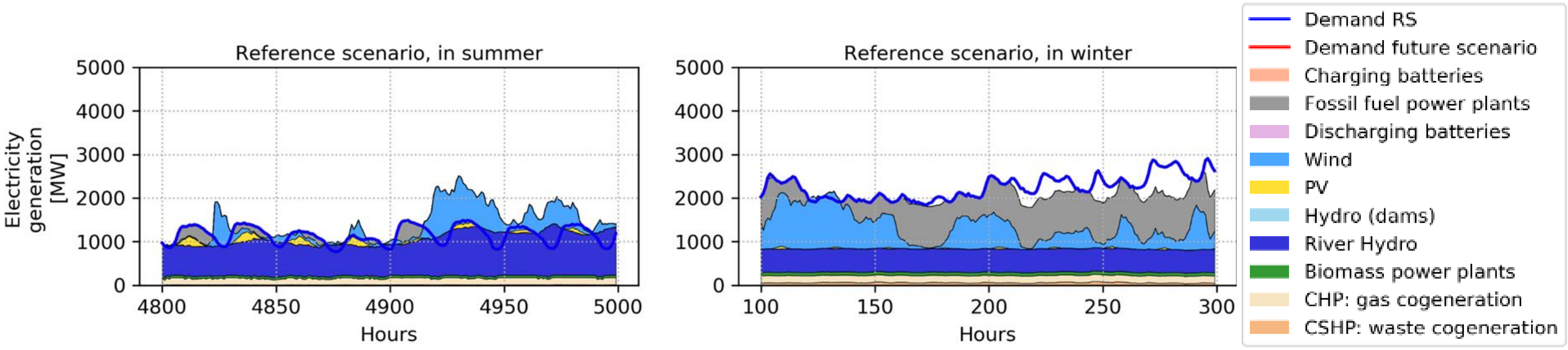
The heat demand peak in Lower Austria (as in most EU regions) is significantly higher than the electric power peak and subject to significantly greater fluctuations

Comparison of heat and electricity demand (electricity and heat demand of the industry sector are not included)



The model:
Starting data and assumptions

Modelling of the reference scenario*: electricity consumption and generation

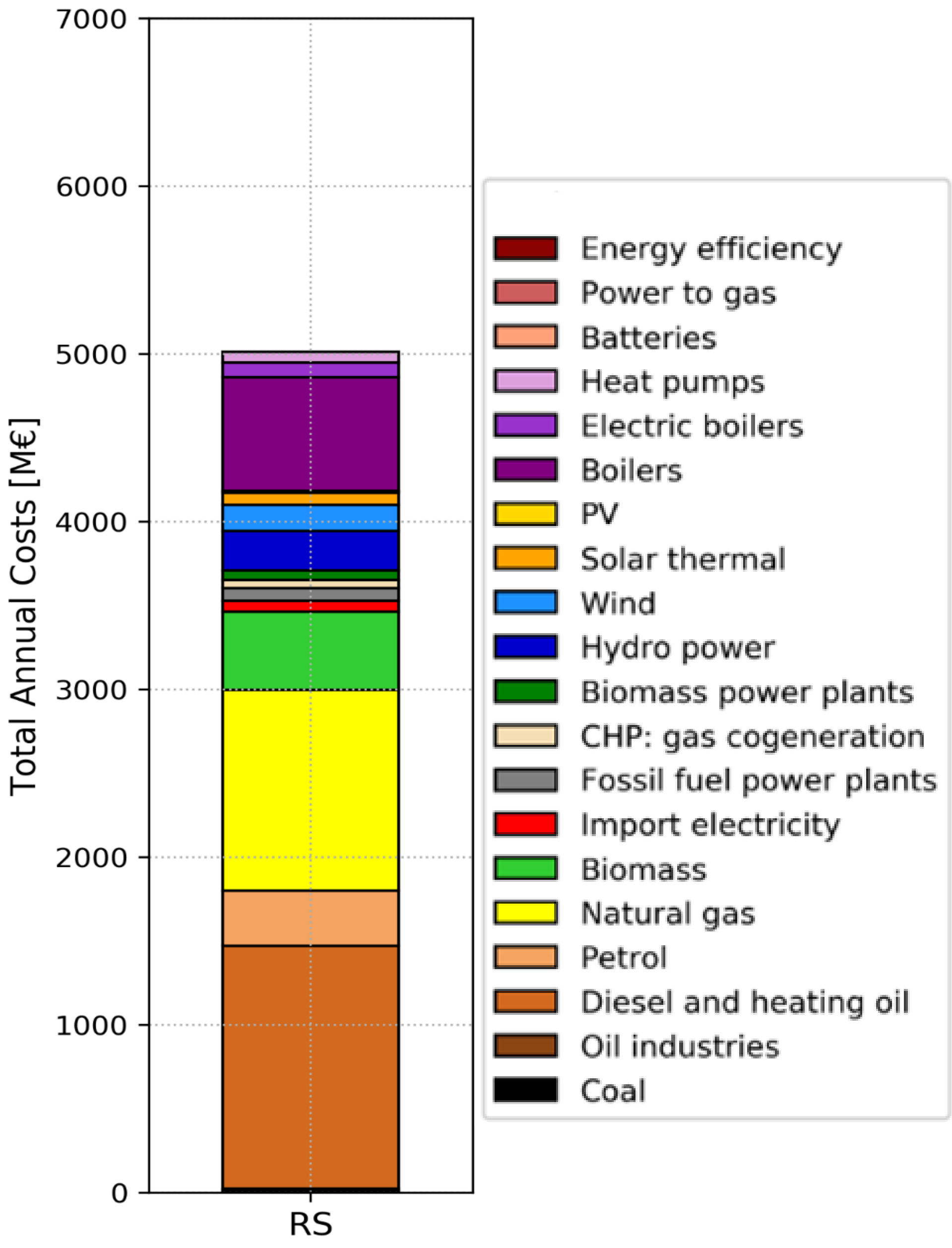


Example for the reference scenario (RS) of the power consumption and electricity production profiles of a week in summer and in winter. The x-axis shows the annual hours

Reference scenario: Cost structure

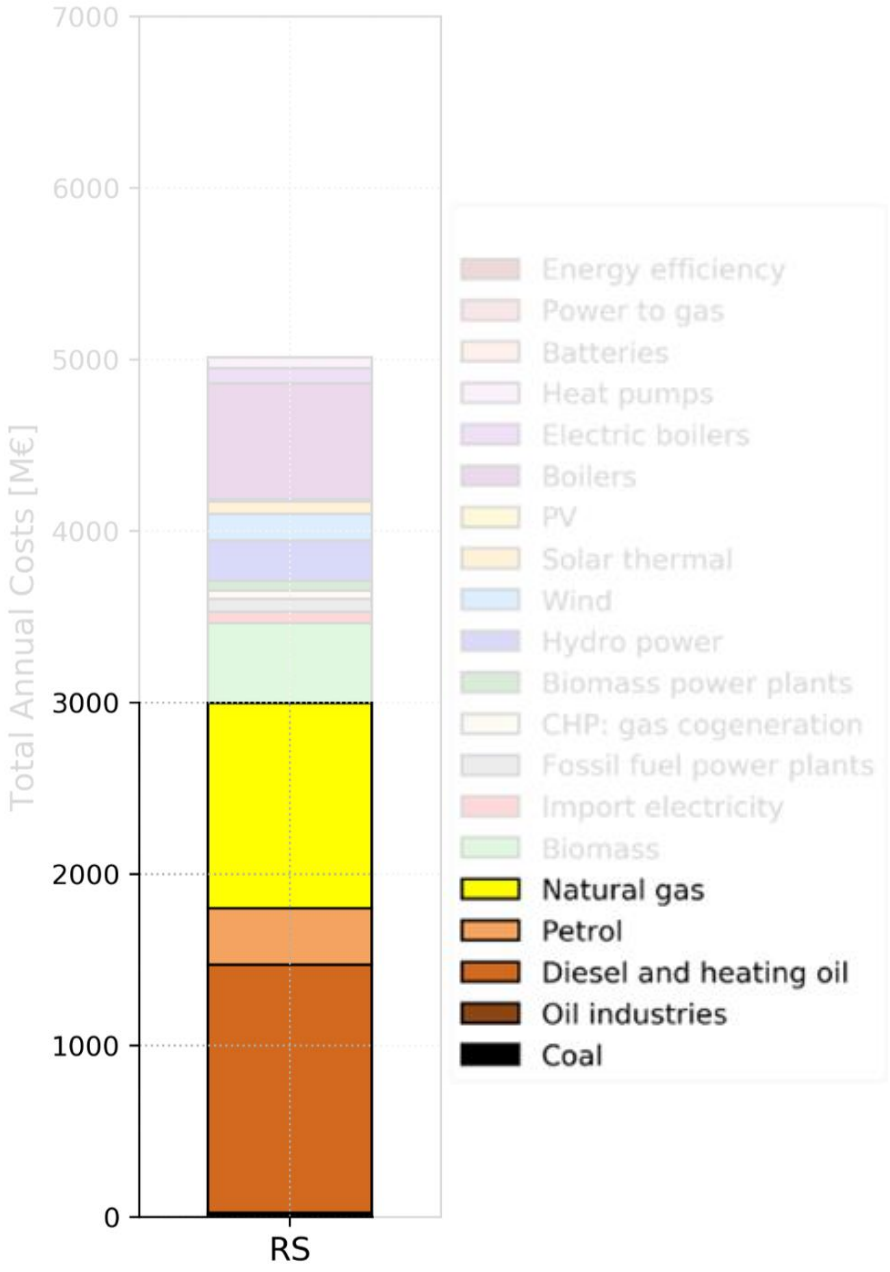
The listed costs (in millions of €) include the purchase costs of raw materials, as well as investment and, operational and maintenance cost of each technology. Efficiency costs refer to thermal energy efficiency passive measures in the building sector.

Appendix 1 contains more information and data sources



Reference scenario: Cost structure

Fossil fuels



In the current energy system, the fossil fuel costs represent the dominant part of the total annual energy costs.

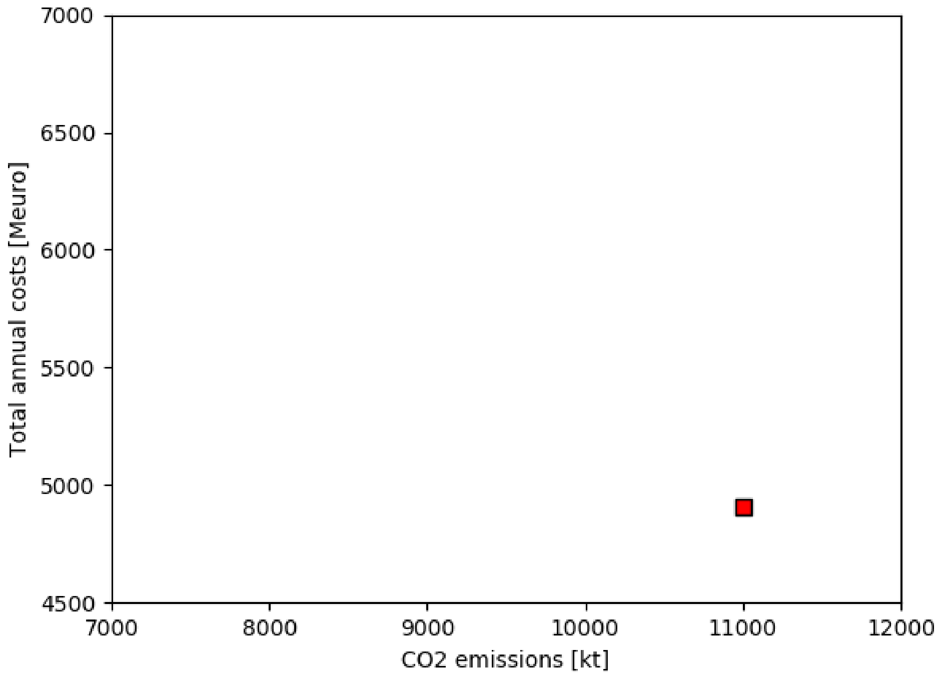
Optimization model of the energy system

Model n objectives - Eurac Research

Simulation model + **Optimization model**

EnergyPLAN (Aalborg University)

Multi objective evolutionary algorithm MOEA



The energy model consists of a coupling of the entire energy system simulation model EnergyPLAN and an optimization algorithm. The algorithm tries to find the combination of technologies that reduces CO_2 emissions and costs.
Each point in the graph represents the total cost and total annual CO2 emissions of a specific combination of technologies of the energy system.

PV

Assumption: Max generation potential: 5000 GWh. Assuming constant equivalent hours (equal to 1050 kWh/kWp) the max capacity potential is 4750 MW. Current status (2016): ≈250 MW

PV modules next to the Zwentendorf nuclear power plant | Source: Fronius, www.photovoltaik.eu

Wind power

Assumption: Max generation potential: 8000 GWh. Assuming constant equivalent hours (equal to 2000 kWh/kW) the max capacity potential is 4000 MW. Current status (2016): ≈1500 MW

Wind farm Höflein, Niederösterreich| Source: Peter Haas, www. commons.wikimedia.org

Storage technologies

Assumption: Lithium-ion batteries max capacity: 20 GWh
(sizing of max capacity is based on modelling results)

The Tesla Big Battery at Neoen's Hornsdale Wind Farm, Australia | Source: Neoen/Floodlight Media, www.esdnews.com

Power to gas

Assumption: Max H_2 produced from power to gas: 15% of total annual natural gas consumption. Electrolyser max capacity: 250 MW (sizing of max capacity is based on modelling results)

Hydrogenics power to gas project in Falkenhagen, Germany | Source: www.flickr.com

Solar thermal

Assumption: Possible use of solar thermal on rooftops for domestic hot water. Max. generation potential 800 GWh. Current status (2016): ≈ 450 GWh

Solar thermal system on a building roof | Source: Claus Ableiter, www. commons.wikimedia.org

Energy efficiency

Assumption: Data elaborated by Eurac Research describing the energy efficiency costs of the building stock, including different types of buildings, construction periods and location (details see annex 1).

Source Photo: Adobe Stock/stockpics, www.stock.adobe.com

Additional assumption - Demographic development

Constant demographic situation from 2016 to 2050

CEV Baden Masters 2013 | Source: Rainer Mirau/Beachvolleyball Baden, www.flickr.com

Additional assumption - Industry sector

Energy consumption of industry sector has been assumed to remain constant

Raffinerie Schwechat | Source: Martin Schachermayer, www.flickr.com

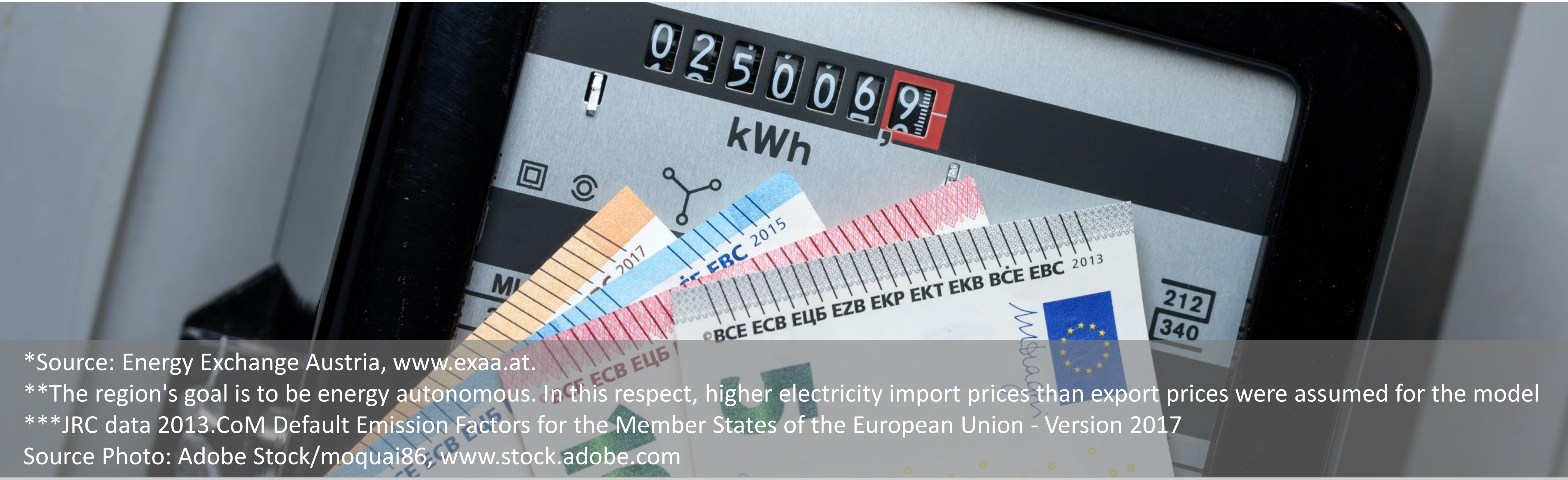
Additional assumption - Wien international airport

Wien international Airport jet fuel consumption is not considered in the analysis

Vienna International Airport | Source: www. commons.wikimedia.org

Additional assumption - Electrical energy exchange

Export price for electricity: 35 €/MWh*
Import price for electricity: 45 €/MWh**
Emission factor of imported electricity: 170 kg/MWh***



*Source: Energy Exchange Austria, www.exaa.at.
**The region's goal is to be energy autonomous. In this respect, higher electricity import prices than export prices were assumed for the model
***JRC data 2013.CoM Default Emission Factors for the Member States of the European Union - Version 2017
Source Photo: Adobe Stock/moquai86, www.stock.adobe.com

Additional assumption - Hydroelectric

Constant hydroelectric use

Current electricity generation from Hydro: 7.16 TWh per year

Pernegg, Niederösterreich | Source: ©VERBUND

Additional assumption - Biomass

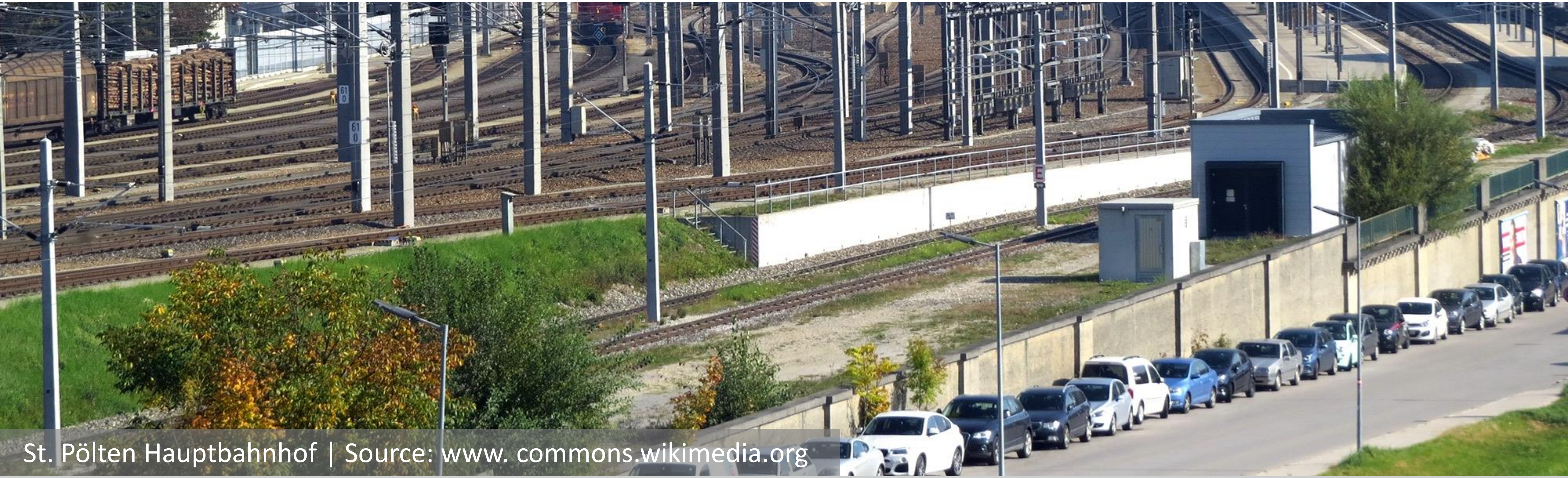
Constant use of biomass

Current status of Biomass consumption: 14.45 TWh per year

European beech trees near Hainfeld, Niederösterreich | Source: www. commons.wikimedia.org

Additional assumption - Transport

Transport demand in terms of driven km and modal split has been assumed constant



St. Pölten Hauptbahnhof | Source: www. commons.wikimedia.org

16.000

Different combinations of technologies of the energy system were simulated to understand which one present the best characteristics under the given conditions

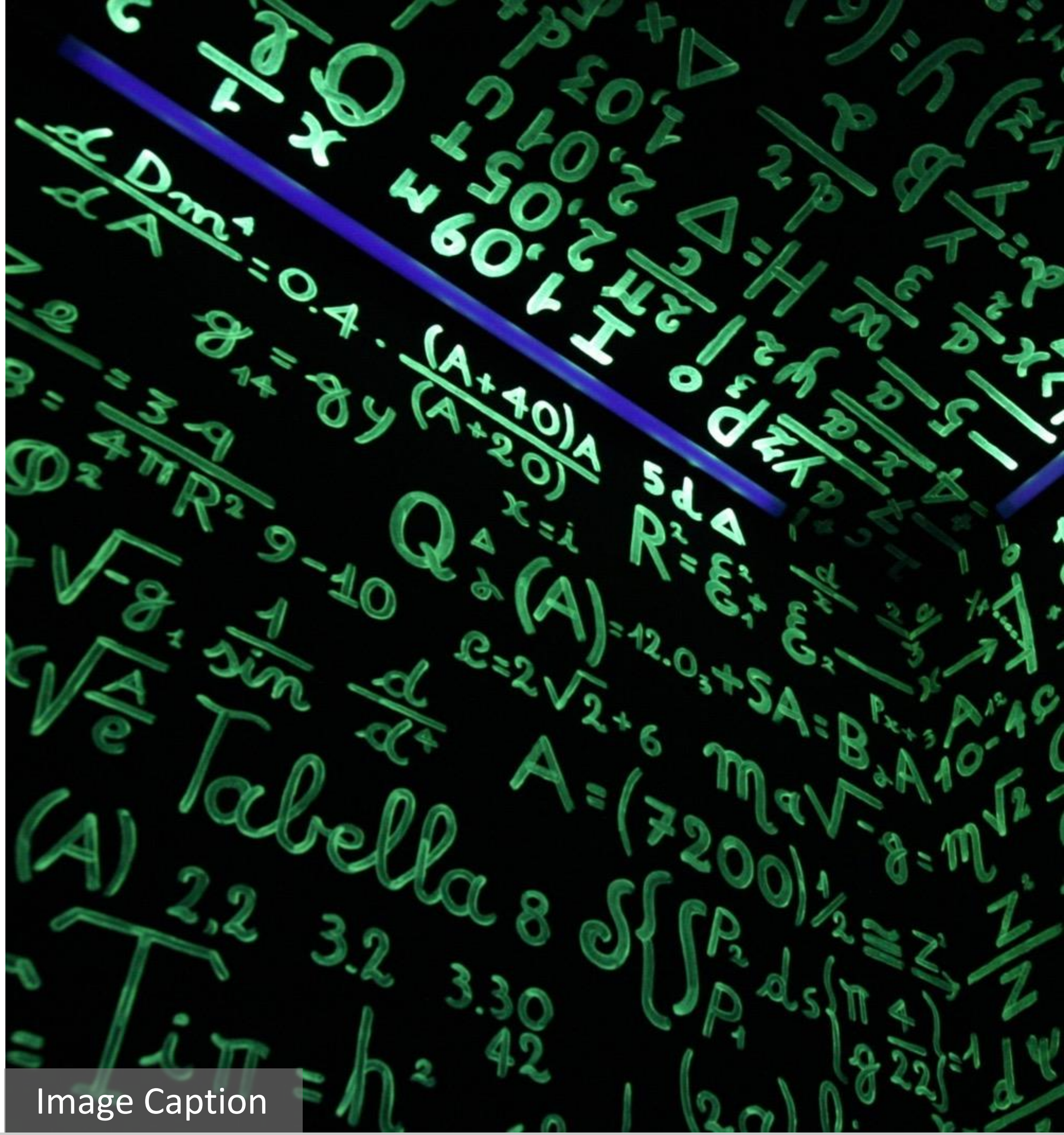
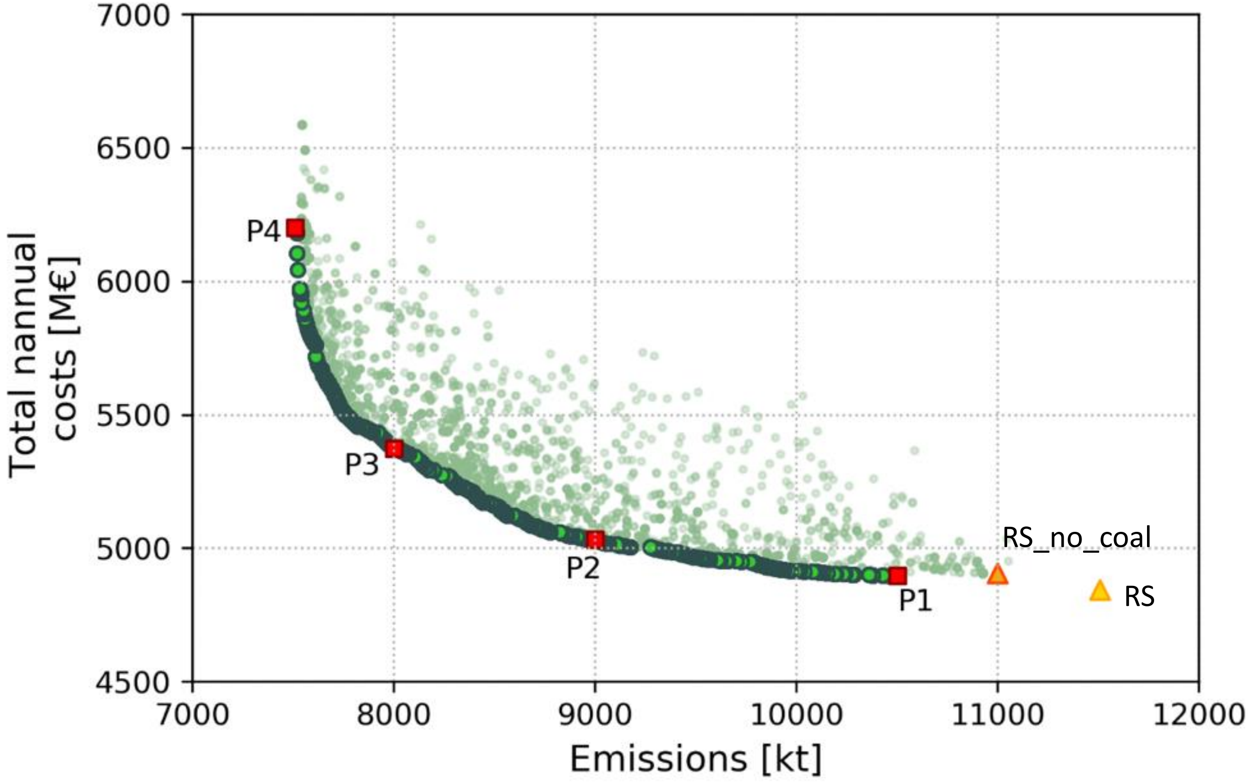


Image Caption

Results

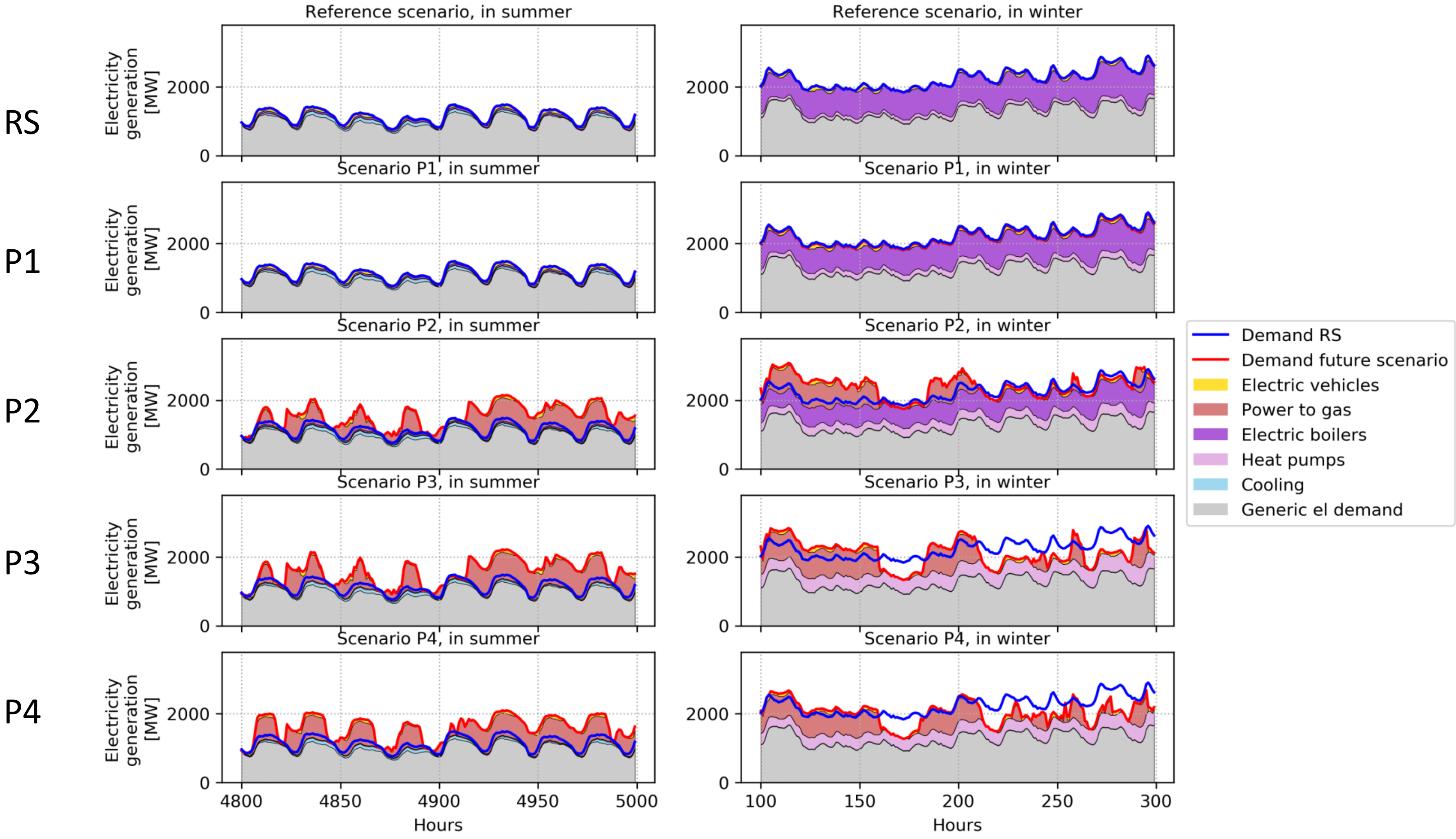
Results of system simulation by optimizing the power and heat sectors



- Each point in the cloud represents the annual cost and CO_2 emissions of a specific energy system scenario (combination of exploited potential of each renewable energy sources and energy efficiency measures). The details of the energy scenarios represented by the points P1-P4 are listed in the following slides.

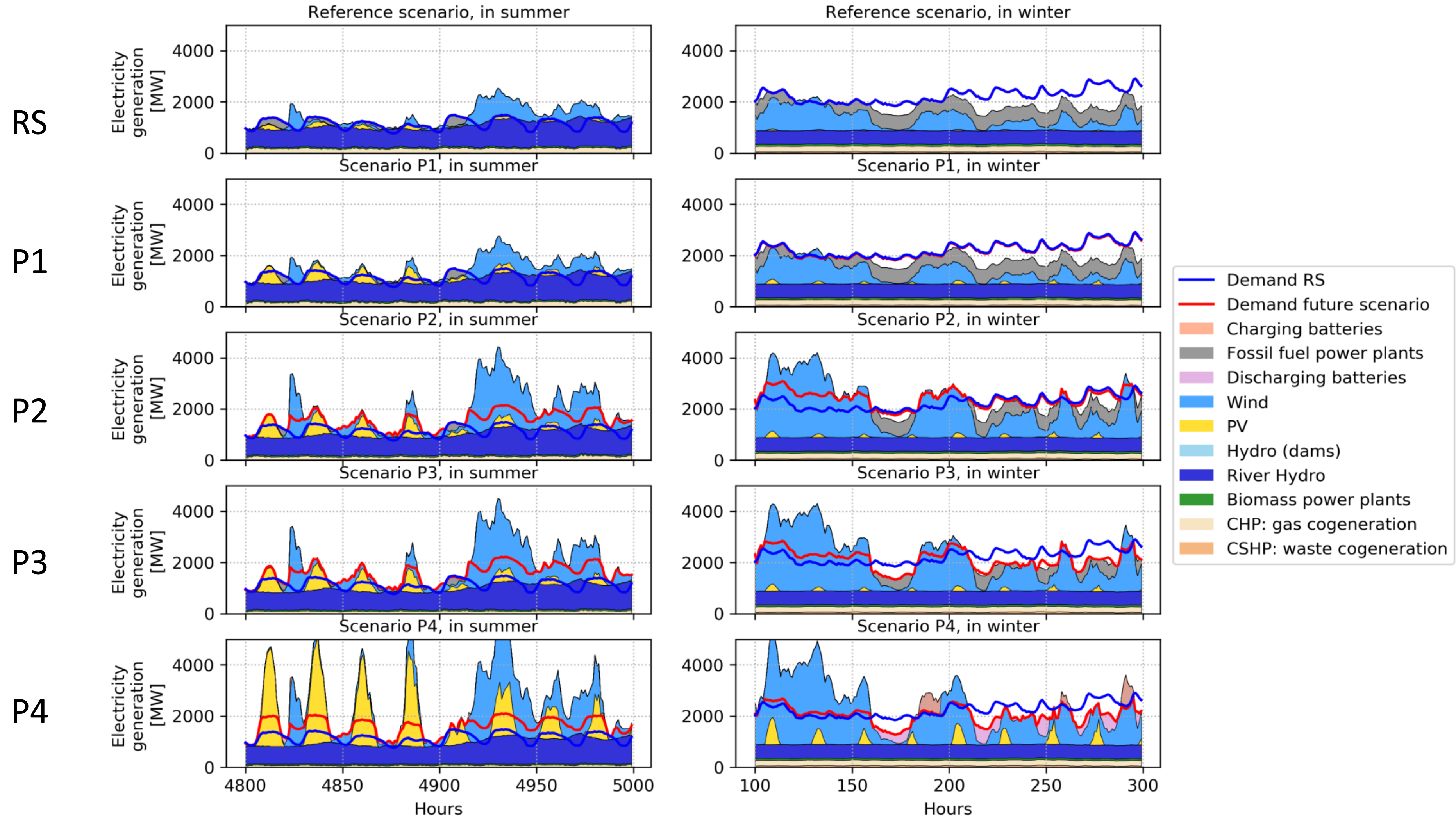
The point RS represents the reference scenario. Since opting out of coal-fired power plant is a clear target of the government, a second reference scenario without coal-fired power generation was calculated and displayed

Electricity demand in various scenarios



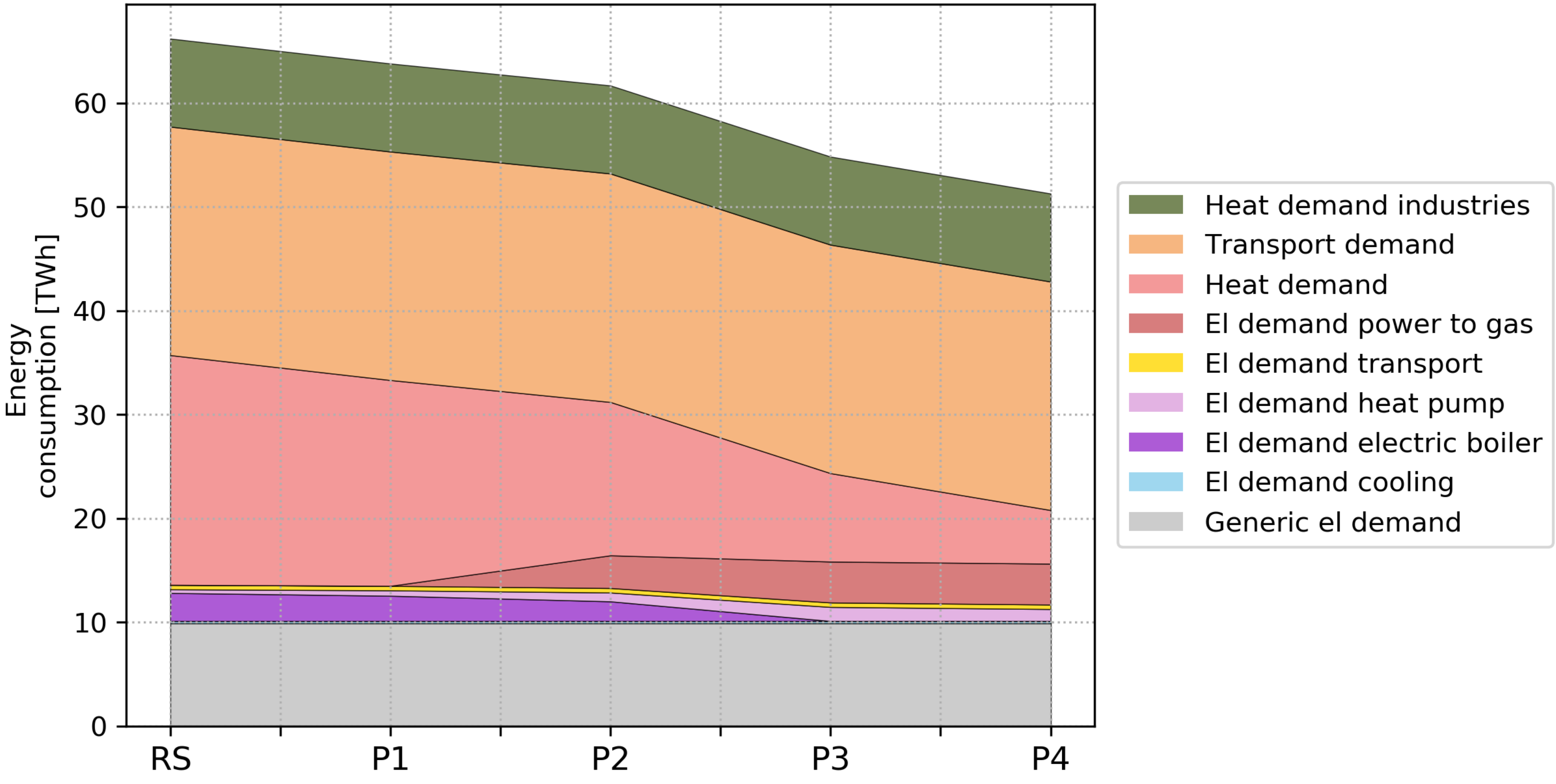
Scenarios P1-P4 are characterised by a decrease of the electricity consumption of electric boilers and an increase of the consumption of heat pumps and power to gas

Electricity production in various scenarios



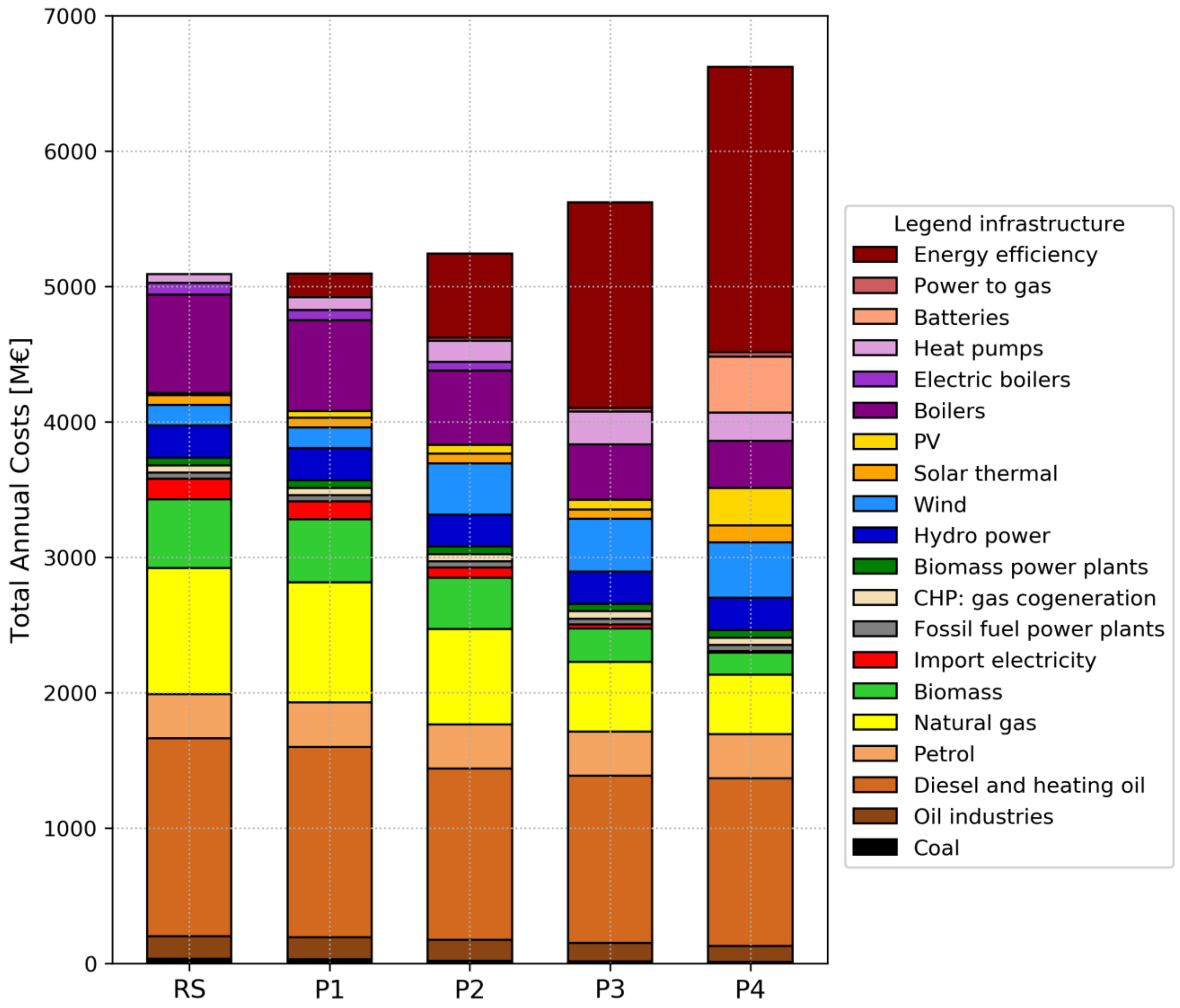
Scenarios P1 - P4 are characterised by the gradual increase in the use of renewable resources, in particular wind and solar energy (shown in light blue and yellow)

Total energy consumption – a focus on electricity and heat



The graph shows the significant reduction of heat demand due to the gradual increase of passive energy efficiency measures in buildings. Electricity demand increases with heat pumps and power to gas. EVs in the transport sector are yet not considered.

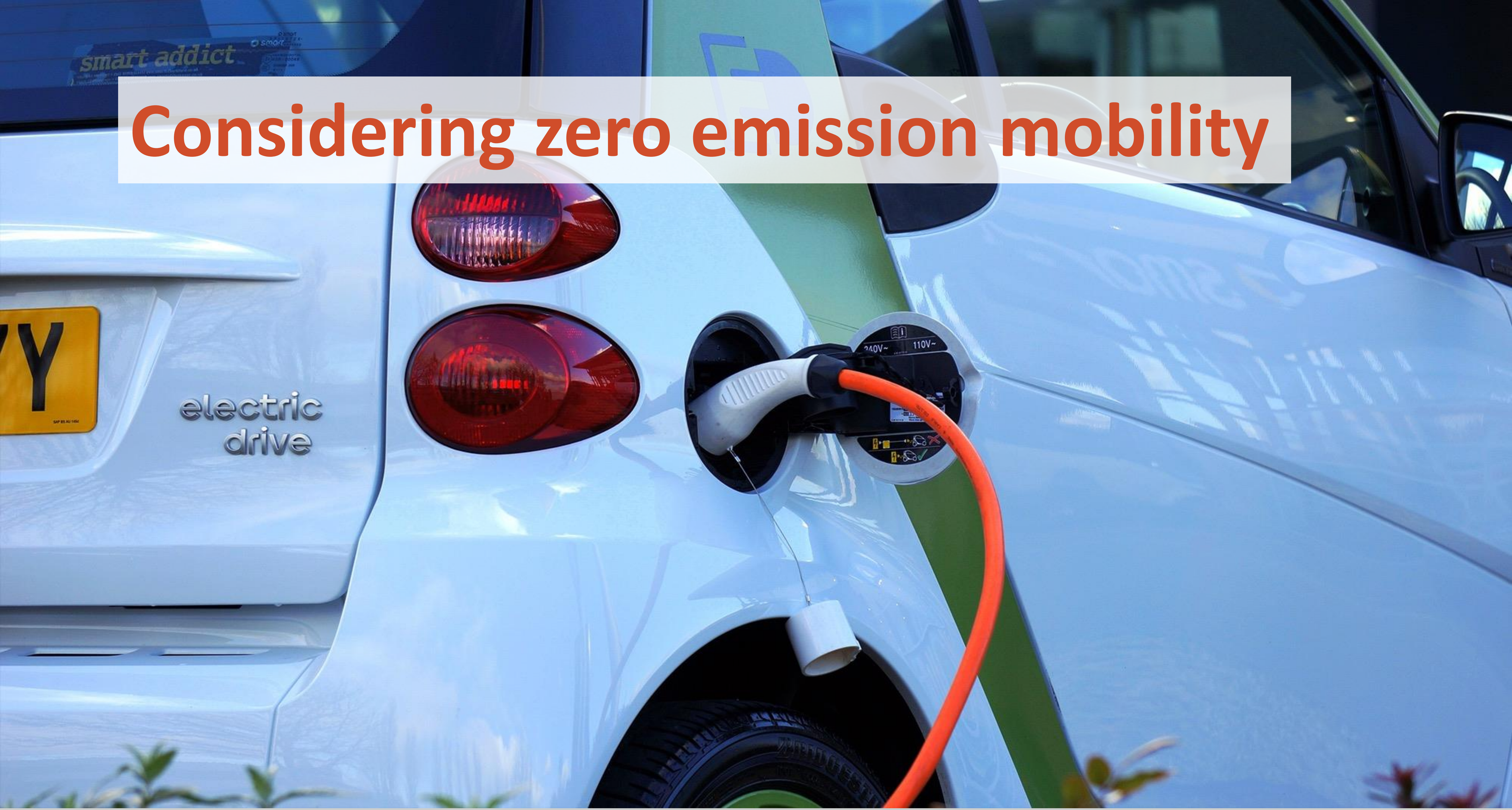
Cost structure changes in the different scenarios



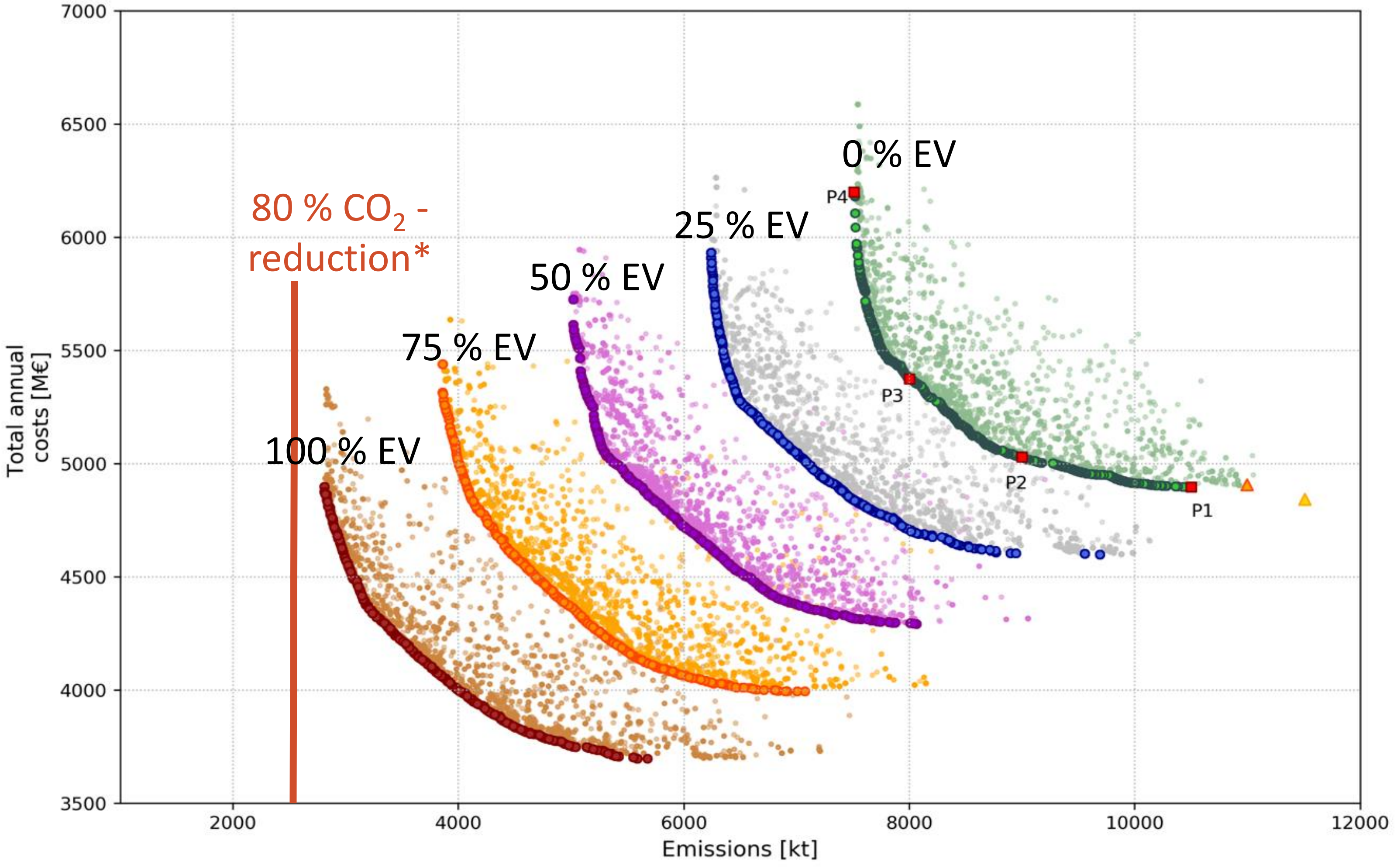
The graph shows the changes in the total cost of the energy system in each scenario.

Energy efficiency measures and heat pumps investments costs raise gradually thus inducing a significative reduction of purchasing costs for natural gas and heating oil. A cost increase in the electricity sector is visible due to solar and wind energy, in scenario P4 also by the use of batteries. Power to Gas is barely noticeable from a cost viewpoint. The transport sector has not yet been considered.

Considering zero emission mobility



Results System Simulation - Integration of E-Mobility



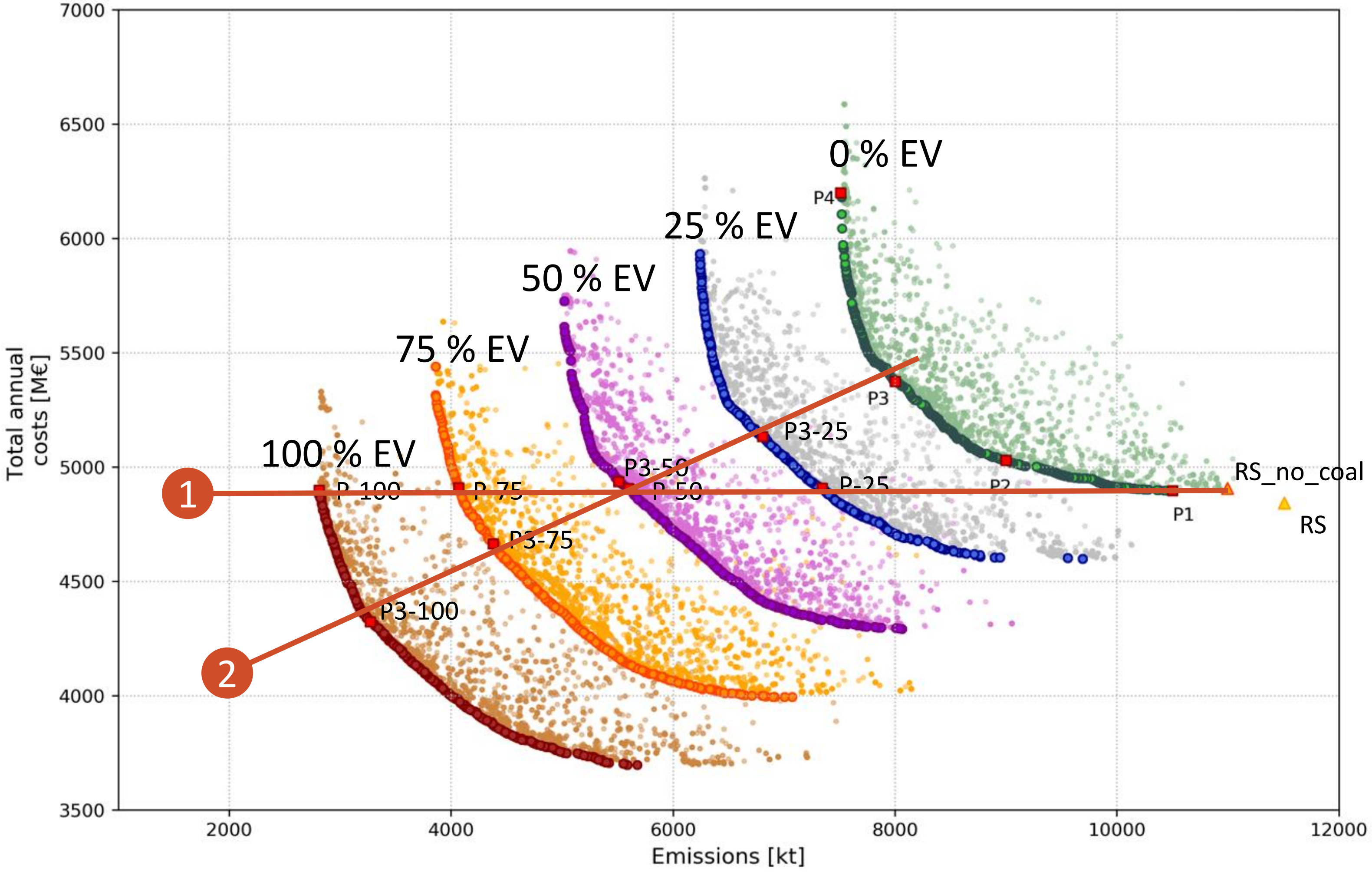
The individual curves result from a gradual increase in e-mobility of 0, 25%, 50%, ... of the total annual driven kilometres.

The increase in e-mobility leads to a gradual reduction of emissions and to a reduction of the total costs based on the high efficiency of electric motors and the reduction of fossil fuels.

Even in the final scenario, the target set cannot be achieved without the inclusion of energy efficiency measures in the industry sector.

*with respect to the value of 2016

Results System Simulation - Integration of E-Mobility

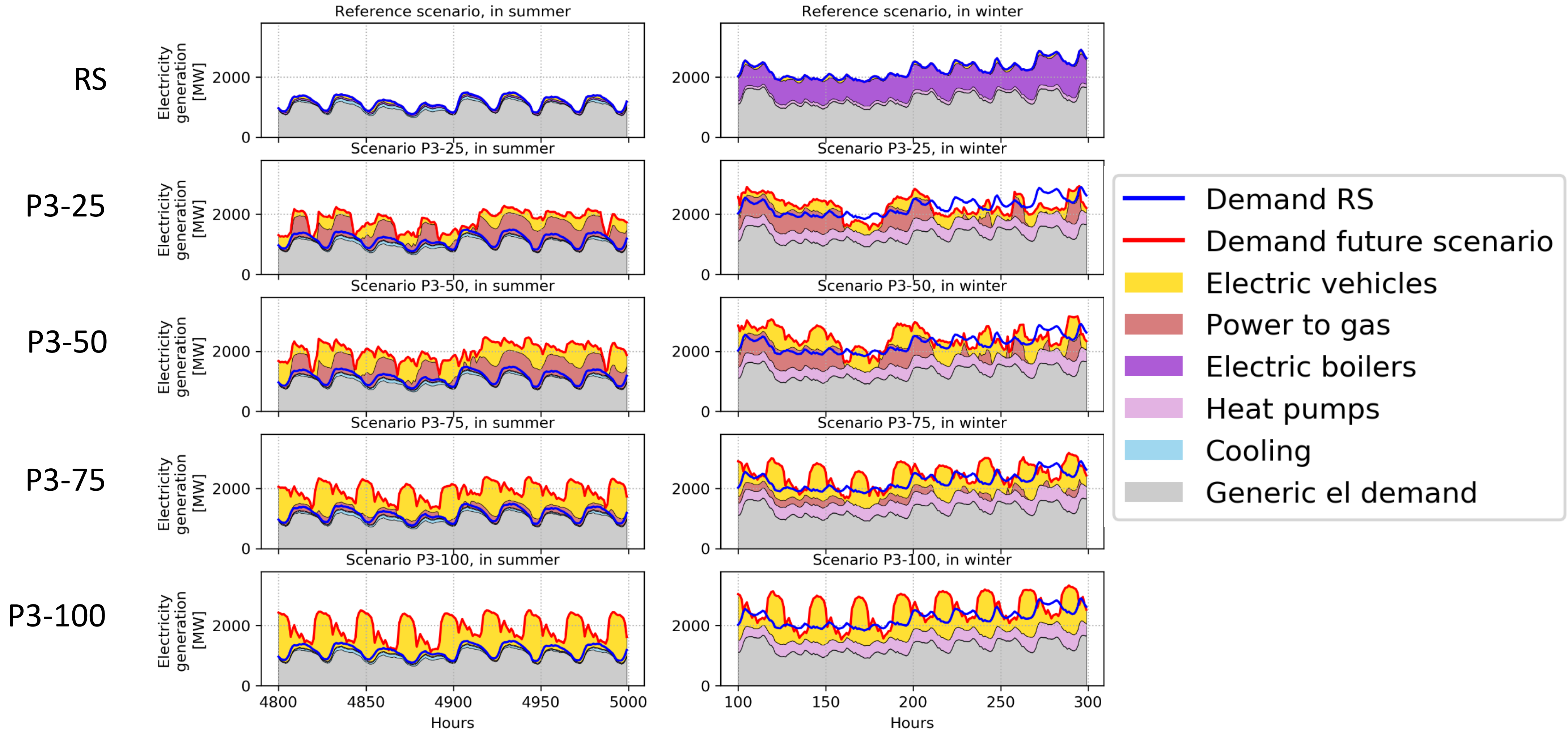


Examination of two different paths related to the scenarios.

Path 1: Constant costs compared to the reference scenario (coal phased out)

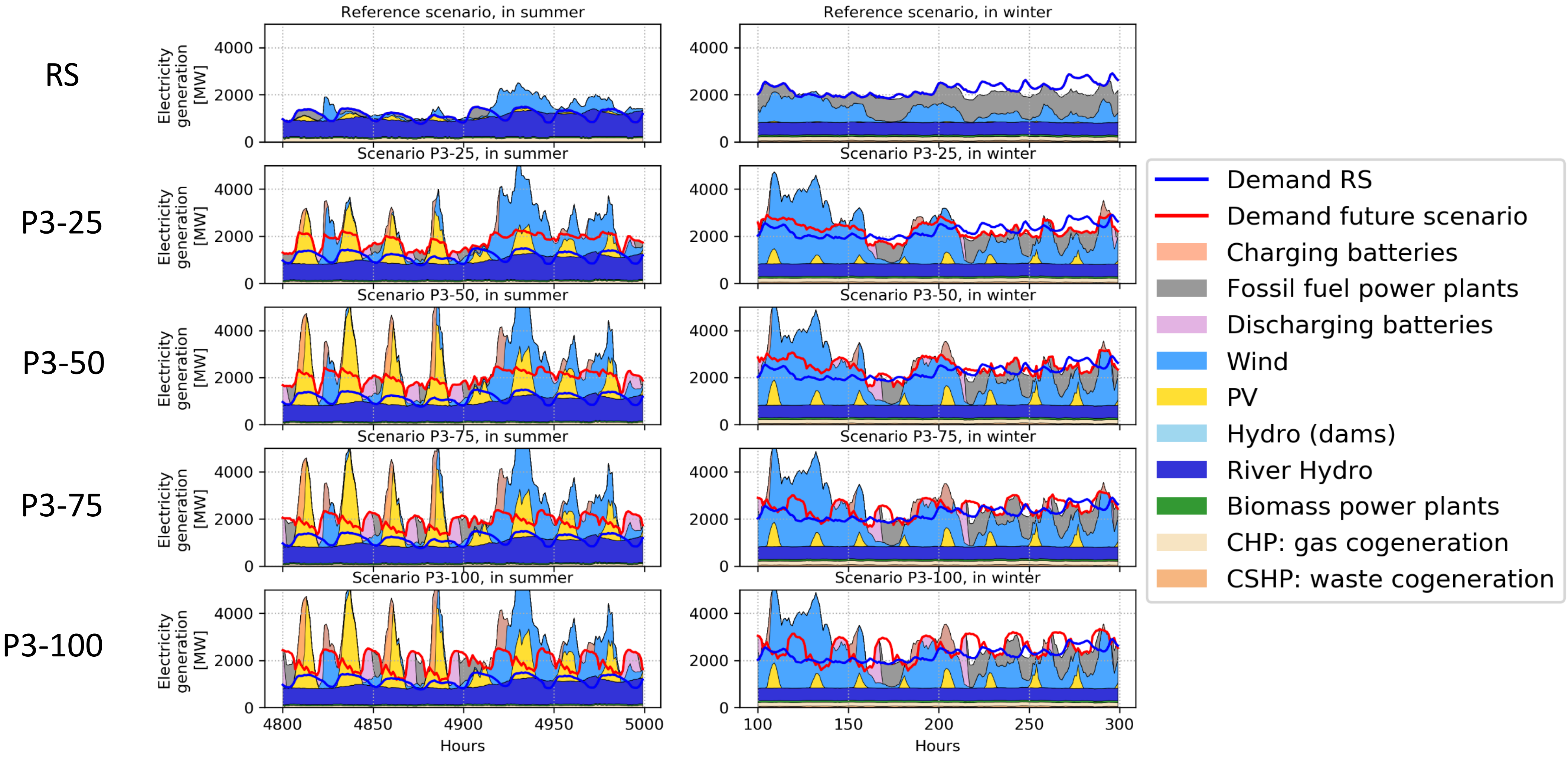
Path 2: same relative position on the pareto front, trade-off between cost development and emission reduction; which leads to relevant reduction of the total energy costs with increasing e-mobility.

2 Path 2: Electricity demand in different scenarios including transport sector



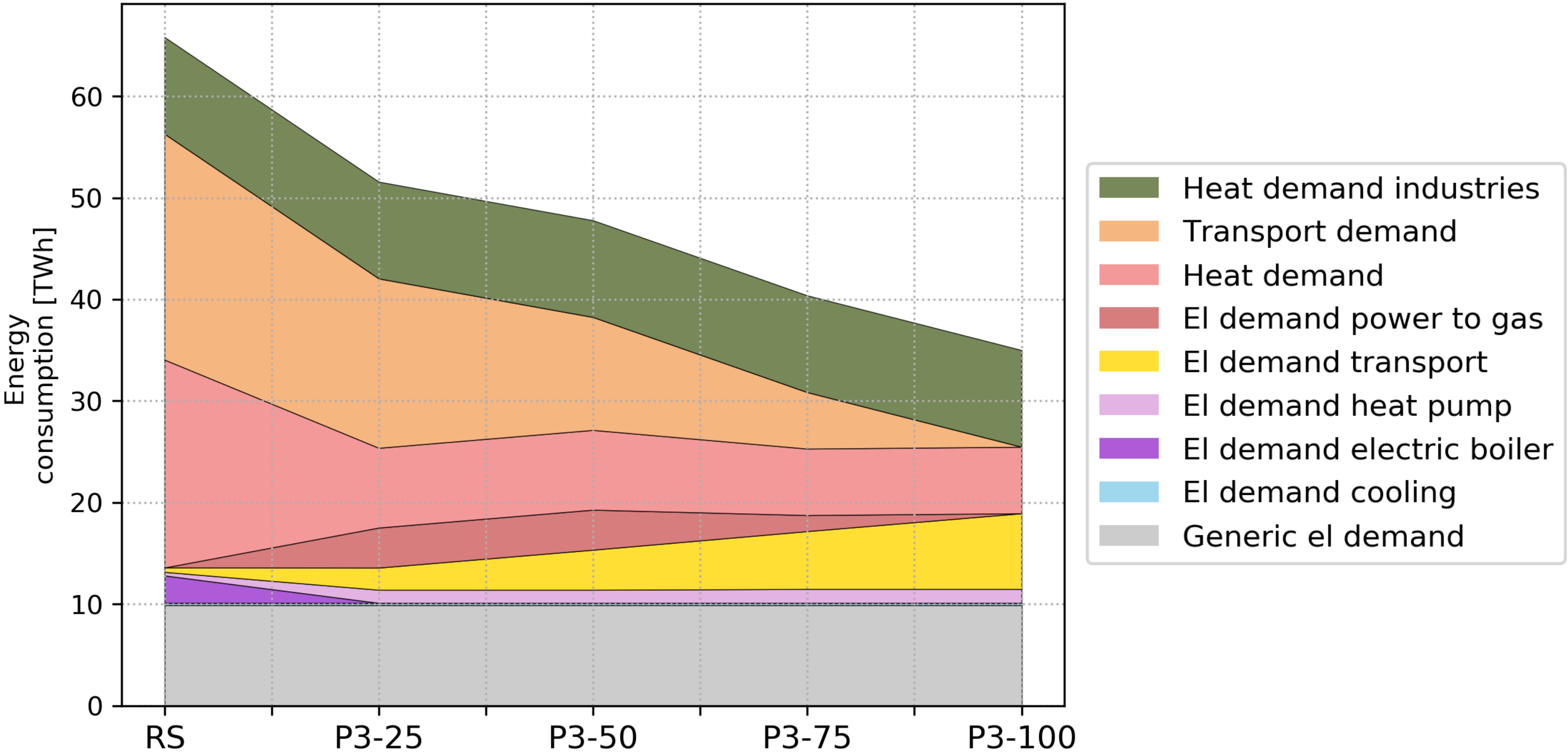
The scenarios with 25% to 100% electrified transport sector are characterised by an increasing demand for electricity, and a demand for power to gas that initially assume a relevant role for then disappearing at high penetration of e-vehicles

2 Path 2: Electricity production in different scenarios including transport sector



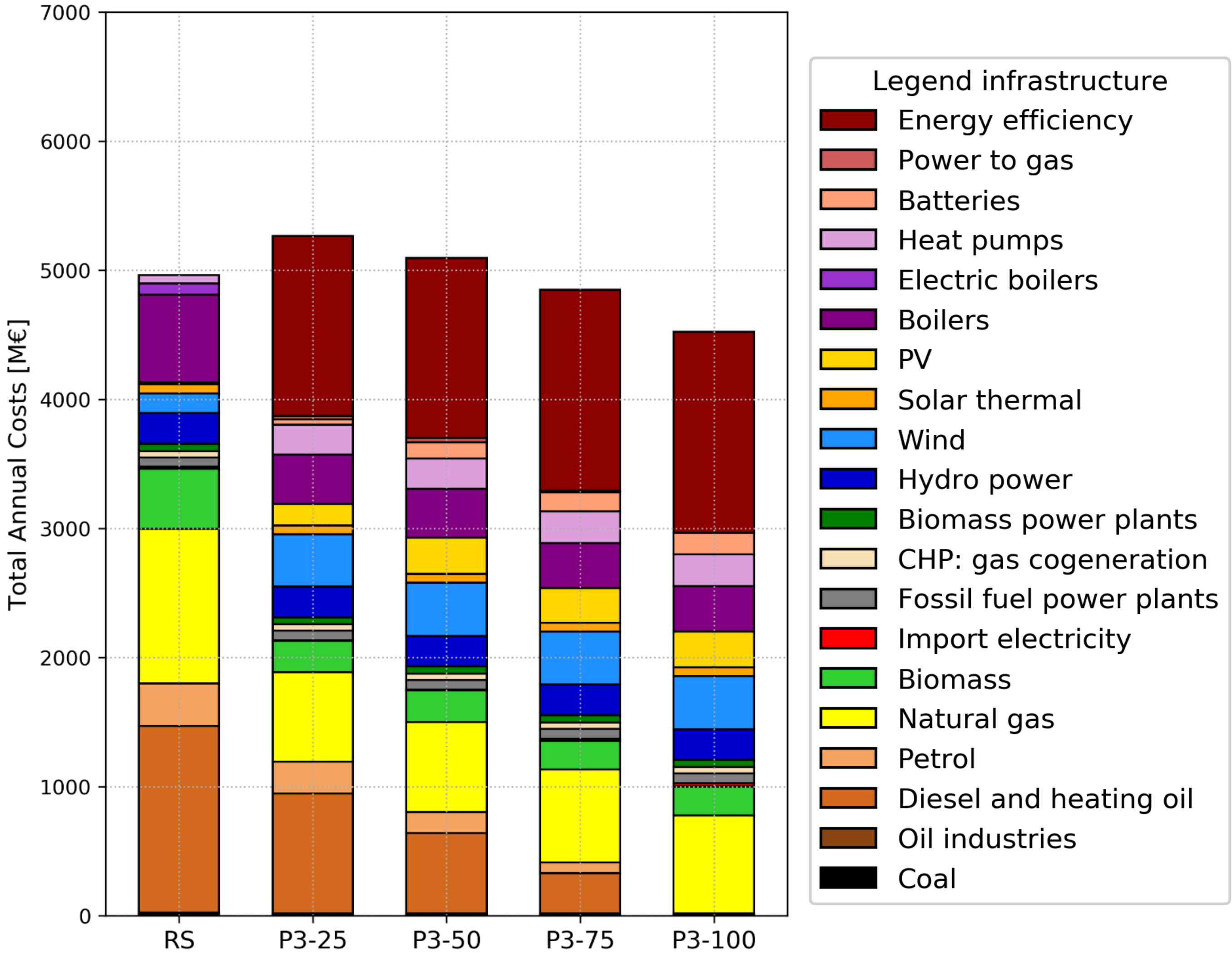
The scenarios with 25% to 100% electrified transport sector are characterised by a even greater use of the existing solar and wind energy potential with corresponding high production peaks

❷ Total energy consumption – a focus on electricity, heat and transport



The graph shows the significant reduction in heat demand and the decreasing fuel consumption due to increasing electrification of the transport sector. Power-to-gas rises and falls, the electricity demand in the transport sector increases.

❷ Change in the cost structure – a focus on electricity, heat and transport

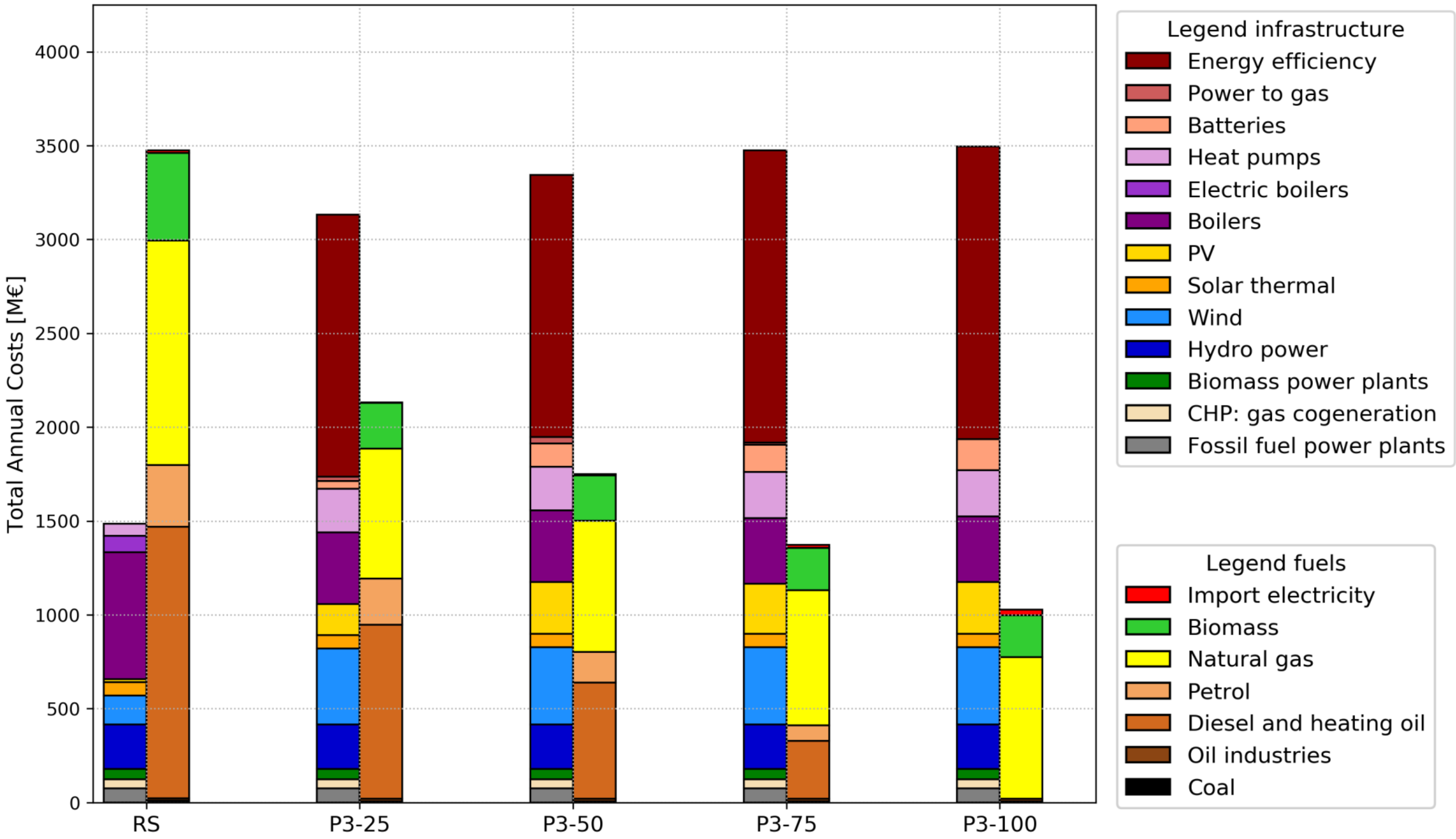


The graph shows the change in the total cost of the energy system in each scenario.

The gradual increase in electrified transport sector causes a significant reduction in gasoline and diesel consumption in addition to the decline of fossil heating fuels due to buildings renovation.

Due to the high efficiency of electric vehicles, the necessary increase in power consumption and associated costs is much lower, resulting in a step-by-step reduction in the total energy system cost of approximately 10%.

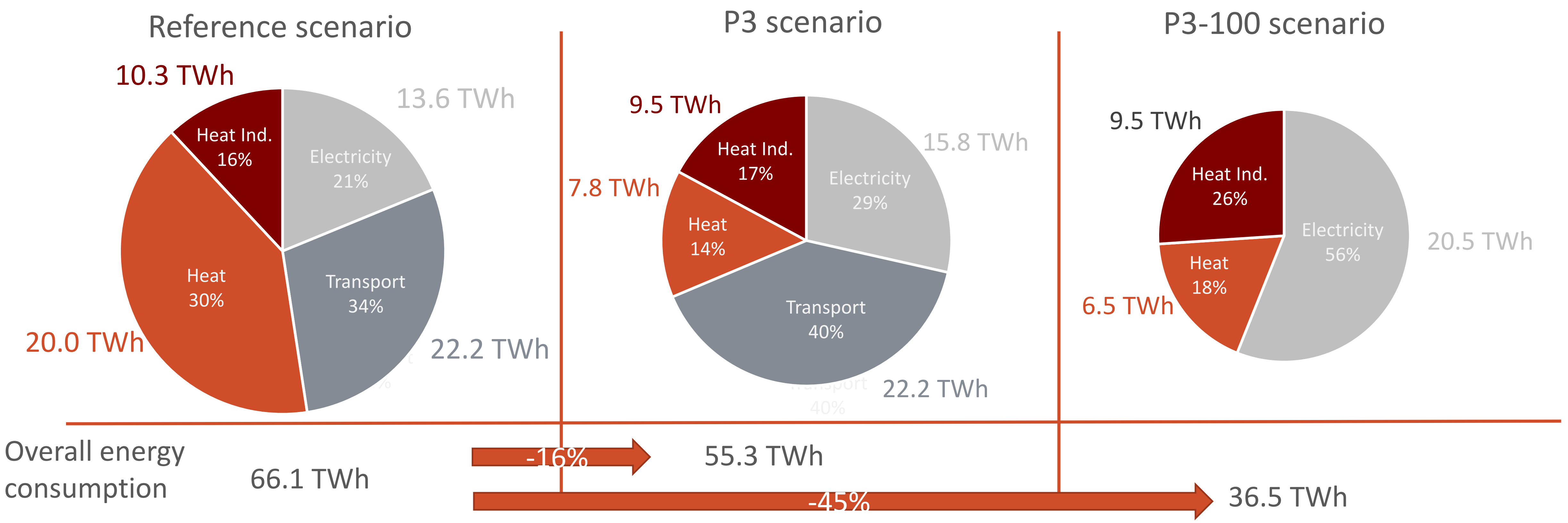
❷ Analysis - Development of raw material costs and investment costs



The chart shows how the gradual decrease of energy system emissions reduces fossil raw material costs while increasing investments in regional infrastructures (especially building efficiency and renewable energy production).

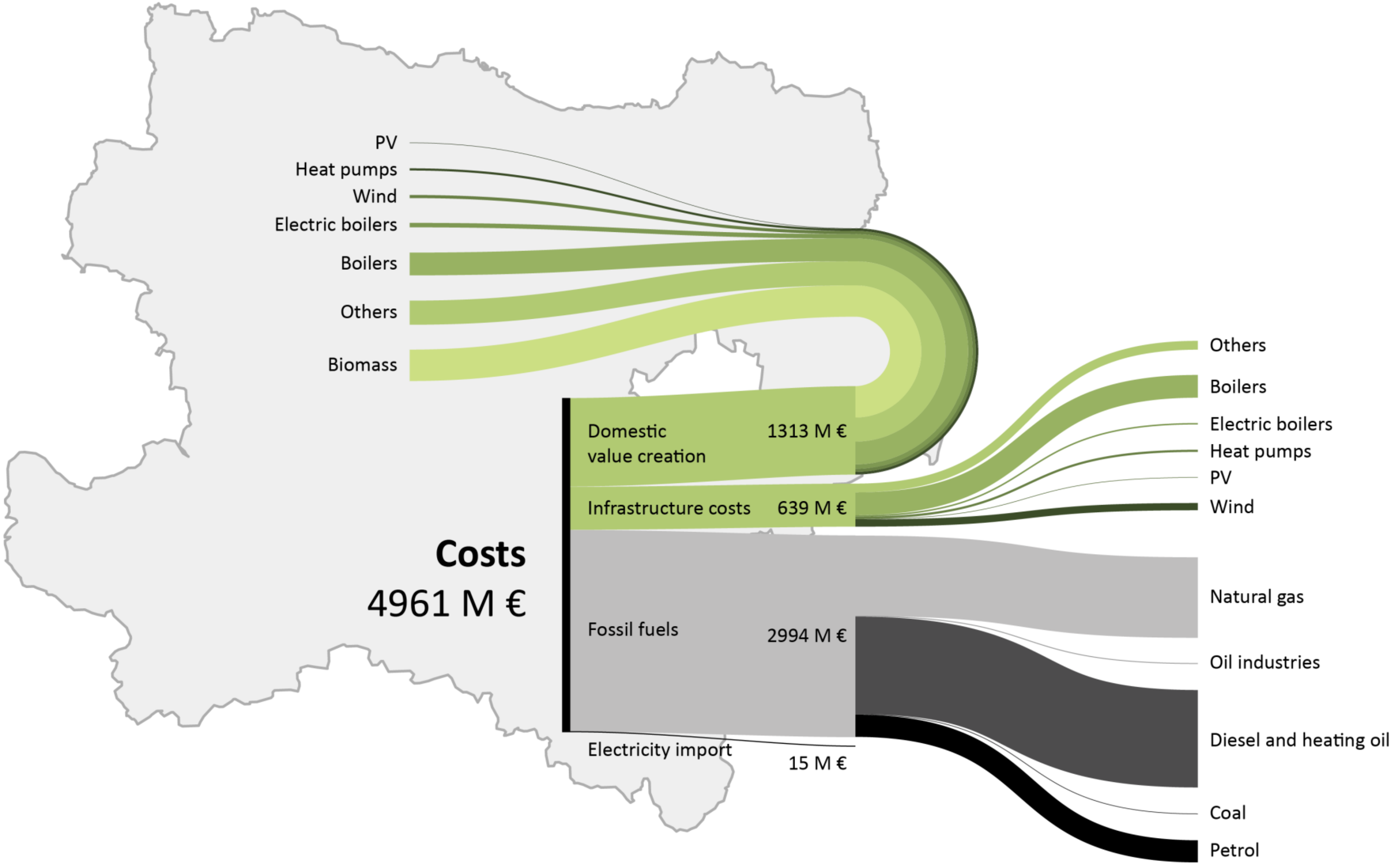
Thus also significantly increase the economic added value remaining in the region.

Evolution of total energy consumption in three scenarios



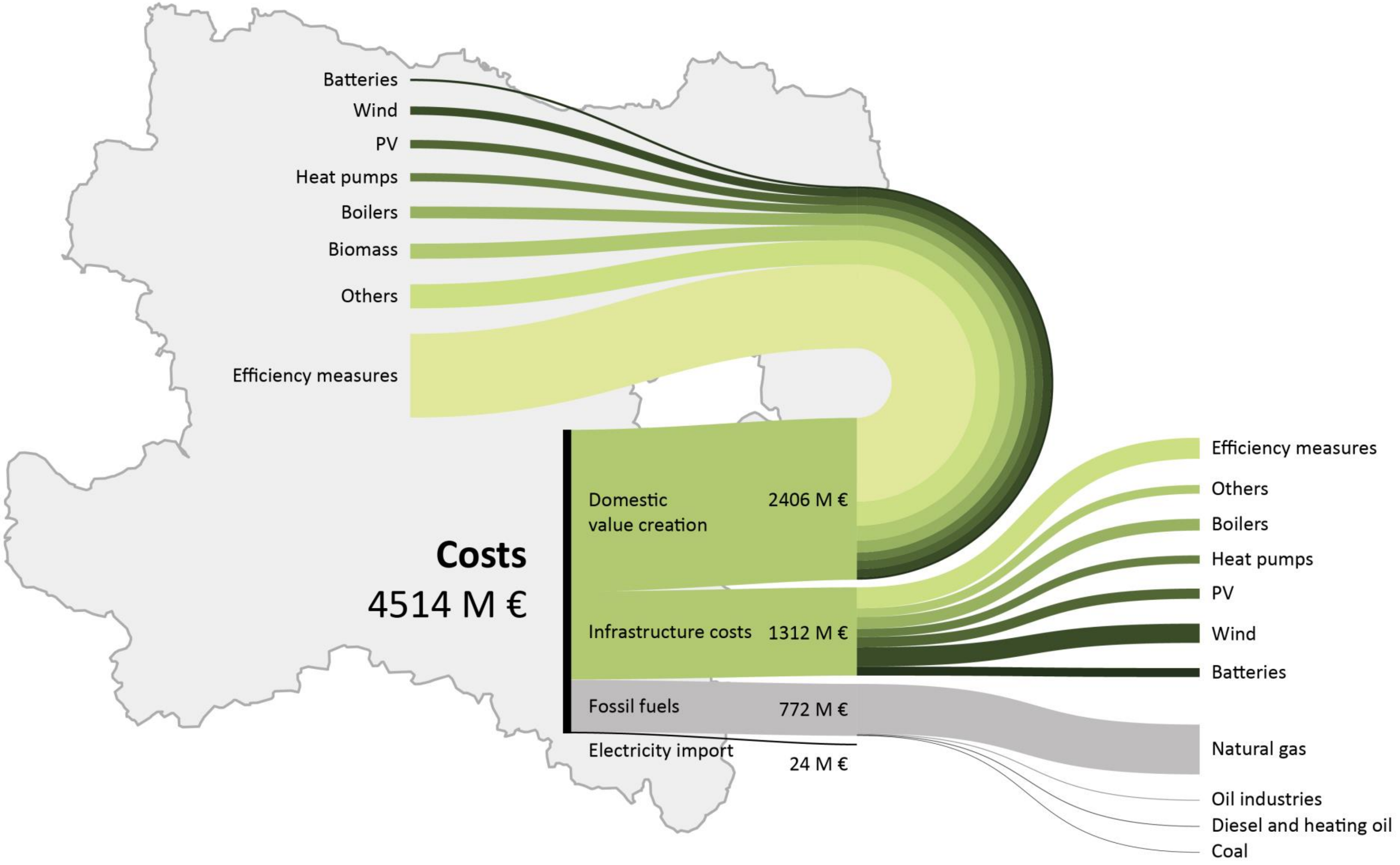
The graph shows the reduction of total energy consumption in the three scenarios. The share of the individual energy sectors changes significantly showing: decreasing heat demand and decreasing energy demand from transport by internal combustion engines with related increasing electrification of the energy system

Cost Structure - Reference Scenario



Subdivision of investments in the region and import of technology and raw materials

Cost structure - target scenario (P3-100)



Subdivision of investments in the region and import of technology and raw materials

Key messages (1/2)

- The objective of 80% emission reduction is an ambitious target that can be met only with a strong sustainable transformation of the energy system

- The key transformations are
  - Energy efficiency of buildings
  - Electrified transport sector
  - A deep exploitation of the renewable energy potential
  - Contribution to decarbonisation from the industry sector

Key messages (2/2)

- The transformation is possible with large scale application of available technologies and a further development of them

- The transformation is a relevant economic opportunity as a large shift from costs for fossil fuels to investments in on place technologies and infrastructures is taking place

Thank you for your attention

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