Workshop on International Electricity Modelling
EIA, U.S. Dept. of Energy

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Electricity Demand modelling and projections in Europe combining the advantages of macro-economic and technology-oriented models by hard links

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Overview presentation

- Current EU-Wide context for Electricity Demand
- Overview of Modelling Approaches and FORECAST FC4 Platform
- Hybrid Modelling Approach and Challenges
- The case of Steel Modelling and TRANSFORM/MATEFF/IMPULSE Module
- Results for:
  - Steel Modelling
  - Energy and Electricity Demand Projections in EU
- Conclusion - Discussion

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EU-Context: current Energy Efficiency objectives must fulfill long term requirements across different sectors

- The EU Energy Roadmap, published in 2011 by the EU Commission, serves as a basis for discussion for the future energy and climate policy in EU until 2050.
- All sectors must contribute to the Emissions Reduction Objective of -85% compared to the 1990 levels.
- The new Energy Efficiency Objectives in the framework of the Directive require actions from electricity consumers and producers
- The role of Energy Efficiency is until now insufficiently analysed
- Electricity is highly probable to be the most important energy carrier in 2050
- Energy Efficiency influences significantly in which way the electricity sector must be reorganized

Source: German Federal Ministry for Environment and Fraunhofer ISI,
http://www.isi.fraunhofer.de/isi-en/x/projekte/bmu_eu-energy-roadmap_315192_ei.php

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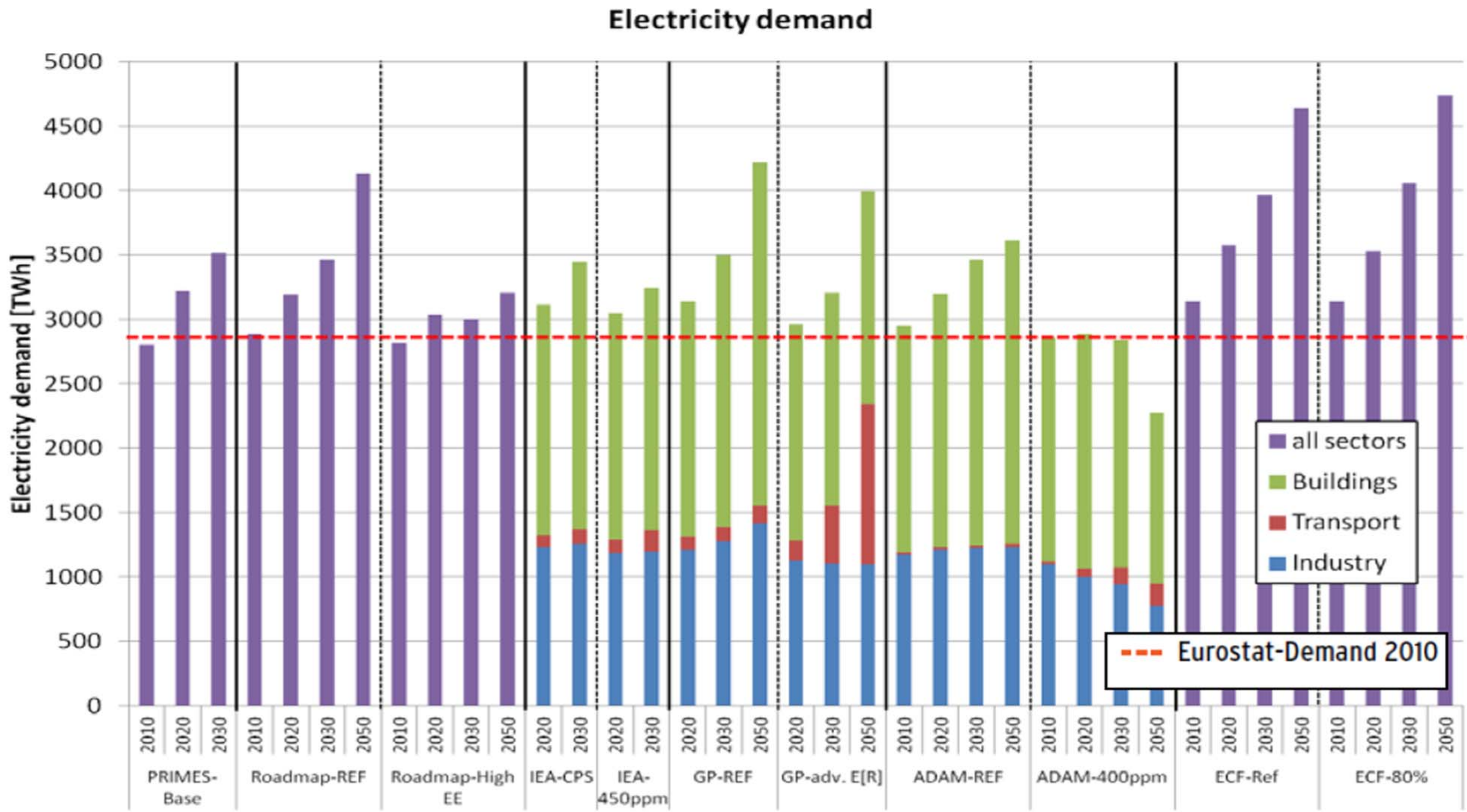
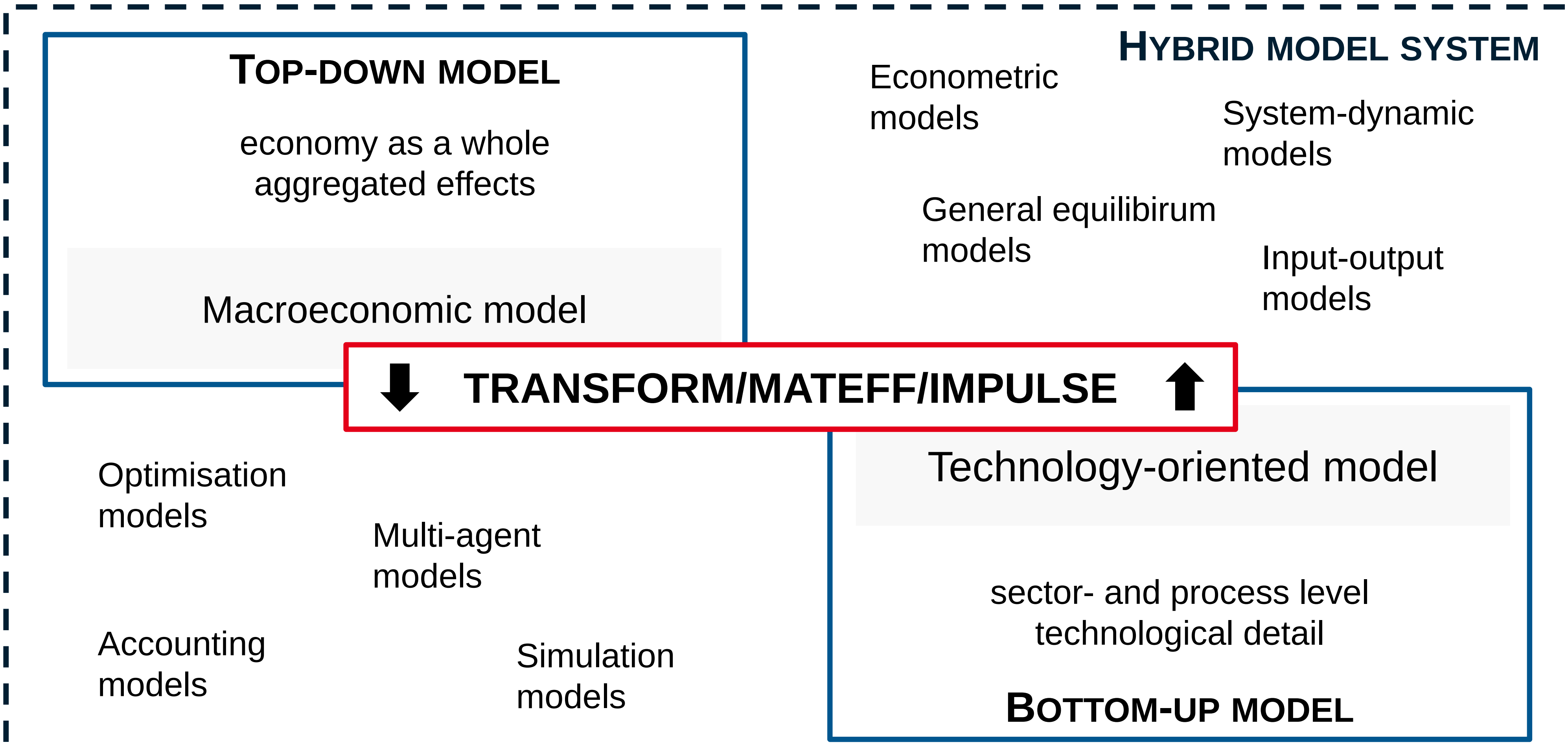
EU Context: Electricity Demand will **continue to increase** in case, if not handled



EU27	Total 2008	2003 vs. 2008	Relative change 2008-2050			
			EU Energy Roadmap		Energy [R]evolution	
			REF	EE	REF	Adv. E[R]
Primary Energy	1800 Mtoe	±0,0%	-2,0%	-40%	+1%	-39%
Final Energy	1160 Mtoe	+0,3%	+5%	-37%	+17%	-26%
Electricity Demand	2860 TWh	+7,0%	+44%	+12%	+48%	+40%

Combining aspects from both Top-Down and technology-based bottom-up simulations for Electricity Demand and Energy Efficiency Potentials



Source: Herbst et al. 2012a, 2012b

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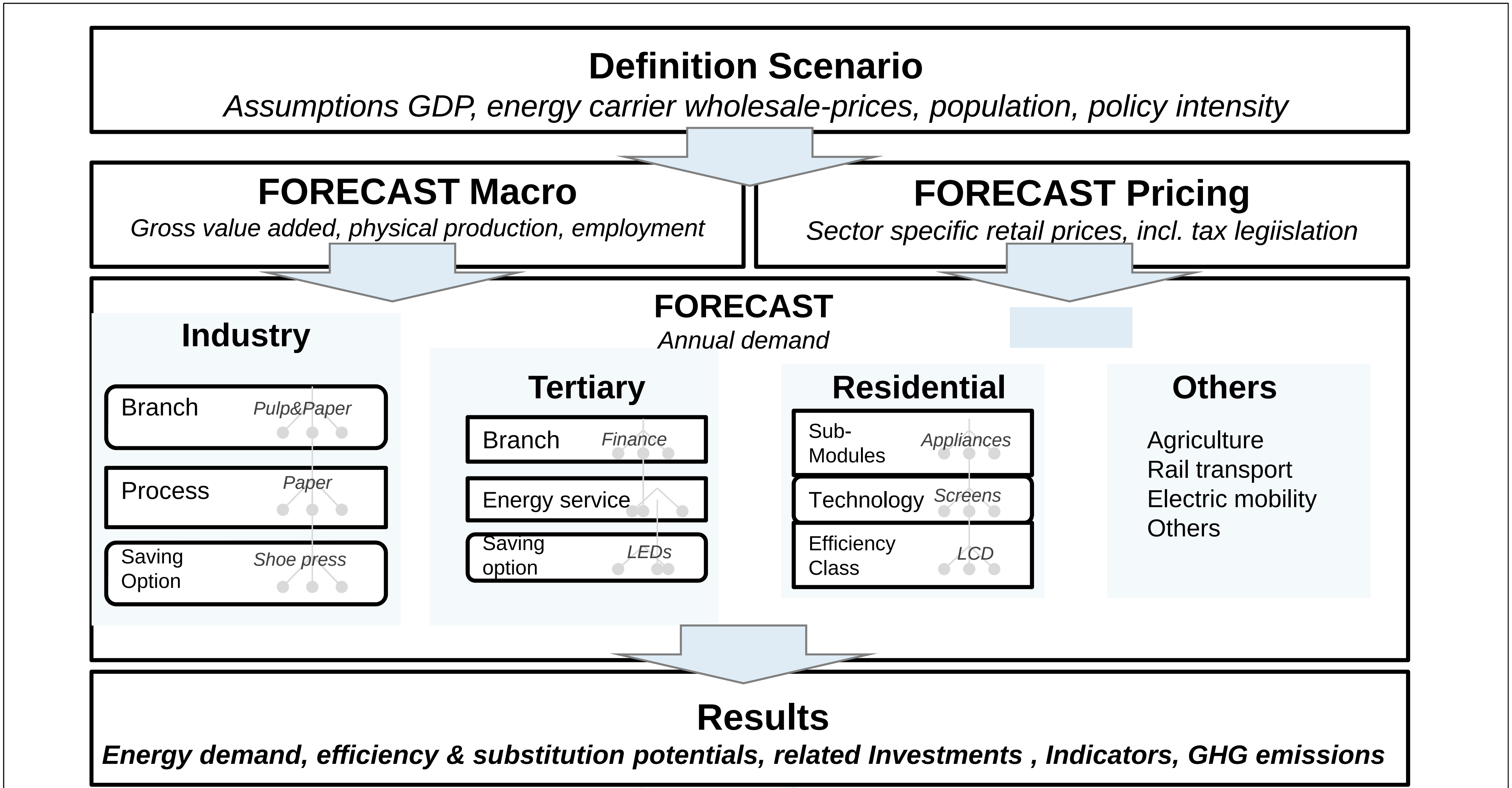
A technology-based bottom-up modelling platform for electricity and energy demand simulation and energy efficiency potentials



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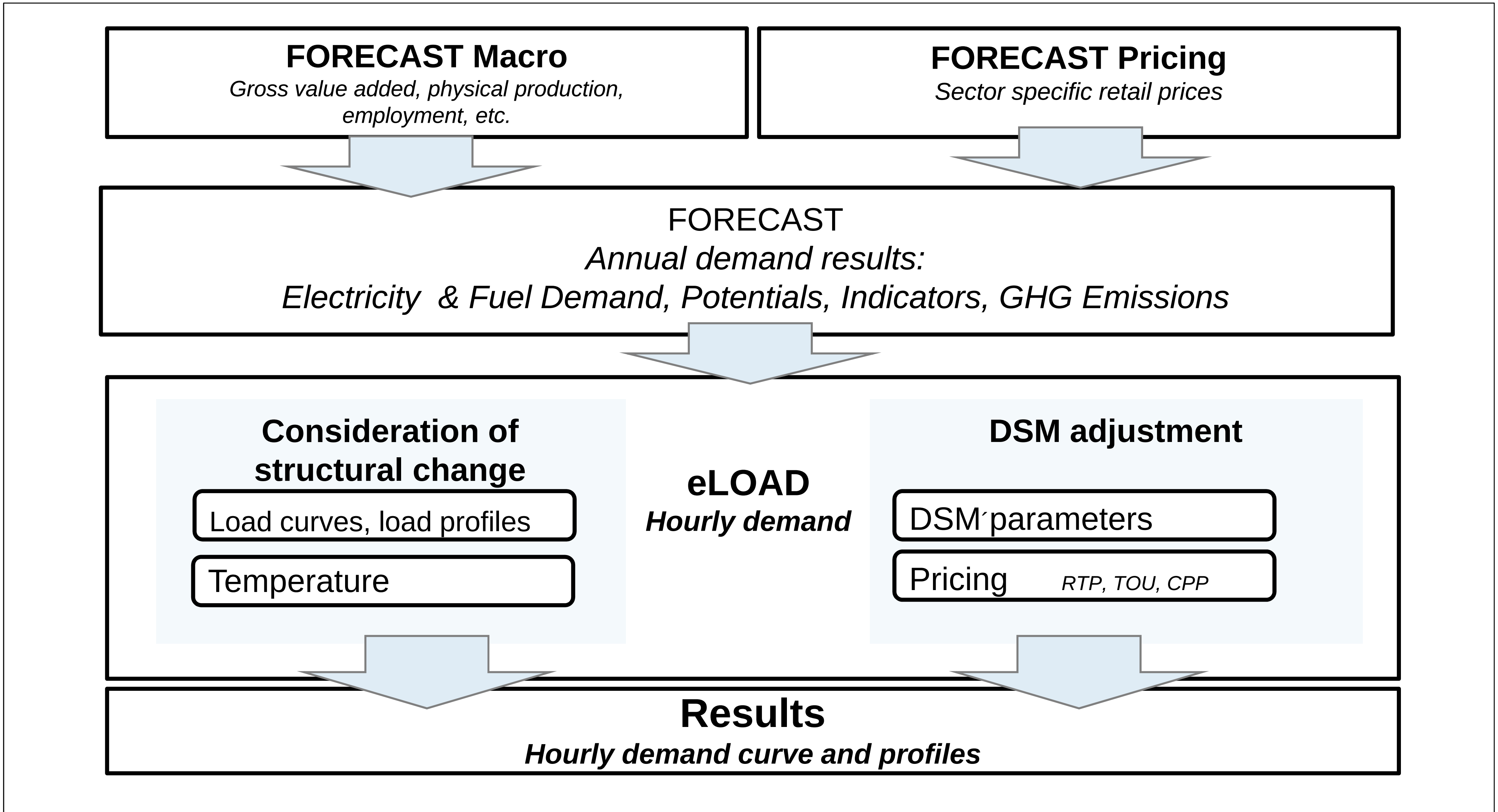
eLOAD: Simulating hourly electricity demand from annual results for different sectors and electric appliances and processes



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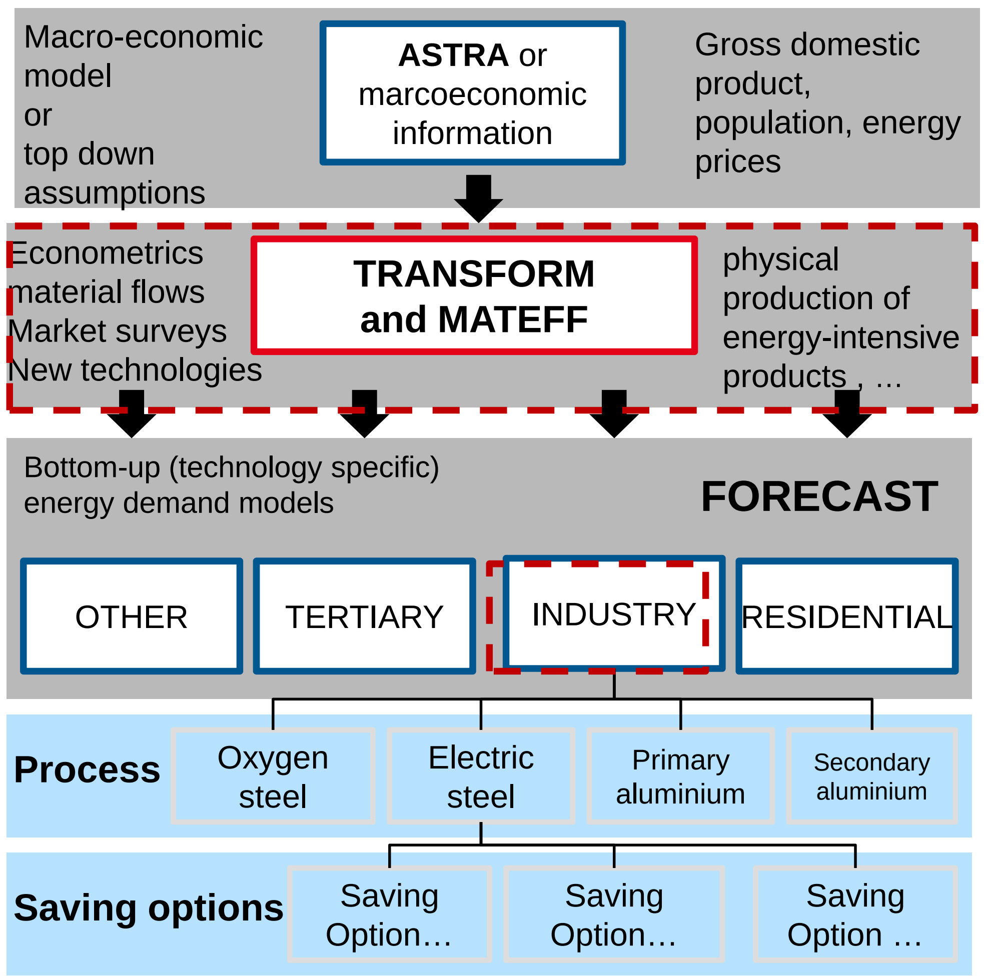
Transparent simulation of inter-sectoral and intra-industrial structural change and its influences on future energy and electricity demand

Objectives:

- Linkage of a macro-economic model with a bottom-up model by means of transparent transformation of value added into physical units of production (tons) of energy- intensive products
- structural changes (foreign trade) and material efficiency & substitution considered

Challenges of the TRANSFORM-module:

- Decoupling of gross value added and physical production development (e.g. quality improvements, additional product-accompanying services)
- Insufficient or no knowledge about process-shifts
- Improvements in material efficiency by design or properties & recycling
- Changes due to material substitution & saturation effects
- Trade effects



Source: Herbst, A., Jochem, E. (2013a) following Jochem et al., 2007&2008; Schade et al., 2009; Fleiter et al. 2013, TEP Energy

STEEL PRODUCTION ROUTES AND SCRAP AVAILABILITY

Final basic product, distinguishing primary and recycle chains of production

- Traditional metal, energy-intensive, very much quality differentiated, highly traded, stagnating production in Europe since 1979
- Used in construction, vehicle industry, shipbuilding, investment goods and durable goods industries

Basic oxygen furnace route (BOF)

- Primary production
- Raw material: **iron ore, coke, gas and raw iron and some steel scrap**
- Primary energy consumption three times higher than for secondary production route

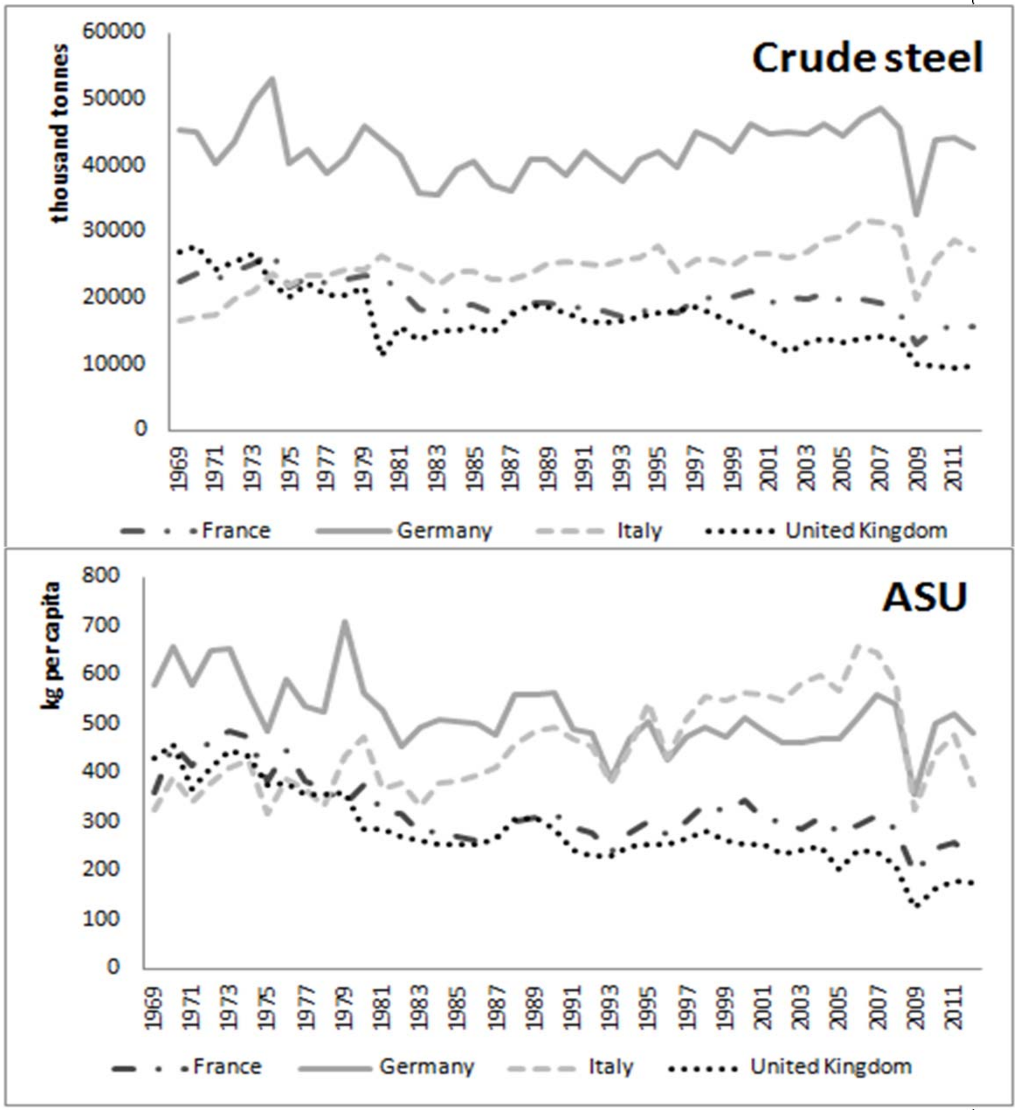
Electric arc furnace route (EAF)

- Secondary production
- Raw material: **steel scrap**

Apparent Steel Use (ASU)

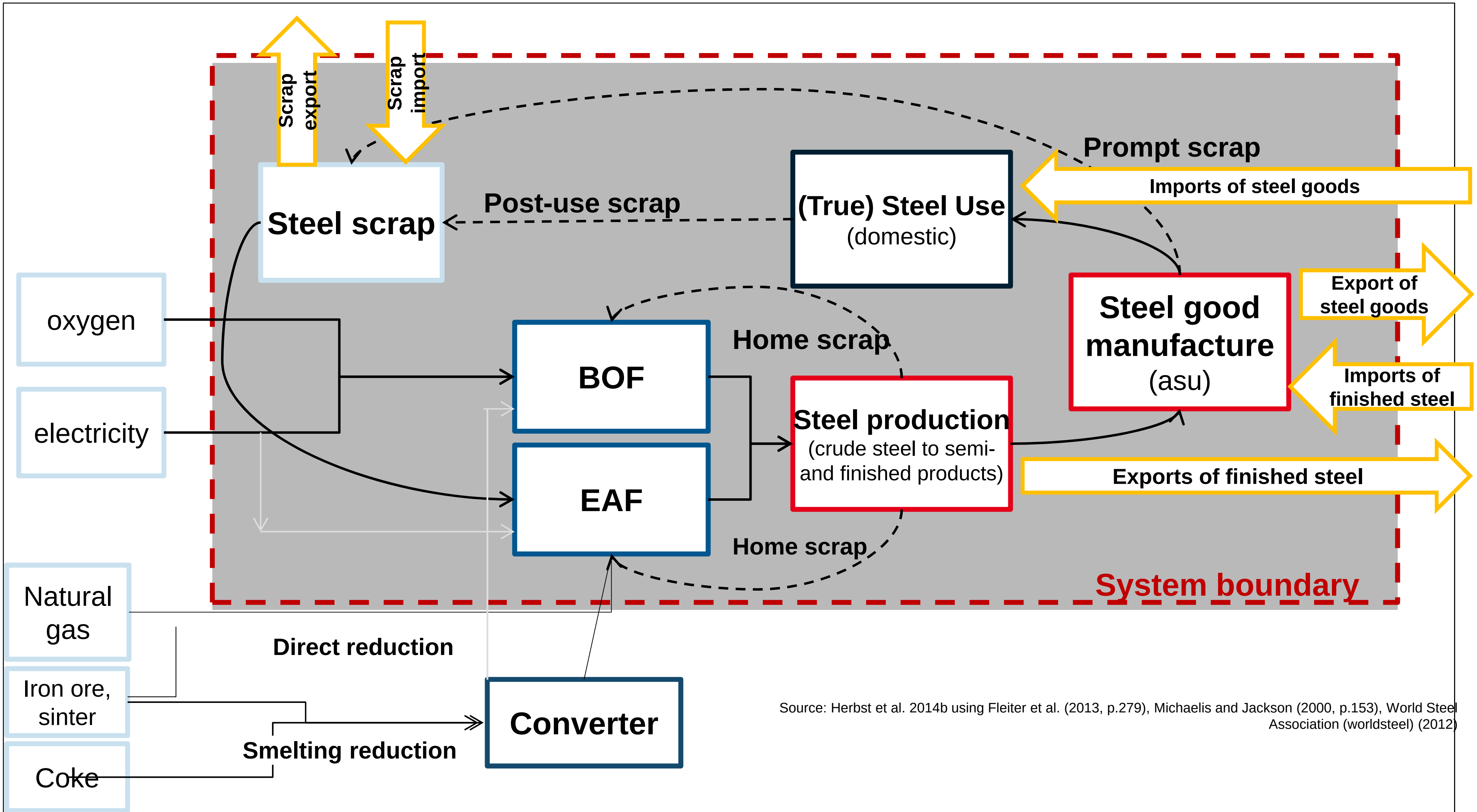
- steel production minus exports of finished steel and foreign trade of steel products
- per capita ASU declining since 1979 (except Italy)

Steel production and apparent steel use (1970-2011)



Source: Herbst et al. (2014)

STEEL MATERIAL FLOW ANALYSIS – HIGHLY COMPLEX AND DATA DEMANDING SIMULATION AND MODELLING



Source: Herbst et al. 2014b using Fleiter et al. (2013, p.279), Michaelis and Jackson (2000, p.153), World Steel Association (worldsteel) (2012)

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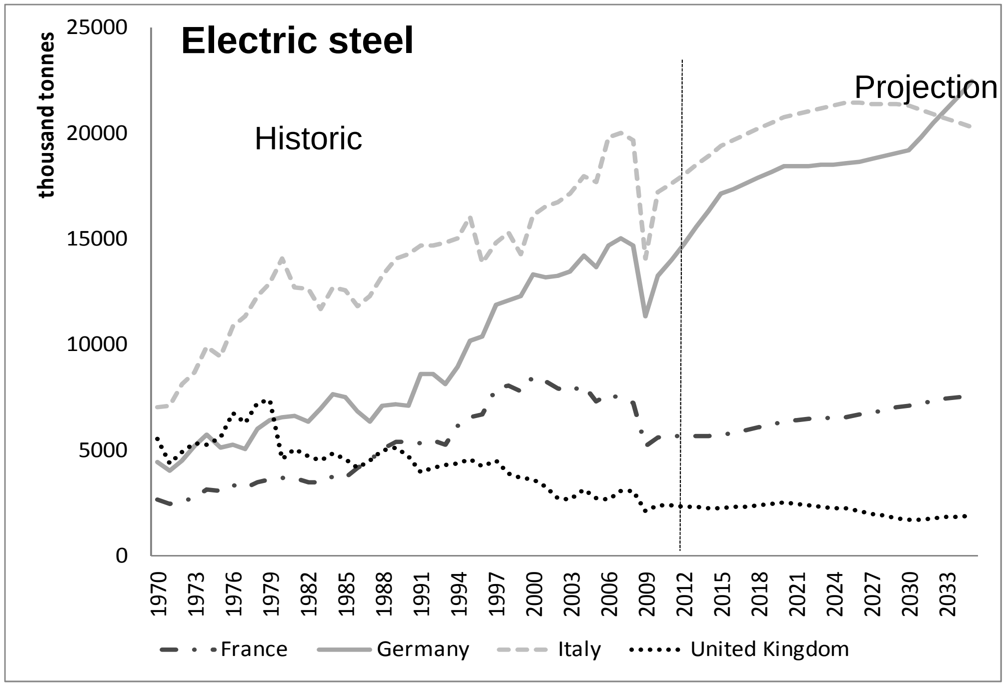
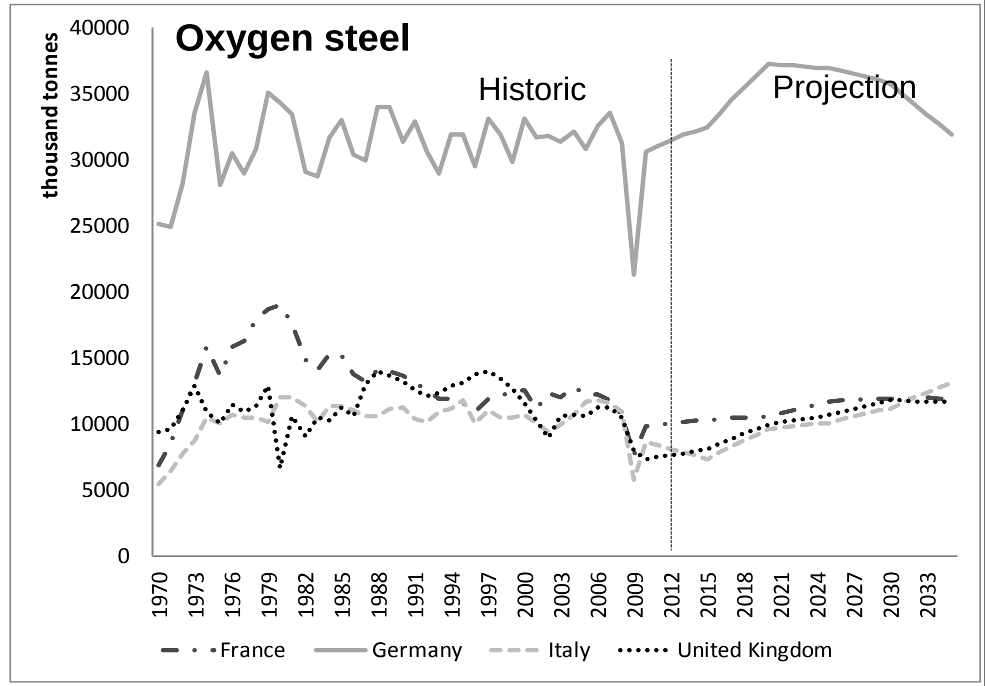
Results reflect **stagnation in total steel production**, slight **increases in post-use recycling rates** further increase the share of electric steel (the basis of this projection is high economic growth in Europe)





- **Electric steel production** follows rather **different pathways**:
  stagnation/decrease in Italy after 2025; France little increases; United Kingdom continues historic trends; Total steel use (TSU) dominates German results (stagnation in oxygen steel and increase in electric steel)
- In less favourable economic growth scenarios, Europe has to face surplus production capacity particularly in oxygen steel production

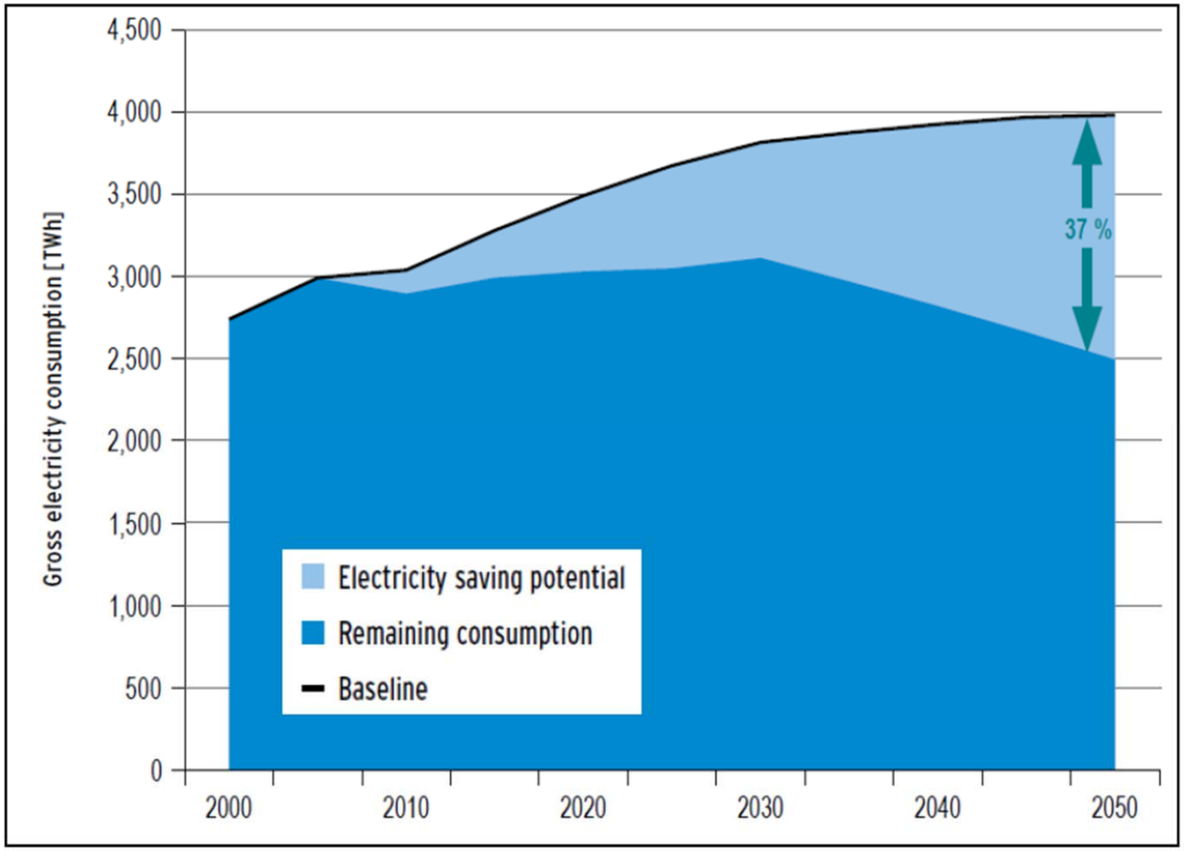
Source: Herbst et al. (2014)

A STABILIZATION OF THE ELECTRICITY DEMAND IN EUROPE TO THE PRESENT LEVELS IS POSSIBLE

Assumptions

- Baseline from EU official source PRIMES
- Almost 70 TWh correspond to heat pumps in households and services sectors (12% all European Households)
- 60 TWh correspond to ca. 23 Mio. E-Cars (8% of Pass. Car Stock)
- On the contrary: the electrification of 66% of the complete passenger car stock would require an additional of 260 TWh

Gross electricity demand and efficiency potentials

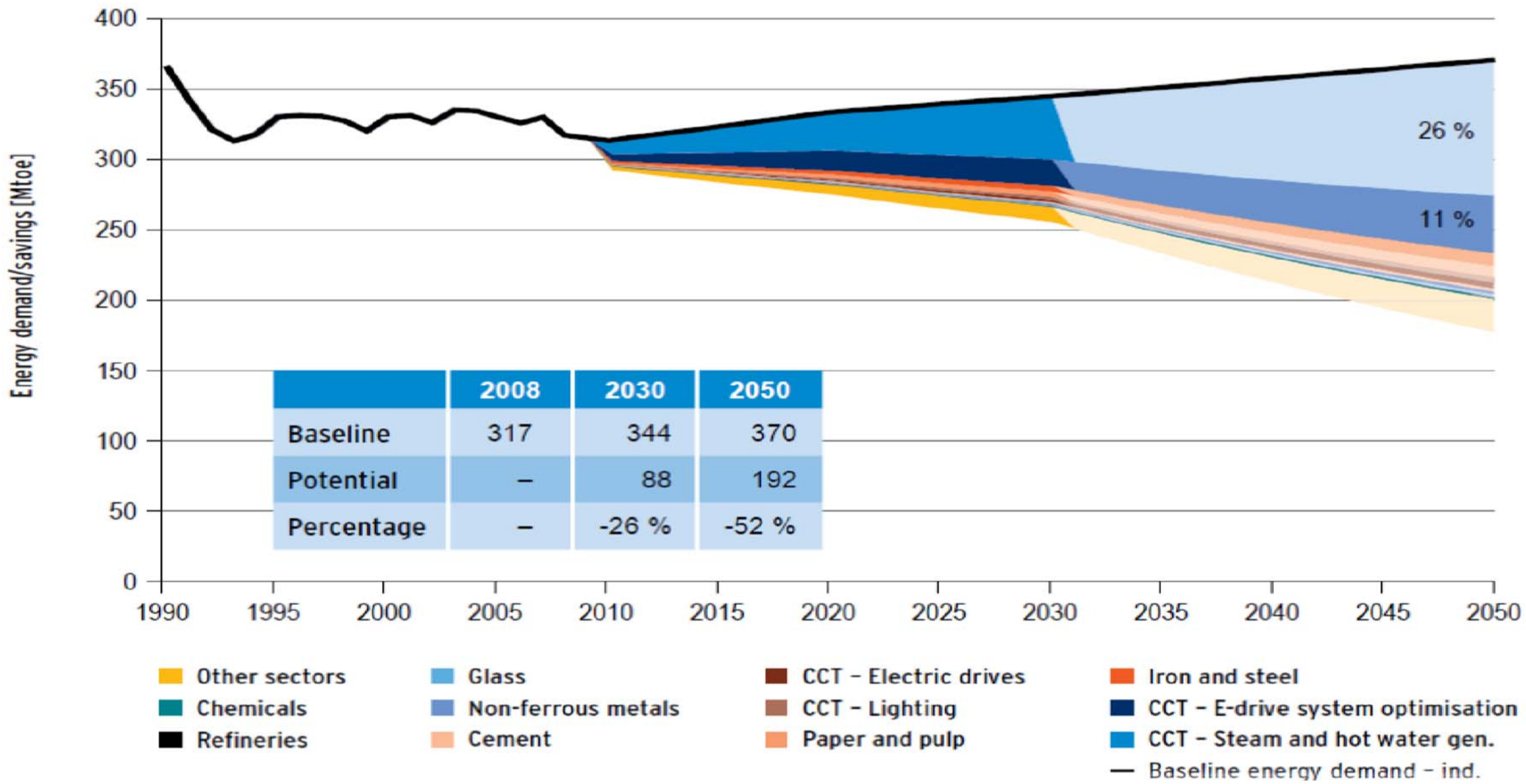


EU27, [TWh]	2020	2030	2050
PRIMES baseline	3,480	3,803	3,969
Reststromnachfrage	3,020	3,102	2,485
Relative Einsparung	13%	18%	37%

Source: Fraunhofer ISI on behalf of Federal Environmental Ministry, 2012

INDUSTRIAL ENERGY AND ELECTRICITY DEMAND CAN BE REDUCED BY 52% IN 2050

Total Final Energy Efficiency Potentials in Industry (CCT: Cross Cut Technologies)



	2008	2030	2050
Baseline	317	344	370
Potential	–	88	192
Percentage	–	-26 %	-52 %

- Baseline from EU official source PRIMES grows 17% compared 08.
- Final energy demand reduction potential of 52% compared to BL
- 75% efficiency increase from cross-cutting technologies
- Cost savings in 2050 amount to 102 billion Euros (€2005).

Source: Fraunhofer ISI on behalf of Federal Environmental Ministry, 2012

Conclusions

- The design of a bridge between macro-economic and technology-oriented energy demand models combines the advantages of both model types. However,
  - the econometric analysis is cumbersome and data-intensive,
  - future structural and technology changes may vary the coefficients of those equations
  - energy-intensive basic products: effects of material efficiency & substitution, and recycling, changes in foreign trade have to looked at from a material flow perspective
- Future electricity demand should be clearly separated in effects of electricity efficiency, structural changes, and additional electricity demand due to new electricity applications.
- Future electricity demand of Europe is likely to stagnate in the next decades. Electricity efficiency and structural change to less energy-intensive branches may fully compensate effects of additional electricity applications and growth effects.
- Load shaping and shifting by DMS will be one of several strategies to make the transition to renewables in the coming decades a success story, as electricity use has to follow the electricity supply in the long term, opposite to present supply patterns.

Thank you for your attention!

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Research Areas

- Modelling Electricity and Energy Demand and simulation of the diffusion of Energy Technologies in Industry, Services and Transport sectors
- Barriers for Energy Efficiency Technologies in Industry and Services and development of Strategies, Policy Instruments and promoting factors
- Techno-Economic Potential Analysis and Cost-Benefit for industrial Co-Generation and Renewable Energies
- Modelling of Energy and Material Efficiency in energy intensive industries based on scenario assumption and frameworks
- Energy Policy, Economics and Climate Policy

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EU Long-Term Scenarios: http://www.isi.fraunhofer.de/isi-en/x/projekte/314587_bmu-langfristszenarien.php

Examples of energy projections and policy advice of FORECAST/eLOAD

European Commission

- Energy saving potentials in all sectors until 2030 (http://www.eepotential.eu)
- Long-term climate mitigation scenarios for the EU (www.adamproject.eu)
- European Institute of Technology: "Case studies of the EU energy system in 2050" (www.esa2.eu)

National governmental institutions

- Long-term climate policy scenarios for Germany (http://www.umweltbundesamt.de/uba-info-medien/4412.html)
- Saving potentials and costs in German energy-intensive industry (http://publica.fraunhofer.de/dokumente/N-214110.html)
- Support of integrated heating and cooling strategy

European energy utilities

- Long-term EU electricity demand scenarios in European countries
- Load curves and DSM potentials in European countries
- CHP potentials and structure of heat demand (temperature levels) in Switzerland
- Long-term electricity demand and load curves of the German household sector
- Scenarios for industry demand for EU ETS CO2 certificates (EUAs)

Forecast development: Common work of the involved four research institutes

- **Fraunhofer Institute for Systems- and Innovation Research (ISI), Karlsruhe**
  - Responsibilities: Coordination, programming, industry sector, household sector, load curves
- **IREES (Institut für Ressourceneffizienz und Energiestrategien), Karlsruhe**
  - Responsibilities: TRANSFORM/MATEFF and support tertiary and industry sectors, agriculture
- **TEP Energy, Zurich**
  - Responsibilities: tertiary sector, programming, load curves

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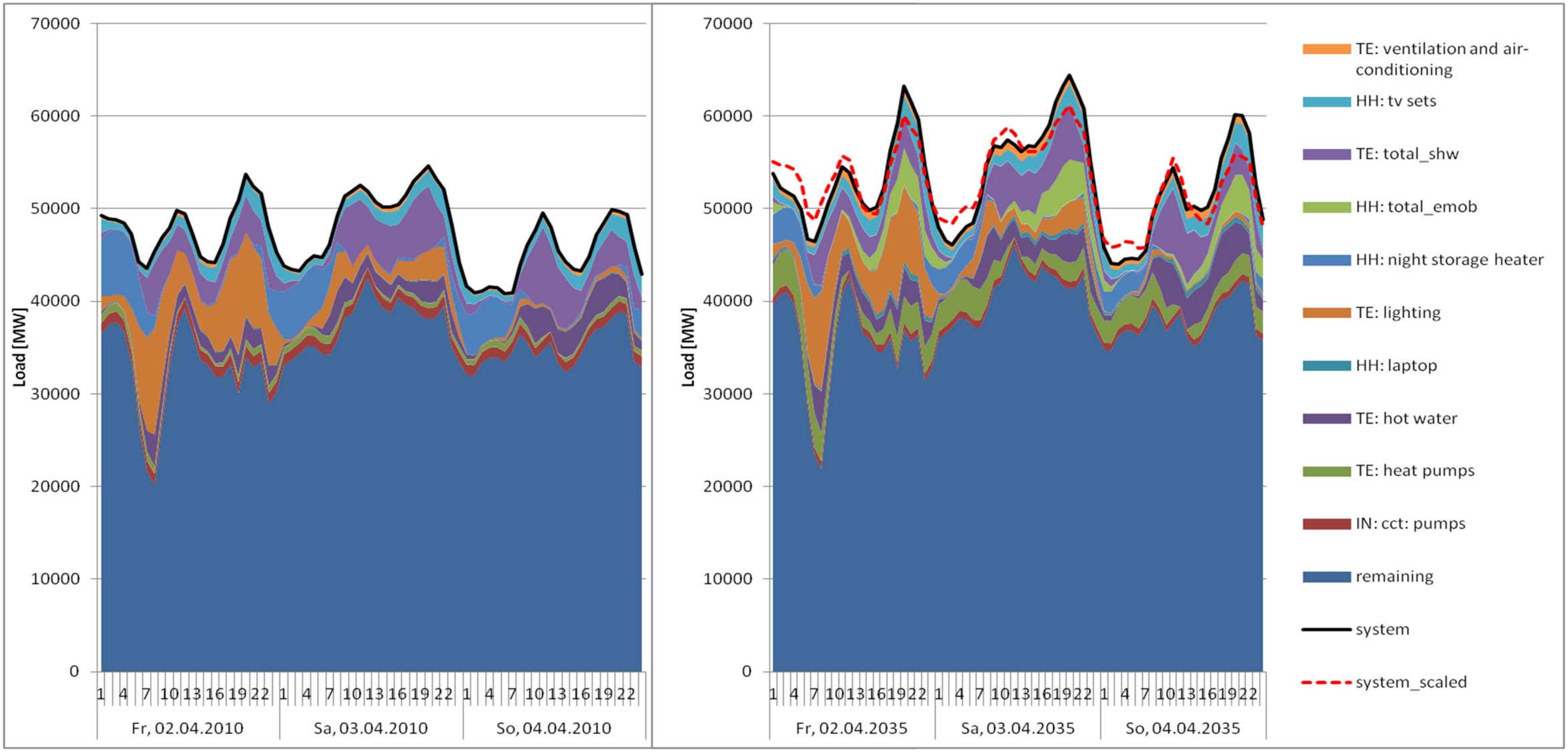
Example: loadcurve in Germany 2010 (left) and 2035 (right)



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