Energy and environmental systems modeling design

Dr. Janis Rekis

Institute of Physical Energetics

ZOOM seminārs

Klimata mērķu ekonomiskās ietekmes modelēšana un analīze

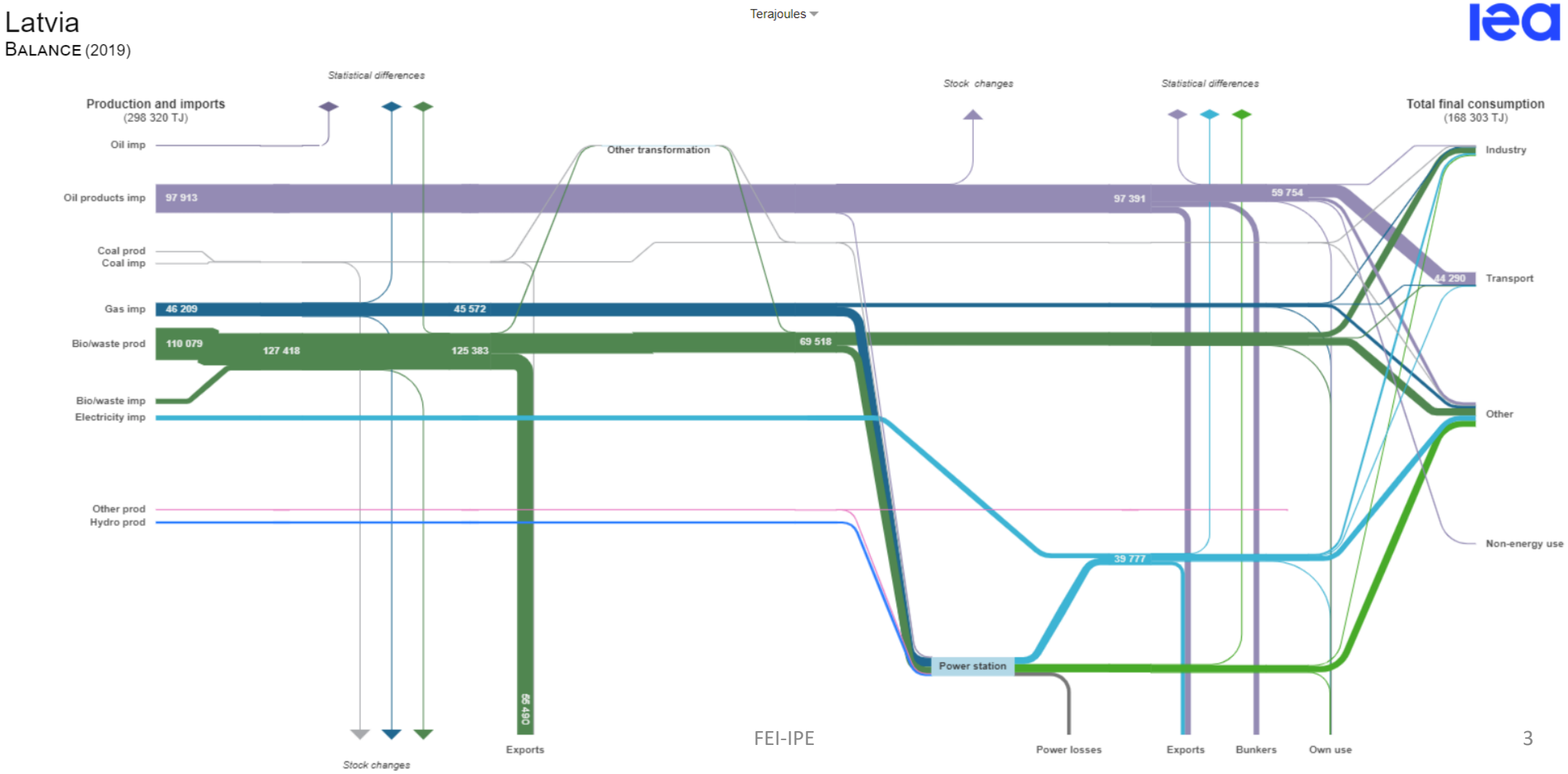
What is energy environment system?

- The energy system describes all energy flows and conversion processes as well as their interdependence from resource extraction and trade to final energy use
  - Energy balance

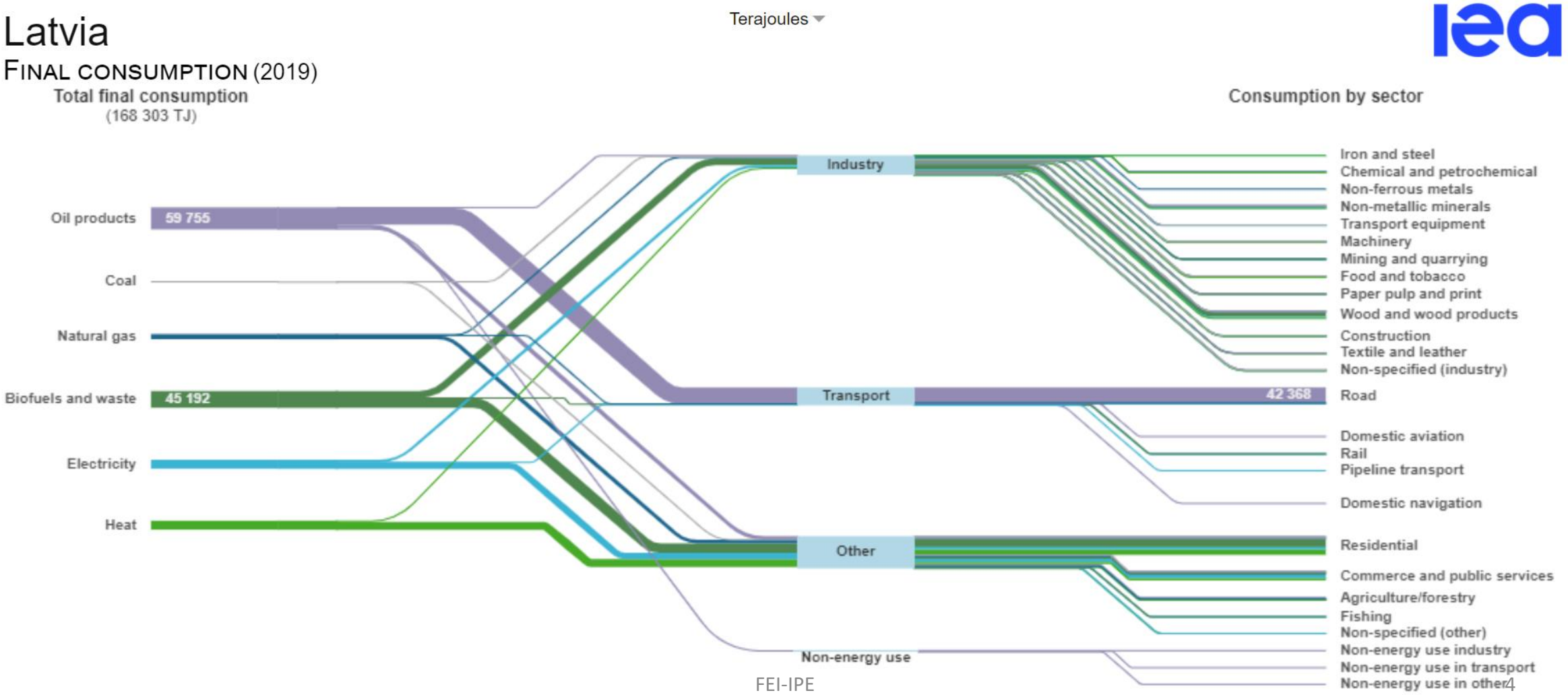
+ impact on the environment: GHG emissions, air pollutants, land use, material use and similar
  - Emission inventory

The IPCC Fifth Assessment Report defines an energy system as "all components related to the production, conversion, delivery, and use of energy"

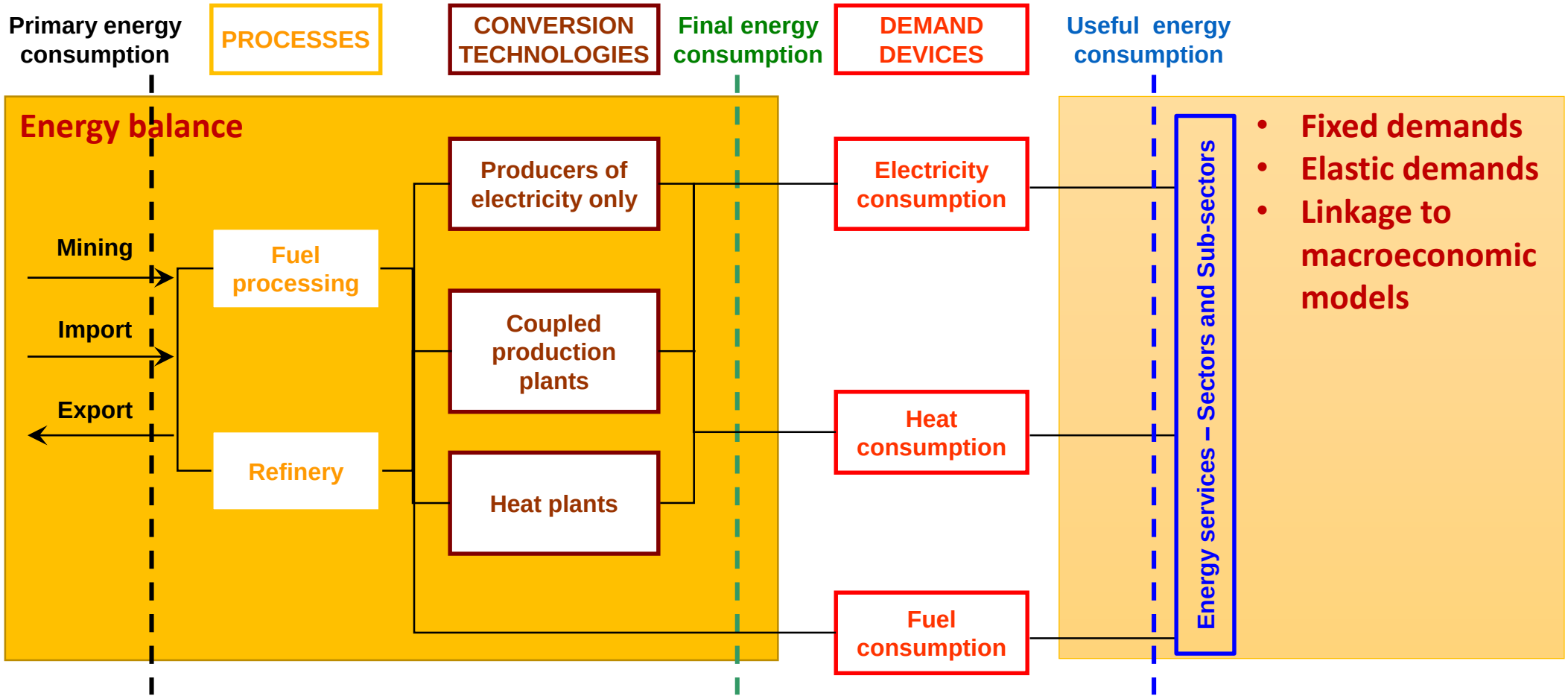
Energy balance – energy flows



Energy balance – final consumption energy flows



Energy system simple building blocks



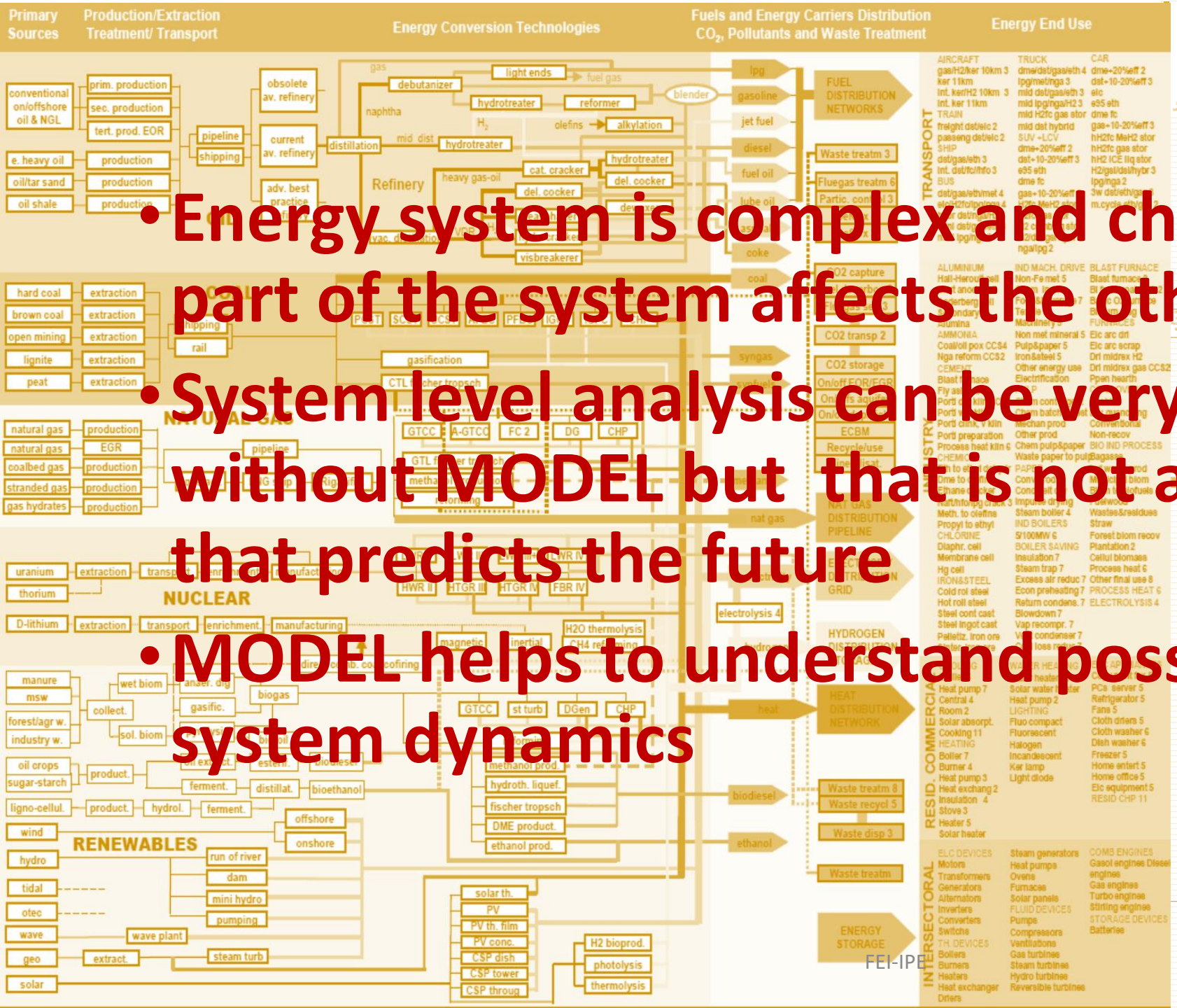
An energy technology is any device that produces, transforms, transmit, distribute or uses energy

Motivation

- How to project energy use and impacts to environment?
- Why use a model for the energy environment system analysis?

… because in real-life systems are complex

fragment of ETSOG System Development Map

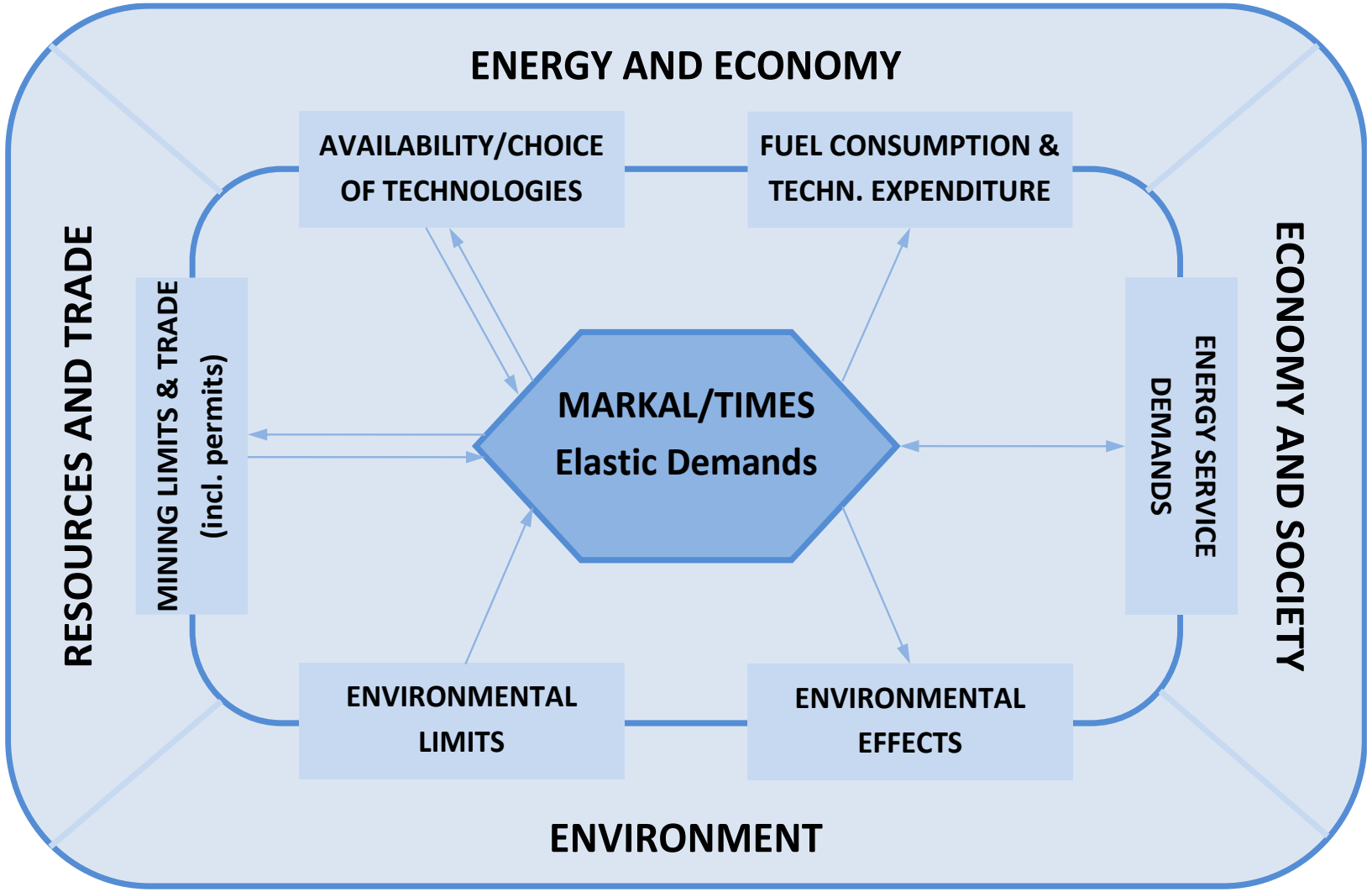


- Energy system is complex and changes in one part of the system affects the other parts
- System level analysis can be very difficult without MODEL but that is not a crystal ball that predicts the future
- MODEL helps to understand possible context of system dynamics

Examples of modelling approaches

- Types
  - Computable General Equilibrium models
  - Simulation models
  - Optimization models
  - Accounting Frameworks
  - Hybrids Models combining elements of each approach
- Modelling foresight
  - Perfect
    - Every detail of the full modelled time horizon known from the start
  - Myopic
    - Decisions done for right now, with no concern over what happens after the current period
  - Partial
    - Combination of the two above - part of the future is seen clearly

Assessing energy, economy, environment, trade interactions



What questions can answer?

- How do particular technologies and policies affect GHG and emissions of other pollutants?
- What are the costs of meeting mitigation targets?
- How do demand-side actions affect the supply-side and vice versa?
- How do technology and fuel mix changes resulting from environmental policies affect energy prices?

Shortcomings and remedies

- Data intensive characterization of technologies and a reference energy system used to be labor intensive
- Results sometimes sensitive to small changes in data assumptions
  - However, stepped supply curves and market share algorithms remedy this
- Limited ability to model consumer behavior
  - However, growth constraints, “hurdle” rates, and demand elasticities partially remedy this
- Limited representation of jobs and GDP impacts of energy policy
  - But “linkage” to economy-wide models being used

Data Requirements and outputs

Key input parameters

- Useful Energy Demands / Energy Services (and Elasticities) - to a detailed sub-sectoral level
- Detailed Costs
  - Resources, Investment, fixed, variable, fuel delivery, hurdle rates
- Technology Characteristics
  - Fuels in/out, efficiency, availability, technical life duration
  - Resource supply curves/steps - imports and domestic production, cumulative resources limits, installed capacity of technologies, new investment possibilities
- System configuration - potential energy pathways and interactions
  - Reference Energy System (RES) concept is used to summarize the relationships in energy system among Demands, Energy sources, Technologies, Commodities
- Environmental Impacts
  - Unit emissions per resource, per technology
- System and other parameters
  - Discount rate, seasonal/day-night fractions, electric reserve margin
- Constraints – physical and policy driven

Key output parameters

- Primary energy, final energy - by sector and by fuel
  - Imports, exports & domestic production of fossil & renewable fuels
  - Electricity generation mix– by fuel and by technology
  - Transport fuels, transport technology by mode
- GHG emissions/air pollutants - by fuel, sector; marginal emissions prices
- Total and annual energy system costs
- Use of energy efficiency

LV model

- ETSAP (http://iea-etsap.org/) tools are used
- Model implemented with IFE (Norway) support in 1995
- Technology rich bottom-up integrated energy systems model of the Latvia
  - Calibrated to Latvia energy balance for period 2000-2020 and other IPCC CRF sectors represented at GHG emission level
  - Existing infrastructures, current policies, physical constraints
  - Model horizon until 2050/60 by 5-year/1-year time steps
- A least cost optimization model
  - Elastic demands (Partial equilibrium formulation i.e. demands respond to price changes)
  - Rational decision making with perfect information, competitive markets and perfect foresight
- Detailed description of the technological options
  - End-use technologies, energy conversion technologies, resource supplies, infrastructures etc.
  - Energy carriers, resources, processes, electricity/CHP, industry, services, residential, transport, agriculture, emissions, taxes, demands
- Range of scenarios and sensitivity analysis is carried out in a systematic ‘what-if’ framework

Scenario analyses

- The set of projections scenarios that countries (parties) are reporting fall into the following categories
  - Projections scenario **'without measures' (WOM)** means projections of anthropogenic GHG or air pollutant emissions by sources that **exclude the effects of all PAMs which are planned, adopted or implemented** after the year allocated as the starting point for the relevant projection
  - Projections scenario 'with measures' (WM) or **'with existing measures' (WEM)** means projections of anthropogenic GHG or air pollutant emissions by sources that **encompass the effects of currently implemented or adopted PAMs**
  - Projections scenario **'with additional measures' (WAM)** means projections of anthropogenic GHG or air pollutant emissions by sources that **encompass the effects of PAMs which have been adopted and implemented, as well as planned policies that are judged to have a realistic chance to be adopted** and implemented in the future
- Target scenarios or new policy scenarios, e.g.,
  - GHG emission reduction, RES, EE targets
  - New taxes/subsidies
- Taking into account existing PAMs, recommendations are being developed for PAMs to achieve the various targets in the future

Energy environment system modelling use

Use of scenario analyses to evaluate alternatives in energy sector

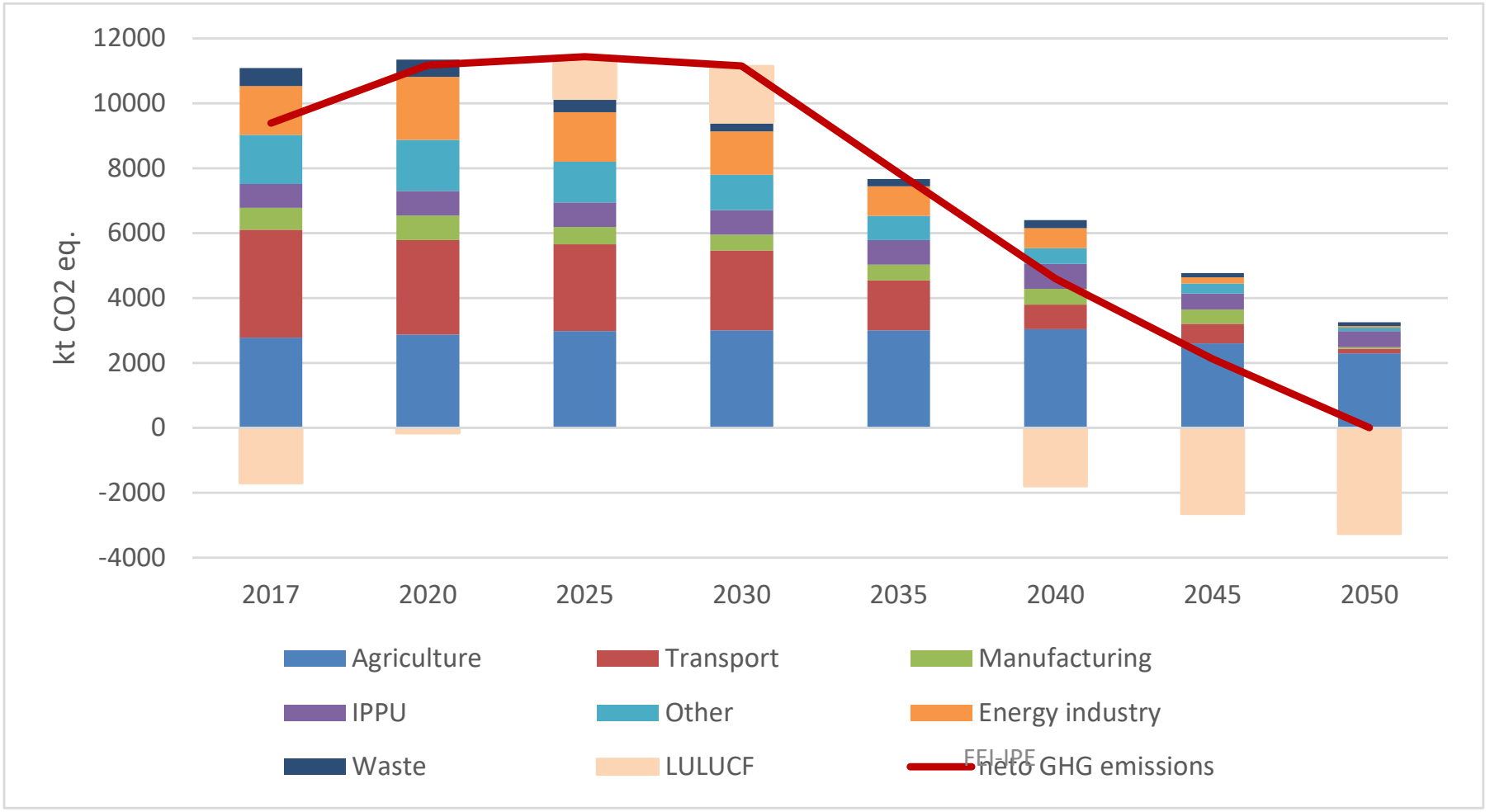
- Identifying least-cost solutions for energy system planning
- Evaluation of impact of introduction of energy & emissions taxes
- Evaluation of impact of introduction of different RES targets and use of new fuels/propellants in transport
- Evaluation of impact of introduction of energy efficiency targets
- Impact assessment of the PAMs

Projections of energy use and emissions scenarios (WOM, WEM, WAM, target) for energy sector

- National studies
- UNFCCC National Communications and Biannual Reports (starting from 2nd NC)
- Monitoring EU GHG emissions (Commission Decisions 280/2004/EC and 2005/166/EC)
- Reporting to Convention on Long-Range Transboundary Air Pollution
- Latvia's NECP PAMs/Target scenario
- Assessment scenarios for Fit for 55
- Strategy for the Achievement of Climate Neutrality by 2050

Example of result

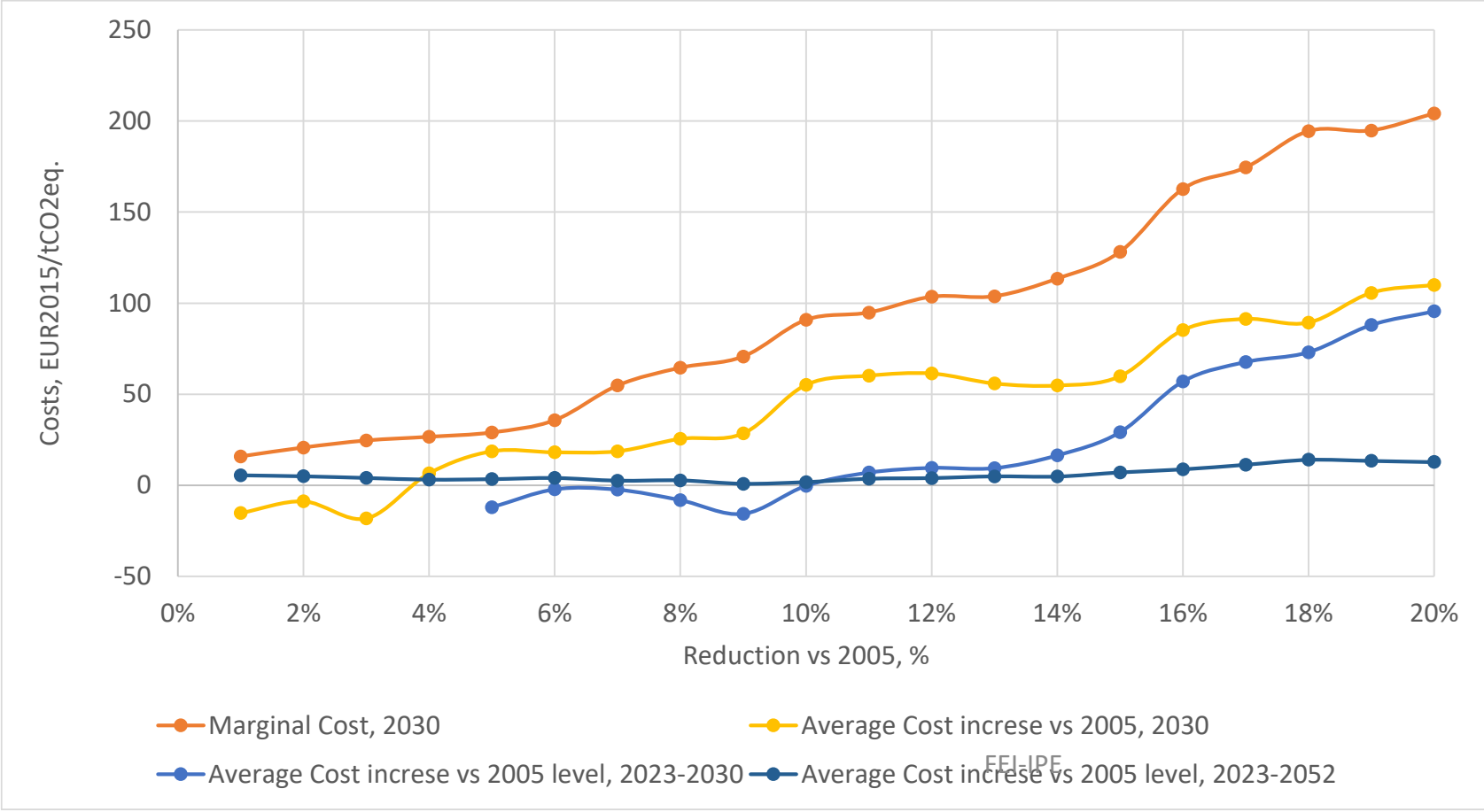
GHG emissions in climate neutrality scenario



Example of result

More about the results of the analysis for "the Fit for 55" please look at today's seminar presentation by dr. Gaidis Klavs

Estimated GHG emission reductions costs depending on the GHG emission reduction target in non-ETS compared to 2005 GHG emission level



All decisions are based on model
... and all models are wrong
(John D. Sterman, Jay Wright Forrester Prize Lecture, 2002)

Thank you!