Abstracts Speeches Day 1

First Session: Energy modelling practice at European level and involved communities

How the European Commission uses energy modelling in policy planning

(DG ENERGY) Tom Howes

Data openness in EU Energy Models

(DG JRC)Andreas Zucker

Market equilibrium models of energy and the economy and their use supporting European Commission's impact assessments. The example of PRIMES, GEME3 and POLES models.

Pantelis CAPROS (E3Modelling Lab, National Technical University of Athens)

At the beginning of 1990, the European Commission supported the development of market equilibrium models for energy, the environment and the economy. The new modelling approach was meant to discontinue the older model practice in the European Commission which was using the approach of overall linear programming optimisation.

The PRIMES (European energy markets), GEM-E3 (computable general equilibrium model of the European and the global economy) and POLES (world energy markets) models resulted from this support. Since 1995 these models have been used in numerous studies supporting impact assessment of European Commission's policy proposals initiated by various DGs. The models supported among others: the first studies for the ETS; the Green Paper on the security of energy supply; the 20-20-20 energy and climate package; the Low Carbon and the Energy Roadmaps, the "2030" targets, the White Paper on Transport and the transport decarbonisation communication; the Effort Sharing Decision and recently the "Winter Package" in November 2016. Periodically, every 2-3 years, the Commission publishes a book on Energy and Transport Trends (similar to the World Energy Outlook of IEA) which includes a reference scenario that is widely used by third persons, consultants, researchers and companies.

The basic idea behind these model is the explicit representation of the behaviours of market players, the simulation of price-driven equilibrium in simultaneous markets and the explicit computation of prices. The new models are non-linear, modular, multi-agent and both technology- and policy-rich. They are also formally linked with each other to cover the closed loop interaction between energy, the environment and the economy both at a European and at a World scale. The NEMS model for the USA's energy system follows a similar approach.

The mathematical formulations used to represent the behaviour of market players is meant to be founded on the microeconomic theory of consumer or producer behaviour. Similarly, the modelling of the markets is also intended to be founded on the economic theory of competition, either perfect or oligopolistic. In essence, the overall model formulates a concatenation of several mixed complementarity problems, each representing the Kuhn-Tucker conditions of the optimisation problem of a market player, with market equilibrium conditions and overall constraints representing policy targets. After many years of improvement and extension, these models are at present very comprehensive and sophisticated modelling suites which operate on high-performance computers. They work together with large database systems and dedicated user interfaces.

Fostering European Energy Transformation: Reconciling the modelling and stakeholder communities

(EU-Calc) Jürgen Kropp (Potsdam Institute for Climate Impact Research - PIK)

Increasing perception of climate change and growing scientific evidence of its negative consequences culminated in the signing of an ambitious and shared plan to slowdown global warming. Although the "accord de Paris" 2015 was a great success for climate policy, the agreement still needs to be brought to life. The transition to a sustainable, low-carbon Europe is an extremely demanding task and poses numerous policy, technological, economic, societal, and environmental challenges and risks. While current coupled energy-economic-climate models constitute current state-of-the-art tools to explore the range of transformation options required for Europe (and the world) to achieve its ambitious climate protection commitments. These models have been designed from the start as research tools and they are influential from two perspectives:

i) They have been intensively used to inform policy making and ii) due to various methodological challenges they also shaped the scientific debate for more than 20 years by providing important sectoral and national insights. However, as societal transformations need time, scientific underpinning should be expanded by other approaches, which are more intuitive and easily to grasp for various stakeholder groups, but without not loosing scientific accuracy. The European Calculator project tries to make advances in this regard, because it relies not only scientific achievements, but integrates also expert knowledge. By doing so (politically) desirable futures are used as benchmark for greenhouse gas emissions from various sectors. For this purpose it is also needed to modify a number of canonical approaches used in classical energy-economic-climate modelling. A broader consultation of option-feasibility beyond the scientific arena is undertaken and explicitly addresses a co-generation and co-learning of scientists and stakeholders. Using such an approach analyses of trade-offs and synergies of different sector decisions, their climatological and societal implications can be investigated. Using a smart and intelligent exploratory tool this accelerates learning, fosters societal discussion and interrogation, i.e. brings questions related to the deep transformation challenge to those groups who have to implement it, namely to politicians, planners and laypersons.

Second Session: insights in the LCE 21 projects

Linking models

Gustav Resch (TUW) and Ruud Egging (NTNU)

In SET-Nav, we use three macro-economic models, five energy system models, seven sector models and two risk / robustness assessment tools to analyze eleven different bottom-up case studies and four overarching transformation pathways. Each model has its specific scope, detail and analytic strenghts, while relying on exogenous inputs and approximate or aggregate representations for other aspects. Models complement each other and sometimes partly overlap. A significant part of the work is to create interfaces between different models in order to provide consistent assumptions and starting points as well as to benefit from the strengths of all different modelling approaches.

We will discuss issues and challenges that arise when linking models and provide examples based on our project work.

Openness, sharing and reproducibility

(MEDEAS) Jordi Sole Olle (CSIC)

One of the issues that need to be addressed in the energy modelling research is the openness in energy models and energy data. However, other additional questions should be considered. Thus, making models accessible is not enough for ease the model use, it is a necessary condition but it is not sufficient. Most energy models are very complex, so they require a learning curve to use them. Such learning curve depends strongly on model complexity. Moreover, energy models are necessary for policy design, thus policymakers and stakeholders will be more confident in the model results if such a model is used openly and widely tested. Then, transparency, not only in model design, but also in model basic assumptions is a must. Policymakers and other key stakeholders require tools that focus beyond the energy sector by including other domains such as economy, society and environment. Currently, most available tools lack integration of these important areas despite being tightly connected to the energy sector. Besides, currently, there are different academic-led initiatives that are going in the direction of openness: Enipedia (worldwide open database on power plants), Open Power System Data project (data for electricity consumption, which also aims for clarity on the licensing under which these data are made available), and Open Energy Modelling Initiative, which is emerging as a platform for coordinating and strengthening such efforts. MEDEAS project, starting from an initial code (in Python language) designed within the MEDEAS Consortium, aims at being community based/developed model. In addition, to improve and ease the use of the model, and to improve the user's learning curve, the user will be helped with the model modularity. Thus, the complexity of the model can be reduced switching on/off the different modules. The learning curve can be speed up by starting from the core model and then, as the user acquires more proficiency, adding more modules to end up with the full model. Additionally, teaching material will be provided for the potential modellers; a detailed user manual addressed to a wider non-specialist audience; a user forum, where questions about the model can be answered by other user/model developers and also a Massive Open Online Course. All in all, MEDEAS aims at pushing forward the open source models and software community development in energy research.

Modelling of flexibility and technological progress

(REFLEX) Angelo Martino, (TRT Trasporti e Territorio srl)

The future energy system is challenged by the intermittent nature of renewables and requires therefore several flexibility options. Still, the interaction between different options, the optimal portfolio and the impact on environment and society are unknown. The core objective of REFLEX to analyse and evaluate the development towards a low-carbon energy system with focus on flexibility options in the EU to support the implementation of the SET-Plan. The analysis is based on a modelling environment that considers the full extent to which current and future energy technologies and policies interfere and how they affect the environment and society while considering technological learning of low-carbon and flexibility technologies. For this purpose, REFLEX brings together the comprehensive expertise and competences of known European experts from six different countries. Each partner focusses on one of the research fields techno-economic learning, fundamental energy system modelling or environmental and social life cycle assessment. To link and apply these three research fields in a compatible way, an innovative and comprehensive energy models system is developed, which couples the models and tools from all project partners based on a common database and scenario framework.

EU28 decarbonisation pathways: multi-model impact assessment and diagnostics

(REEEM) Mark Howells (KTH)

Kicked-off in February 2016, REEEM is a 42-month modelling project funded under Horizon 2020 LCE21. Its objective is to gain a clear and comprehensive understanding of the system-wide implications of (and feedbacks created by) energy strategies. Specific strategies focus on transitions to a competitive low-carbon EU energy society, described by the Strategic Energy Technology (SET) Plan.

The project takes advantage of a large ensemble of models and approaches – to provide a comprehensive set of insights. The models vary widely – each capturing an aspect of special relevance. They include: a global economic model; a technology rich investment model; a detailed power dispatch model, geo-spatial water, ecosystem and pollution dispersion models. Special attention is paid to behavior focusing on two aspects. The first in terms of technology innovation and its adoption. Therein assessment of technology is quantified in terms of its maturity, societal acceptance, uptake potential and other determinants. The second focuses on simulating market and consumer behavior.

These in turn are examined with the aim of developing internally consistent narratives of possible energy transition pathways that are useful for policy making. The narratives are informed by member state (MS) specificities, EU objectives and global trends and are formulated jointly with stakeholders. A set of tools is created to ensure the transparency of the modelling process and convey the key messages from its results: reports and policy briefs summarise the outcomes of the project; a Pathway Diagtnostic Tool, linked to a publicly available Pathway Database, enables stakeholders to surf through the results of the exercise and capture the impacts of the pathways on the EU economy, society and environment; an Energy Systems Learning Simulation engages students and non-experts in the multi-sectoral modelling approach.

Keywords: REEEM, Energy Transition Pathways, Ensemble of Models, Technology Innovation, Behaviour.

Third Session (pathways, sector coupling, case studies)

The ambitious task of setting policy targets for energy efficiency: a multi-scale analysis of societal metabolism

(MAGIC) Maddalena Ripa, Autonomous University of Barcelona (UAB)

Within the framework of a wider project entitled MAGIC (Moving Towards Adaptive Governance in Complexity: Informing Nexus Security), funded by the EU in 2016, this study aims at a better understanding of the nature of the challenges implied by the European energy policies via a better quantitative representation. MuSIASEM (Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism) (Giampietro et al., 2009), an innovative method of accounting having the goal of keeping coherence across scales and dimensions of quantitative assessments generated, is here used to provide a diagnostic analysis of the metabolic pattern of energy in Europe at the level of the union and the individual states. This analysis is useful for characterizing the level of self-sufficiency and the long-term stability of the existing state of the SES (Socio-ecological systems). The analysis also provides a quantitative criterion to define what should be considered as feasible, viable, and desirable at the moment of discussing a policy in relation to the nexus.

Modelling EU cities decarbonisation pathways

(InSMART) Sofia Simoes (NOVA University of Lisbon)

Over 73% of the European population lives in cities and according to the UN, by 2050 this proportion will have risen to 80%. Urban areas have a pivotal role to play in climate change mitigation, as they provide many opportunities for more efficient generation, distribution and use of energy. Innovation in energy is supported in many cities and is occurring across different economic sectors in response to a range of drivers. There are several city-led initiatives, such as the Covenant of Mayors Pact or the C40 Climate leadership group. This makes the case for energy modelling also at city level, as done by the InSMART EU project. InSMART identified the optimum mix of measures for a sustainable energy future for four European cities, addressing the efficiency of energy flows across city sectors. Energy modelling at urban level brings with it a new set of challenges. For a well-known territory, transparency and effective communication with local decision-makers are even more important. Model results should be geographically explicit and thus can be more easily traced and commented upon. At local level it becomes even more clear that an energy model is only as good as it is perceived by its final users.

ECF's Energy Union Choices report: integrated gas/electricity/demand infrastructure modelling

(ECF) Julien Pestiaux (Climact)

A Perspective on Infrastructure and Energy Security in the Transition

Based on extensive technical analysis conducted by the Artelys, ElementEnergy and Climact, the study looks at which infrastructure investments are lowest risk and regret to ensure resilience throughout the transition, and whether an integrated view on infrastructure (gas, power, buildings) help meet security of supply challenges at a lower cost. It finds that, overall, the existing gas infrastructure in Europe is resilient to a wide range of demand projections and supply disruptions. In places where gas security of supply concerns do occur, the report finds that an integrated, regional approach that looks at gas, electricity and buildings together, can help meet these challenges at significantly lower costs.

Insights from EU Integrated gas and electricity modelling

Paul Deane (University College Cork)

We present a freely available, open data integrated gas and electricity model of the EU 28. The model is developed using the PLEXOS Integrated Energy Model and is available for academic non-commercial use. Detailed hourly results, model input data and all associated files have been published in the Journal Applied Energy. We use this model to examine a number of hypothetical scenarios where gas supply routes are interrupted for yearly periods and the impacts on power system operation and gas flow in Europe observed. Model results show that interruption of Russian gas supply to the EU could lead to a rise in average gas prices of 28% and 12% in electricity prices. When supply from North Africa was removed all Southern European states were affected heavily, Spain in particular saw large increases of 30% in gas prices with a corresponding rise of 18% in electricity prices as a result. This resulted in an average increase in power prices of 6% across Europe. These additional insights offer an increased understanding of the interplay between the gas and power systems and identify challenges which may arise when seeking to understand energy systems as a whole.

Energy modelling and the Nexus concept: design and tools in SIM4NEXUS

(SIM4NEXUS) Floor Brouwer, Wageningen Research, the Netherlands; Chrysi Laspidou, University of Thessaly, Greece; Hector Pollitt, Cambridge Econometrics, UK; Georgios Avgerinopoulos, Royal Institute of Technology – KTH, Sweden; Eunice Pereira Ramos, Royal Institute of Technology – KTH, Sweden

The energy transition towards a lower carbon economy is a challenge to society, and matching energy demand with supply is increasingly dependent upon resources that could be used for global food production, leading to a potential scarcity of natural resources (i.e. water and land). Water, land, food, energy and climate are interconnected, comprising a coherent system (the 'Nexus'), dominated by complexity and feedback. The Nexus concept is an approach to address trade-offs between these areas, and seeking for synergies among them. An additional layer of complexity is added by the potential future impacts of climate change on all of these areas.

Energy modelling would benefit from an approach that extends capabilities into other parts of the Nexus, but this would also require the careful design of the modelling concept, and use of well-accepted tools. SIM4NEXUS ('Sustainable integrated management for the nexus of water-land-food-energy-climate for a resource-efficient Europe') is a four-year H2020 project that aims to do this by integrating methodologies and tools for the Nexus. We build on well-known and scientifically established existing models, simulating different sectors of the Nexus. The thematic models used in SIM4NEXUS are designed independently and with distinct purposes, using independent data sets, assumptions, and methodologies.

The project involves both the development of the existing models and the creation of new tools, as well as exploring potential feedbacks and linkages between the different models. The set of tools available also allows for a comparison of different modelling approaches (e.g. optimisation and simulation-based methods) and of the outputs through an assessment of the results of standardised scenarios. The analysis will identify the key underlying assumptions in the models, how they impact on the model results and how they relate to different aspects of the Nexus at global, regional, national and sub-national levels.

Abstracts Speeches Day 2

Fourth Session (models and transparency)

Models in Energy System Analyses

Michael Grubb (UCL)

Transparency in EU energy system modelling – METIS open-book approach

(METIS) Laurent Fournié (Artelys)

Description of the model

METIS is a mathematical model which can provide highly detailed analysis of the whole European energy system for electricity, gas and heat. It can simulate the operation of both energy systems and markets for electricity, gas and heat on an hourly basis for a whole year, while also factoring in uncertainties like weather variations. The model can be used at EU country or regional level, right down to the 276 economic regions.

METIS works alongside other energy system models. It is used by European Commission experts to further support the European Commission's evidence-based policy making, for electricity and gas. It has been used for example to support the Commission's proposals for a new energy market design, as well as to analyze renewable energy and energy security issues.

The METIS models and datasets are owned by DG ENER, with the final intention to share its source code with the public. METIS relies on Artelys Crystal Super Grid platform, property of Artelys, for computation and visualization services.

Who uses it?

METIS has been designed for two categories of users:

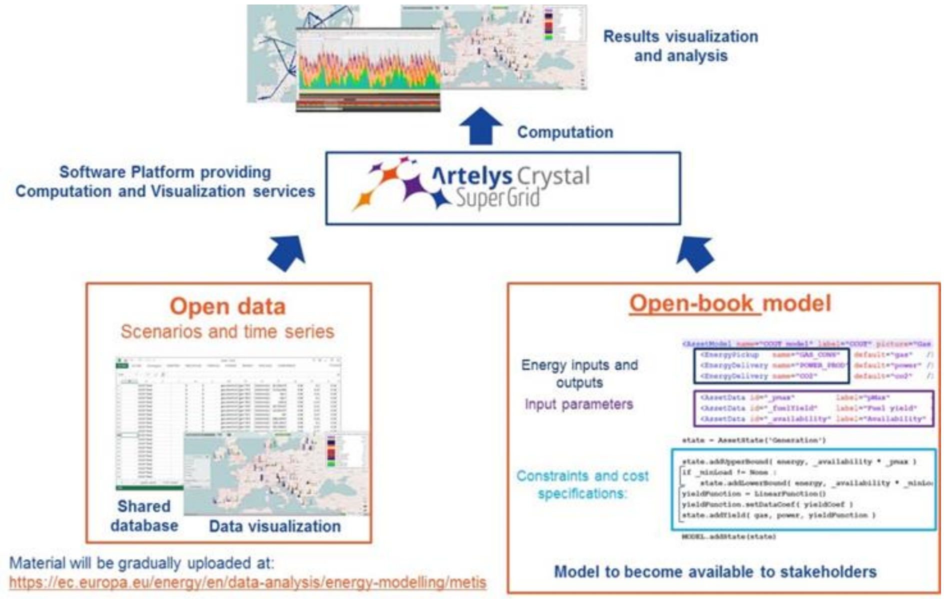
- Policy-makers and analysts
  - Modify the inputs of pre-defined scenarios
  - Choose the level of detail of the simulation depending on the question to study
  - Run the model and analyse the results
  - Export the results for exchanges with stakeholders
- Advanced users and modellers
  - Define new scenarios
  - Change asset constraints and cost function
  - Configure visualization parameters and KPIs for analysts

The open-book approach

METIS tries to reconcile two conflicting objectives:

- Ensure full transparency concerning input data and the modelling techniques applied,
- Provide intuitive and easy-to-use graphical user interfaces for policy-makers and analysts, based on a commercial platform.
- This is done by using the structure described below. All datasets can be scrutinised by METIS users, and should eventually be made publicly available. All datasets are open and can be visualized by analysts. All model parameters, constraints and cost function are

described using a dedicated API. Advanced computation and visualisation services are provided to help analysts to use the model and understand the results.



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- More information can be found on the DG ENER webpage dedicated to METIS: http://ec.europa.eu/energy/en/data-analysis/energy-modelling/metis

POTENCIA

JRC (N.N.)

An adaptable energy systems model

(EERA Joint Programme on Energy Systems Integration) Juha Kiviliuoma (VTT Technical Research Centre of Finland)

Backbone is a generic energy network optimization tool written in GAMS with adaptability as the primary design principle. It can present different energy grids and energy conversions between those grids. What is actually modelled is driven by the input data. Backbone can support multiple different models due to the modifiable temporal structure. For example, it can be used to run an investment model first and then an operational model. The model uses stochastic model predictive control with short-term forecasts and longer-term probabilistic uncertainty. It has the possibility to use ramp-based scheduling instead of block scheduling. Once a reasonable level of maturity has been reached, the model will be open sourced.

Modelling complex systems of heterogeneous agents to better design sustainability transitions policy

(E3ME) Jean-Francois Mercure (Radboud University Nijmegen)

This presentation aims at describing the method used in the novel E3ME-FTT-GENIE1 integrated assessment model (IAM), involving the dynamical integration of several sectoral models to a robust economic treatment at the core. Our IAM integrates 4 key elements. (1) It is a data-driven simulation-based model, which avoids notions of the representative agent and agent perfect rationality and information, but instead builds upon bounded rationality and agent heterogeneity. Large differences can arise between our non-optimal but policy-driven descriptive scenarios, and idealised social planner scenarios from standard energy models. (2) Our model includes a substantial number of possible sectoral and cross-sectoral policy instruments, which enables us to study portfolios much beyond the traditional carbon price (e.g. regulatory, pricing, investment, subsidy policy instruments). Instruments typically interact with one another. (3) Our modelling platform is highly dynamically integrated, such that feedbacks play an important role. (4) Our model is demand-led and implicitly includes money and finance, which allows for positive GDP impacts of climate policy. We stress that model methodology can influence highly what analysts present to policy-makers, and that a clear distinction must be made between normative (agenda setting) and descriptive (impact assessment) scientific methods when informing policy-making.

The PRIMES Model

Alessia de Vita (E3M lab NTUA)

PRIMES is a modelling system that simulates a market equilibrium solution in the European Union and its Member States involving economic decision making of various stylised actors. It determines energy consumption, transformation and supply of various sectors, the costs involved and market prices. The PRIMES model simulates the response of energy consumers and the energy supply systems to different economic developments, exogenous constraints and drivers.

It is a partial equilibrium model simulating the entire energy system both in demand and in supply; it contains a mixed representations of bottom-up and top-down elements. The PRIMES model covers the 28 EU Member States as well as non-EU countries (total 37 countries). The timeframe of the model is 2005 to 2050 by five-year periods; the years up to 2015 are calibrated to Eurostat. It covers in detail energy demand with detailed submodules for industry, and residential and services, energy supply, energy markets, and CO_2 emissions from industrial processes, and it represents policy measures, technologies, means for emission reduction in all sectors, and evaluates cost of emission reduction. The transport sector is covered by the satellite model PRIMES-TREMOVE model which is integrated into PRIMES. The PRIMES model family also includes PRIMES-Biomass supply, PRIMES Gas supply and the PRIMES TAPEM for transport activity.