Final report

1.1 Project details

Project title	Engelsk titel: EUDP 10-II,Danish participation in IEA-ETSAP, Annex XII, 2011-2013
Project identification (program abbrev. and file)	Journalnr.: 64010-0404
Name of the programme which has funded the project	EUDP Programområde Øvrige
Project managing company/institution (name and address)	DTU Management Engineering (formerly Risø DTU), Systems Analysis
Project partners	
CVR (central business register)	30060946
Date for submission	14 November 2014.

1.2 Short description of project objective and results

ENGLISH

The project will continue the Danish participation in the IEA Implementing Agreement ETSAP (Energy Technology Systems Analysis Programme), Annexes X and XI under the new Annex XII "Policy Analysis Tools for Global Sustainability (PAT-SUS): E4 systems tools and joint studies". The main activities are semi-annual workshops focusing on model analyses, and use of the ETSAP modelling tools and technology data (the MARKAL/TIMES family of models), participation in training sessions on ETSAP tools, and participation in collaborative projects using and improving the ETSAP tools.

Contributions to the workshops are based on past, present and future collaborative projects, in particular within the EU research programmes and projects under the Danish Strategic Research Council.

Dissemination of results of ETSAP activities will be made through participation in workshops arranged within the Danish modelling community and as Pre-Conference meetings before ETSAP meetings. The project aims at enabling Danish model studies, which are consistent with European and global models.

A TIMES model for Denmark was developed within EU research projects as a part of the Pan European TIMES model, which now covers 36 European countries, using harmonised assumptions based on Eurostat data, and with results that are becoming available online (PET36).

Another development within ETSAP is the TIMES Integrated Assessment Model (TIAM), which is a global model covering 15 or 16 regions and time horizon year 2100

DANSK

Projektet skal fortsætte den danske deltagelse i ETSAP (Energy Technology Systems Analysis Programme), Anneks X og XI under det nye Anneks XII ""Policy Analysis Tools for Global Sustainability (PAT-SUS): E4 systems tools and joint studies". Hovedaktiviteten bliver delta-

gelse i halvårlige workshops, der vil fokusere på præsentationer af modelanalyser og anvendelse af ETSAP's modelværktøjer, dvs. MARKAL/TIMES modelfamilien. Bidragene til disse workshops vil blive baseret på resultater fra tidligere, nuværende og fremtidige samarbejdsprojekter inden for EU's forskningsprogrammer og projekter under det Strategiske Forskningsråd.

Resultater fra ETSAP's aktiviteter vil blive formidlet gennem deltagelse i workshops inden for det danske modelmiljø og på møder forud for ETSAP's halvårlige workshops. Det er et vigtigt formål at bidrage til danske modelstudier, der er i overensstemmelse med europæiske og globale modeller.

En TIMES model for Danmark er udviklet inden for europæiske forskningsprojekter som en del af den Pan European TIMES model, som nu omfatter 36 land med harmoniserede parametre, der bygger på Eurostat data, og resultater, der er tilgængelige online (PET36).

ETSAP udvikler desuden TIMES Integrated Assessment Model (TIAM), der er en global model opdelt i ca. 15 regioner og en tidshorisont til 2100

1.3 Executive summary

This is the final report from the project "Danish participation in IEA-ETSAP, Annex XII, 2011-2013", which continued the Danish participation in ETSAP (Energy Technology Systems Analysis Programme), Annexes X and XI under the Annex XII "Policy Analysis Tools for Global Sustainability (PAT-SUS): E4 systems tools and joint studies". The main activity has been semi-annual workshops focusing on presentations of model analyses and use of the ETSAP tools (the MARKAL/TIMES family of models), participation in training sessions on ETSAP tools, and collaborative projects using and improving the ETSAP tools. Contributions to these workshops have been based on various collaborative projects within the EU research programmes and projects under the Danish Strategic Research Council. The project aimed at enabling Danish model studies, which are consistent with European and global models. The first TIMES model for Denmark was developed within EU research projects as a part of the Pan European TIMES model. A new model, TIMES-DK with time-horizon 2050 is being developed in collaboration with the staff of the Danish Energy Agency and consultants from the ETSAP-TIMES community. TIMES-DK is part of IntERACT, which links economic and technical modelling within the Danish Energy Agency. Another development within ETSAP is global models (ETSAP-TIAM and EFDA-TIMES) covering 15-17 regions and time horizon year 2100. In addition, DTU Management Engineering is using the ETSAP model tools for projects, papers, and presentations, as well as three Ph.D. projects funded by Danish research programmes. The activities will continue under ETSAP Annex XIII. The autumn meeting 2014 will be in UN City, Copenhagen, arranged by the Danish Energy Agency and DTU Management Engineering.

1.4 Project objectives

The project aims at enabling Danish model studies, which are consistent with European and global models and to benefit from the large IEA energy-environment-economic model community on optimisation models and linked models.

2. Project results and dissemination of results

The main results are participation in ETSAPs semi-annual workshops and workshops on related model developments.

2.1 Semi-annual workshops

Contributions to the semi-annual workshops under annex XII are listed in Table 2.1, and the Danish participants from the Danish Energy Agency and DTU Management Engineering are listed in Table 2.2.

Table 2.1. Danish contributions to ETSAP workshops.

Regular ETSAP workshop (Stanford, July 2011).

A global or a partial climate agreement – what difference does it make? *Kenneth Karlsson, Risø DTU; Pernille Seljom, IFE; Wouter Nijs, VITO.*

China's role in global climate change mitigation: The Chinese potential for biomass & CCS *Kenneth Karlsson, Risø DTU.*

Semi-annual ETSAP meeting (Athens, November 2011).

Coordination of ETSAP-TIAM related activities. Work session 3. Model improvements. *Facilitators: Kenneth Karlsson; Francesco Gracceva.*

Workshop for ETSAP-TIAM Collaboration (Cape Town, June 2012).

The potential role of wind energy in China in a world with ambitious climate constraints. *Kenneth Karlsson, Peggy Mischke, Olexandr Balyk, DTU.*

Large-Scale Integration of Wind Power: Addressing the Smoothing Effect of Distributed Generation in ETSAP-TIAM. *Olexandr Balyk, Kenneth Karlsson, DTU.*

Regular ETSAP workshop (Lisbon, December 2012).

Nordic Energy Technology Perspectives – The Power Sector. *Kenneth Karlsson, DTU*.

Regular ETSAP workshop (Paris, June 2013).

Understanding mathematical modelling tools to evaluate China's future energy-economy interactions – a review of the Chinese perspective. *Peggy Mischke, DTU, Jing Li, African Development Bank.*

A Danish TIMES-CGE system. *Kenneth Karlsson, DTU*

Regular ETSAP workshop (Seoul, November 2013).

First results from TIMES DK. *Kenneth Karlsson, DTU.*

ETSAP-TIAM and EFDA-TIMES Workshop (Video link and continuation in Denmark).

Impact of technology and regional specific discount rates. *Poul Erik Grohnheit, DTU,*

TIAM in China. *Peggy Mischke, DTU*

Biomass assumptions and results from other models to global TIMES models. *Simon Bolwig, Jay S. Gregg, DTU*

Data development for time slices. *Helge V. Larsen, DTU*

Overview of existing tutorials, Poul Erik Grohnheit, DTU, Maurizio Gargiulo, E4SMA,Italy; Konstantinos N. Genikomsakis, DeustoTech, Bilbao, Spain.

Towards the development of advanced TIMES demo models for electric vehicles. *Konstantinos N. Genikomsakis, DeustoTech, Bilbao, Spain. Visiting researcher, DTU (September-October 2013).*

Table 2.2. Participants in ETSAP workshops from Danish Energy Agency and DTU Management Engineering (formerly Risø DTU).

Stanford July 2011	Kenneth Karlsson, Risø DTU.
Athens November 2011	Kenneth Karlsson, Jay Gregg, Risø DTU.
Cape Town, June 2012	Kenneth Karlsson, Peggy Mischke, DTU.
Lisbon December 2012	Sigurd Lauge Pedersen, Kristoffer Steen Andersen, Rikke Næraa, DEA, Kenneth Karlsson, Stefan Petrović, DTU.
Paris June 2013	Rikke Næraa, DEA, Kenneth Karlsson, Peggy Mischke, DTU.
Seoul November 2013	Rikke Næraa, DEA, Kenneth Karlsson, Olexandr Balyk, Poul Erik Grohnheit (video), DTU.

2.2 TIAM collaboration

The ETSAP-TIAM workshops bring together researchers from across Europe that work with the global energy system model TIAM. During the workshop, each participant presents current and planned research projects related to TIAM of their institution. The aim is to build up a common knowledge base on TIAM and a harmonised version of the model.

Table 2.3. Participants from DTU Management Engineering in ETSAP-TIAM meetings on TIAM Collaboration.

Stuttgart, 4 May 2011	Kenneth Karlsson.
Sophia Antipolis, 15 February 2012	Poul Erik Grohnheit.
Cape Town, 18 June 2012	Kenneth Karlsson, Peggy Mischke.
Amsterdam, 15 October 2013	Peggy Mischke.

The collaboration continues under ETSAP Annex XIII. The next meeting is scheduled for the ETSAP meeting in Copenhagen 19 November 2014.

2.3 Socio-Economic Research on Fusion: The EFDA-TIMES model

Fusion energy research has been conducted since the mid 20th century. Different concepts to achieve the goal of fusion power plants exist. However most experimental research effort has been put into the concept of magnetic confinement, which is the basis for the Joint European Torus (JET) from 1983 and the much larger ITER, which is now under construction at Cadarache, France in a collaboration among China, EU, India, Japan, Korea, Russia, and USA.

Along with technology research the European Fusion Development Agreement is running the Socio-Economic Research on Fusion (SERF) programme. This includes EFDA-TIMES, which is a variant of the global TIMES models, focusing on the possible role of fusion energy in the second part of the 21st century.

Table 2.4. ETSAP workshop, November 2013

EFDA EUROPEAN FUSION DEVELOPMENT AGREEMENT — iea Energy Technology Network ETSAP	
SERF: EFDA TIMES 2nd Modelling Workshop 4-5 November 2013, DTU Risø Campus, Roskilde, Denmark	EFDA-TIMES and ETSAP-TIAM Workshop connected to the 64th Semi-annual ETSAP meeting, Seoul, Republic of Korea
4 November 2013, 08:00-10:30 in Denmark, 16:00-18:30 in Korea. Video conference (Extract) **Chair: Kenneth Karlsson, DTU**.	
08:00 / 16:00 Welcome 08:10 / 16:10 Socio Economic Research on Fusion, Magdalena Gadomska, EFDA, Garching. 08:25 / 16:25 EFDA-TIMES model presentation , Helena Cabal, Ciemat, Spain 08:40 / 16:40 Nuclear fusion in EFDA-TIMES, Chiara Bustreo, ENEA RFX, Italy. **09:00 / 17:00 Global Model cooperation** 09:00 / 17:00 Impact of technology and regional specific discount rates, Poul Erik Grohnheit, DTU, Denmark. 09:20 / 17:20 ETSAP-TIAM co-operation. Markus Blesl, IER, Stuttgart, Germany. 09:40 / 17:40 TIAM in China, Peggy Mischke , DTU, Denmark (presented by Kenneth Karlsson) 10:00 / 18:00 Future development of ETSAP-TIAM and EFDA-TIMES. Discussion	

Fusion units will operate very similar to current large-scale thermal generating units for base-load electricity for supply of industrialised regions and population centres.

In November 2013 a common EFDA-TIMES and ETSAP-TIAM Workshop was held at DTU Risø Campus with video connection to a session at the ETSAP meeting in Seoul, see Table 2.4. The workshop in Denmark continued with more presentations on EFDA-TIMES, TIAM and EV-STEP on modelling of electric vehicles. (Bolwig and Gregg 2013, Genikomsakis et al. 2013, Genikomsakis and Grohnheit 2013, Larsen 2013).

From 2014 the EFDA-SERF programme will be replaced by EuroFusion Consortium, Work Package Socio-Economic Studies (WPSES) under EU Horizon 2020.

http://www.sys.man.dtu.dk/Research/Energy-Systems-Analysis/Research-projects/EFDA-TIMES

2.4 Nordic Energy Technology Perspectives

The IEA sees the Nordic countries of Denmark, Finland, Iceland, Norway and Sweden as leaders in the global transition to a low-carbon energy system advocated by the Energy Technology Perspectives series.

While based on the same global scenarios to limit average global temperature increase to 2°C, the Nordic edition includes an even more ambitious Carbon-Neutral Scenario for 2050 for the Nordic region.

This study marks the first regional edition of the Energy Technology Perspectives series since its inception in 2006. The results will allow the Nordic governments to compare their national climate goals with the contribution required of them in the 2°C world described in Energy Technology Perspectives 2012.

The project was conducted in close collaboration between the IEA, 14 leading Nordic research institutions, and the Nordic Council of Ministers through its energy research funding institution, Nordic Energy Research. A reference group of ministries, energy agencies and industry guided the analysis to ensure a high degree of relevance for Nordic policy-makers.

IEA presented results from the study at five national launch events in January and February 2013.

http://www.sys.man.dtu.dk/Research/Energy-Systems-Analysis/Research-projects/Nordic-ETP

2.5 TIMES-DK

IntERACT links economic and technical modelling. The economic model describes the macro-economic flows and market interactions using a neoclassical computable general equilibrium model framework. The technical energy system model is a Danish version of the internationally used TIMES model.

IntERACT is housed by the Danish Energy Agency. The project was initiated by the Danish Energy Agreement from 22 March 2012, which stipulates the construction of a general equilibrium model for Denmark and the Danish energy system. The development is funded by 15.2 mill. DKK over the period 2012-2015.

The aims of the TIMES-DK model are:

- Building a Danish TIMES model by time containing all sectors. The model should optimise between all sectors to find the cheapest solution while meeting a specific policy target.
- TIMES-DK will be linked to a CGE model of the Danish economy, so macro economic impacts of energy policies can be measured.

The model is based on data available within the Danish Energy Agency, Statistics Denmark, Energinet.dk and international sources. Many of these data are used in sectoral models, which have been used for many years. The structure of the model is illustrated in Figure 2.1.

The team behind IntERACT continually develop the model and produce documentation of the model setup, characteristics and data. This work is published on the webpage:

http://www.ens.dk/en/info/facts-figures/scenarios-analyses-models/models/interact

and the Working Paper Series, which includes work undertaken by Danish Energy Agency staff as well as work undertaken external researchers or consultants. Some of the consultants are from the ETSAP Community

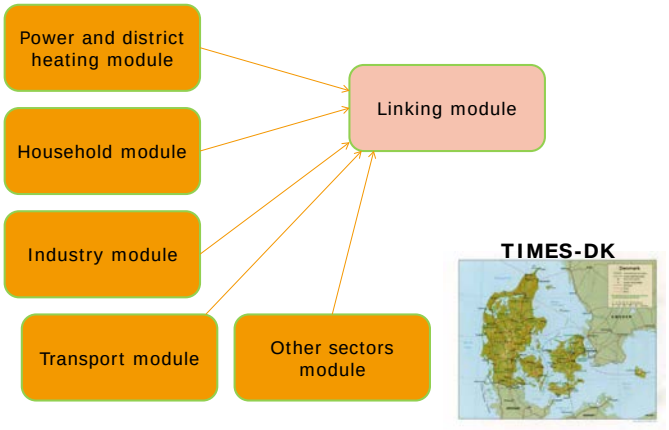

Figure 2.1. TIMES-DK Model development-

An important feature of TIMES-DK is time slices, which represent hours with similar characteristics within the same year. The 32 different time-slices in TIMES DK are obtained as a result of aggregation of periods with specific hourly values:

- Four seasons of the year,
- Periods in a week – workday and non-workday,
- Four critical situations in the Danish power system:
  - Wind power is high, while power demand is low. There is a risk of excess electricity production in these periods which could result in low power prices and need for wind curtailment or export. This situation is named A.
  - Wind power is low, while power demand is high. There is a need for import or backup capacity in these periods. This situation is named B.
  - Peak PV production. There is a risk of excess electricity production in these periods which could result in low power prices and need for export. This situation is named C.
  - Remaining time periods. This situation is named D.

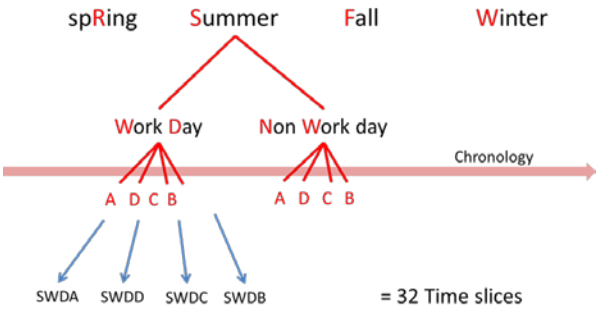

Figure 2.2. Definition of time-slices in TIMES DK

The aggregation of time into time-slices is presented in Figure 2.2. Time-slices have different lengths, ranging from 1 hour in case of time slice covering winter workdays with high wind power and low power demand up to 1409 hours in case of time slice covering workdays in autumn classified as "Remaining time periods". This number of time slices per year was a result of a compromise between long compuation times and accuracy in representing the variations of important variables. One or more years are grouped into time-periods.
Following the general rule that time-periods should be longer as they are closer to the end of analysed period, the length of time-periods in TIMES DK ranges from one to five years.

2.6 Training in ETSAP Tools

An important activity of ETSAP is training in ETSAP tools. Training sessions are normally held as a part of the semi-annual meetings, but also between the meetings when needed for new countries involved in ETSAP modelling. The TIMES-DK team in the Danish Energy Agency and the PhD students and others from DTU management Engineering have taken part in the training.

3. Utilization of project results

The ETSAP tools are used in a wide range of research projects, studies by consultants and academia, including PdD projects at universities worldwide.

3.1 Danish PhD projects

The TIMES model is used in three PhD projects within DTU Management Engineering:

- Representation of Renewable Energy Sources in Integrated Assessment Modelling of Energy and Climate Change Policies, Olexandr Balyk,
- Regional and Global Energy System Modelling with focus on China, Peggy Mischke,
- Geographical representations of renewable energy systems, Stefan Petrović.

The projects are described on the DTU website for DTU Management Engineering, Systems Analysis: http://www.sys.man.dtu.dk/Research/Energy-Systems-Analysis/PhD-projects.

3.1.1 Representation of Renewable Energy Sources in Integrated Assessment Modelling of Energy and Climate Change Policies

PhD project , Olexandr Balyk, DTU Management Engineering, Systems Analysis, funded by Climate DTU 2010-13.

Thesis Title: Application and Development of Energy System Optimisation Models to Meet Challenges of the Future. From the thesis summary:

Climate change, security of supply and local air pollution are among the challenges that are shaping the future of energy systems worldwide. In response to these challenges, various goals are set nationally and internationally that energy systems are supposed to fulfil. These include e.g. EU 20-20-20 targets or the 100% renewable energy system in Denmark by 2050. Nevertheless, the ultimate result with regard to the respective future energy systems remains an open question.

This cumulative PhD thesis deals with application and development of energy system optimisation models to address the various challenges stemming from energy use. It consists of a generic part and eleven papers focusing on different, but related topics. The generic part of the thesis serves to provide the background for the papers as well as to place them within the literature and to highlight various linkages between them. The challenges of climate change, security of supply, and local air pollution are addressed in the papers by focusing on renewable energy systems, demand side management options, climate change mitigation and resource potentials. In the process of the study the energy system optimisation models, Balmorel and TIAM, were further developed in order to enhance their capabilities.

3.1.2 Regional and Global Energy System Modelling with focus on China

PhD project. Peggy Mischke, DTU Management Engineering, Systems Analysis, funded by: Sino-Danish Centre for Education and Research, 2012-15.

The objective of the PhD research project is to use regional and global energy system models to analyse main impacts of China's energy system developments, energy-economy interaction, and global climate change. The focus of the PhD research will include the economic and technical analysis of an increased use of low carbon energy technologies and related policies, which have significant potential in shaping China's energy future. A significant work to compare and benchmark Chinese and internationally commonly used statistics will be carried out.

In the context of this PhD research project energy system assessment modelling was evaluated as well suited for analysing China's complex energy system developments, natural resource uses, energy sector policies, and energy related international trade at the global and regional level. Approaching energy as a system instead of a set of elements gives the advantage of identifying the most important substitution options that are linked to the system as a whole and cannot be understood looking at a single technology or commodity or sector. The research will build on integrated global and regional energy models to analyse and discuss China's role and impacts in the global energy system. One example is the global ETSAP-TIAM.

In this PhD project, ETSAP-TIAM was expanded further in its modelling regions in order to represent a more detailed, sub-regional energy system of China. For this purpose, Chinese national and provincial energy statistics were collected, evaluated and integrated in the model. In order to ensure comparability of China's sub-regions with other model regions, a new methodology to construct the regional energy balances in China in standardized international units was developed specifically for this study. The China specific TIAM model established under the project has therefore 17 model regions and an expanded China-specific database. Furthermore, TIAM drivers for energy service demand for all model regions were reviewed and updated in a joint soft-linking exercise with NIES, Japan.

The PhD research project resulted in various publications in peer-reviewed journals and presentations at energy conferences. New collaborations were set-up with Tsinghua University (China), the Energy Research Institute of the National Development and Reform Commission (China), the National Institute of Environmental Studies (Japan), and the MIT (USA). A website, including a blog on China energy issues, was also set up: http://www.peggymischke.com/china-blog.html.

3.1.3 Geographical representations of renewable energy systems

PdD project , Stefan Petrović, DTU, Management Engineering, Systems Analysis, funded by 4DH Research Centre and PhD Programme.

The main goal is to combine GIS tools and energy system analysis tools and thus achieve better representation of the current and future Danish energy system. On one hand, energy system analysis tools are powerful it when comes to solving complex mathematical representations of energy systems. They usually have detailed temporal division (up to sub-hourly level), cover wide range of technologies, include potentials and prices of various commodities and many more. Results from models provide investment and operation strategies optimized according to a certain criteria, total system costs, environmental emissions, etc. Usually, geographical level of details is not as high – the output from the model is providing the answer on the question "What will happen?", but not "Where will it happen?". Since energy resources, existing production, transmission and distribution infrastructure, and social and economic factors are geographically distributed, lack of geographical details becomes an important issue. On the other hand, GIS tools are providing the possibility for describing energy systems with high level of geographical details and thus complement energy system analysis tools. Essentially, each input or output from the energy system models can be geographically referenced. Accordingly, the work is focusing both on making pre-analysis and providing inputs to energy system models and presenting outputs from the models.

In the first half of the three-year project, work has been done on modelling of heat savings in building stock, district heating, and heat pumps for TIMES DK model. In addition to that, work has been done on the Danish heat atlas and on creating highly detailed GIS Energy Atlas for Ringkøbing-Skjern municipality. Two papers, Petrović and Karlsson, 2014a and 2014b have been published in peer-review international journals.

The project is alse described on the 4 DH project website: http://www.4dh.dk/about-4dh/phd-students

3.2 ETSAP Annexes final reports

By the end of each annex ETSAP issues a final report summarising the activities within the annex.

3.2.1 Model descriptions in ETSAP Final report Annex XI. (2008-2010)

The main structure of the description is the geographical spread of the models (Global, Regional, National, Local)

- The IEA Energy Technology Perspective (ETP) model.
- The original TIMES Integrated Assessment Model (TIAM)
- The Global TIMES Model of the European Fusion Development Agreement (EFDA)
- The Pan-European TIMES model

The structure, usage and selected results from these models are summarised in 8 boxes of model descriptions.

The final report summarizes over 350 references published between 2008 and 2010, including 86 peer-review articles, 7 Ph.D. theses, 9 books or book chapters, 120 research papers and reports, as well as numerous presentations. The peer-review articles were published in a number of international journals, of which 21 in English language are listed in the report. Most presentations were discussed at the IEA-ETSAP workshops. .

3.2.2 Final report Annex XII (2011-2013).

While the previous final reports were organised after the geographical coverage of the various applications of the ETSAP modelling tools (MARKAL and TIMES) the final report for Annex XII will have a different structure, focusing on topics, such as analysis of climate mitigation strategies, the role of energy use technologies and energy sectors, or methodological developments

By October 2014: the literature review is completed and includes 275 peer-reviewed papers published during 2011-2013, plus over 200 papers and presentations from 6 ETSAP workshops and 3 IEW conferences during the same period.

A deeper revision of all peer-reviewed papers is in progress for summary and classification in the Table of Contents, which is by topic and not on a geographical basis like last time.

A first complete draft should be ready to circulate to the ExCo members by the end of 2014 or beginning of 2015.

3.2.3 Reports on the projects on Danish participation in ETSAP Annexes.

After finishing the previous projects on Danish participation in ETSAP Annexes X and XI reports summarising the Danish contributions to the annexes were published as Risø-R-Reports:

- Using the IEA ETSAP modelling tools for Denmark, Risø-R-1656(EN), December 2008.
- IEA ETSAP models in Denmark, Risø-R-1774(EN), March 2011.

A new report "Global and national TIMES models: Use of IEA-ETSAP TIMES models in Denmark (ISBN 978-87-93130-32-6)" is under preparation. It will be made available for download from DTU Orbit during November 2014, http://orbit.dtu.dk/en/publications/global-and-national-times-models%284d003621-959f-41ad-8147-0a823afbb685%29.html.

4. Project conclusion and perspective

The project has contributed to a wide range of modelling activities, which are funded by many Danish and international research programmes.

The activities will continue under ETSAP Annex XIII. ETSAP meets twice a year for workshops. The first workshop under Annex XIII was held in Beijing, China, June 2014, and the

66th ETSAP Workshop will be in Copenhagen 17-21 November. The workshop will include session on Danish models, EV-STEP, TIAM Collaboration, TIMES-CGE and training in TIMES. The venue is the new UN City in Copenhagen, which also host UNEP DTU Partnership (formerly UNEP Risø Centre). It is arranged by the Danish Energy Agency and DTU Management Engineering.

Linking the technology rich bottom-up models MARKAL and TIMES to top-down macroeconomic or general equilibrium models has been an important issue for ETSAP in many years, and it is included in the GAMS codes for the models (MARKAL-MACRO and TIMES-MACRO). A new model collaboration is started under Annex XIII on "Methodologies linking energy system models and economic models". The first workshop was held in February 2014 at University College Cork, Ireland. The next TIMES-CGE workshop will be part of the ETSAP meeting in Copenhagen, November 2014.

ETSAP's website

www.iea-etsap.org

References

Balyk, Olexandr; Karlsson, Kenneth (2012), Large-Scale Integration of Wind Power: Addressing the Smoothing Effect of Distributed Generation in ETSAP-TIAM, ETSAP workshop, Cape Town, June 2012

Bolwig, Simon; Gregg, Jay S. (2013), Biomass assumptions and results from other models to global TIMES models, EFDA-TIMES and ETSAP-TIAM Workshop, Roskilde November 2013.

Genikomsakis, Konstantinos N.; Gargiulo, Maurizio; Grohnheit, Poul Erik; (2013), TIMES demo models, EFDA-TIMES and ETSAP-TIAM Workshop, Roskilde November 2013.

Genikomsakis, Konstantinos N.; Grohnheit, Poul Erik (2013), Towards the development of advanced TIMES demo models for electric vehicles, EFDA-TIMES and ETSAP-TIAM Workshop with 64th Semi-annual ETSAP meeting, Seoul, Republic of Korea

Grohnheit, Poul Erik; Korsholm, Søren B. Lüthje, Mikael (2011), Long-term modelling of Carbon Capture and Storage, Nuclear Fusion, and large-scale District Heating, Risø International Conference 10-12 May 2011. Risø-R-1776, pp. 56-65.

Grohnheit, Poul Erik; Møller Andersen, Frits; Larsen, Helge V. (2011) Area price and demand response in a market with 25% wind power. Energy Policy, Vol. 39, pp. 8051-8061.

Grohnheit, Poul Erik (2013), Impact of technology and regional specific discount rates, ETSAP Workshop, Seoul/Roskilde, November 2013.

Karlsson, Kenneth, Seljom, Pernille, Nijs, Wouter (2011), A global or a partial climate agreement – what difference does it make? ETSAP workshop, Stanford, July 2011.

Karlsson, Kenneth Bernard; Balyk, Olexandr; Zvingilaite, Erika; Hedegaard, Karsten (2011), District heating versus individual heating in a 100% renewable energy system by 2050, 6th Dubrovnik Conference on Sustainable Development of Energy, Water and Environment Systems. 2011.

Karlsson, Kenneth (2011), China's role in global climate change mitigation: the Chinese potential for biomass & CCS, ETSAP meeting, Stanford, June 2011

Karlsson, Kenneth; Gracceva, Francesco (2012), Coordination of ETSAP-TIAM related activities. Workshop for ETSAP-TIAM Collaboration, ETSAP meeting, Athens November 2011.

Karlsson, Kenneth; Mischke, Peggy; Balyk, Olexandr (2012), The potential role of wind energy in China in a world with ambitious climate constraints,ETSAP meering, Cape Town, June 2012.

Karlsson, Kenneth, (2012), Nordic Energy Technology Perspectives – The Power Sector, Kenneth Karlsson, DTU. ETSAP workshop, Lisbon, December 2012.

Karlsson, Kenneth, (2013), A Danish TIMES-CGE system, ETSAP Workshop, Paris, June 2013.

Karlsson, Kenneth, (2013), First results of TIMES-DK, ETSAP Workshop, Seoul, November 2013.

Karlsson, Kenneth, (2014), Nordic Energy Technology Perspectives - Pathways to a Carbon Neutral Energy Future. ETSAP Workshop, Beijing June 2014.

Karlsson, Kenneth; Mischke, Peggy (2014) Modelling tools to evaluate China's future energy system - A review of the Chinese perspective., ETSAP Workshop Beijing June 2014.

Larsen, Helge V. (2013), Data development for time Data development for time slices, ETSAP Workshop, Seoul/Roskilde, November 2013.

Lüthje, Mikael; Karlsson, Kenneth; Gregg, Jay; Føyn, Tullik Helene Ystanes; Balyk, Olexandr (2011), The role of biomass and CCS in China in a climate mitigation perspective,, Risø-R-1776, pp. 258-267

Mischke, Peggy; Jing Li (2012), Understanding mathematical modelling tools to evaluate China's future energy-economy interactions – a review of the Chinese perspective, ETSAP Workshop, Paris, June 2013.

Mischke, Peggy; (2013), TIAM in China, ETSAP Workshop, Seoul/Roskilde, November 2013.

Mischke, Peggy: Karlsson, Kenneth B. (2014), Modelling tools to evaluate China's future energy system – A review of the Chinese perspective. Energy, Volume 69, pp. 132–143. DOI: 10.1016/j.energy.2014.03.019.

Nordic Energy Research; International Energy Agency (2013), Nordic Energy Technology Perspectives: Pathways to a Carbon Neutral Energy Future.

Petrović, S., & Karlsson, K. B. (2014a). Model for Determining Geographical Distribution of Heat Saving Potentials in Danish Building Stock. I S P R S International Journal of Geo-Information, 3(1), 143-165. 10.3390/ijgi3010143

Petrović, S., & Karlsson, K. B. (2014b). Danish heat atlas as a support tool for energy system models. Energy Conversion and Management, 87, 1063–1076. 10.1016/j.enconman.2014.04.084

Ramirez, Andrea; Hoefnagels, Ric; van den Broek, Machteld; Strachan, Neil; Fidje, Audun; Espegren, Kari; Seljom, Pernille; Blesl, Marcus; Kober, Tom; Grohnheit, Poul Erik; Lüthje, Mikael (2011), A Comparison of national CCS strategies for Northwest Europe, with a focus on the potential of common CO2 storage at the Utsira formation, Energy Procedia,, Vol. 4. 2401–2408.

Strachan,Neil; Hoefnagels, Ric; Ramírez, Andrea; Broek, Machteld van den; Fidje, Audun; Espegren, Kari; Seljom, Pernille; Blesl, Markus; Kober, Tom; Grohnheit, Poul Erik (2011), CCS in the North Sea region: A comparison on the cost-effectiveness of storing CO2 in the Utsira formation at regional and national scales, International Journal of Greenhouse Gas Control, Vol. 4. pp. 1517-1532.

Vaillancourt, Kathleen; Tosato, GianCarlo, Eds. (2011), Joint Studies for New and Mitigated Energy Systems. Final Report of Annex XI (2008-2010). IEA ETSAP.