

1. Final report

1.1 Project details

Project title	Danish participation in IEA-ETSAP, Annex XIII, 2014-2016
Project identification (program abbrev. and file)	EUDP 13-II. 64013-0501
Name of the programme which has funded the project	EUDP
Project managing company/institution (name and address)	DTU Management Engineering, SYS Produktionstorvet, bygn. 424, 2800 Kgs. Lyngby
Project partners	
CVR (central business register)	30060946
Date for submission	21 November 2017

1.2 Short description of project objective and results

English

To continue the Danish participation in the IEA Implementing Agreement ETSAP (Energy Technology Systems Analysis Programme), under Annex XIII "Tools for Analysis of a Future Energy Revolution (TAFER): Methodologies, Tools and Data Bases". The main activities are semi-annual workshops and use of the ETSAP modelling tools and technology data.

Danish

Fortsætte den danske deltagelse i IEA's Implementing Agreement ETSAP (Energy Technology Systems Analysis Programme), under Annex XIII "Tools for Analysis of a Future Energy Revolution (TAFER): Methodologies, Tools and Data Bases". Hovedaktiviteterne har været deltagelse i halvårlige workshops samt anvendelse af ETSAP's modelværktøjer og data.

1.3 Executive summary

The project has continued the Danish participation in the IEA Implementing Agreement ETSAP (Energy Technology Systems Analysis Programme), Annexes X to XII under Annex XIII "Tools for Analysis of a Future Energy Revolution (TAFER): Methodologies, Tools and Data Bases". The main activities were 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. Denmark hosted the workshop in the Autumn 2014.

Contributions to the workshops are based on past, present and future collaborative projects, in particular within the EU, Nordic and Danish research programmes. New collaboration opportunities with Chinese partners will be explored.

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 first TIMES model for Denmark was developed within EU research projects as a part of the Pan European TIMES model, which now covers more than 30 European countries, using assumptions based on Eurostat data. A Nordic Energy Perspectives model was developed in 2012 by a collaboration between the IEA and Nordic institutions, and development of a TIMES-DK was initiated 2012 by the Danish Energy Agency.

Another development within ETSAP is the TIMES Integrated Assessment Model (TIAM), which is a global model covering some 15 regions and time horizon year 2100. DTU Management Engineering takes part in a collaborative effort to harmonise and improve various versions of this model, including the EFDA-TIMES model.

The work packages of the project will follow the sequence of ETSAP meetings and some additional activities on the development of modelling tools and data:

1. Participation in ETSAP semi-annual workshops
2. Contributions to ETSAP's R&D.
3. Integration of TIMES and CGE models.
4. ETSAP TIAM model improvement
5. Development and validation of databases for model usage.
6. Final Synthesis report.

The budget does not include the ETSAP annual fee, 20,000 €. Similar to the previous annexes this fee must be paid directly by the Danish Energy Agency.

1.4 Project objectives

To continue the Danish participation in the IEA Implementing Agreement ETSAP (Energy Technology Systems Analysis Programme), under the new Annex XIII – with significant Danish contributions to ETSAP

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

The Autumn workshop in 2014 was held in Copenhagen, organised by the Danish Energy Agency and DTU Management Engineering on the premises of UNEP DTU Partnership (formerly UNEP Risø Centre), which is part of DTU Management Engineering, moved to UN City in April 2014. The new UN city building in Nordhavn hosts many of the UN agencies located in Copenhagen. The UN City is part of the new urban development in the North Harbour of Copenhagen, located only a few kilometres north of the city centre.

Contributions to the semi-annual workshops under annex XIII 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. Selected Danish contributions to workshops within ETSAP Annex XIII.

ETSAP Workshop Beijing June 2014 with International Energy Workshop (IEW2014)

Nordic Energy Technology Perspectives – Pathways to a Carbon Neutral Energy Future. *Kenneth Karlsson, DTU.*

Modelling tools to evaluate China's future energy system – A review of the Chinese perspective. *Peggy Mischke, Kenneth Karlsson, DTU.*

ETSAP Workshop Copenhagen November 2014

Overview of forecasting tools used for planning by DEA, *Kristoffer Steen Andersen, Danish Energy Agency. Kenneth Karlsson, DTU.*

Energy Demand Model and energy efficiency improvements, *Peter Bach, Danish Energy Agency.*

Fossil-free Scenarios for a Danish Energy System 2050 - Model and Results, *Sigurd Lauge Pedersen, Danish Energy Agency.*

The effect of microscale spatial variability of wind on estimation of technical and economic wind potential. *Olexandr Balyk, Jake Badger, and Kenneth Karlsson, DTU.*

Heat planning for the Greater Copenhagen area, *Karsten Hedegaard, Ea Energy Analyses.*

Heat savings and District heating in TIMES-DTU model, *Stefan Petrović, DTU.*

Future of Electric Vehicles in Road Passenger Mobility of India, *Subash Dhar and Priyadarshi R Shukla, UNEP DTU Partnership*

Choice of aggregated parameters for integration of electric vehicles to grid in a TIMES model for a region dominated by wind power, *Poul Erik Grohneit, Cristian Cabrera, and Giovanni Pantuso; DTU.*

IntERACT: Method for linking TIMES with a CGE, *Kristoffer Steen Andersen, Danish Energy Agency*

Benchmarking energy scenarios for China: Perspectives from top-down, economic and bottom-up, technical modelling, *Peggy Mischke, DTU.*

Abu Dhabi, June 2015: No Danish contribution

Sophia-Antipolis, France, October 2015

Integration of VEDA-FE with GIT version control, *Kenneth Karlsson*

Modelling Behaviour in Integrated Energy and Transport Models -A review, *Giada Venturini*

Residential heat pumps in the future Danish energy system. *Stefan Petrović, Kenneth Karlsson*

Accounting for changes in investment flows in a soft-linked hybrid model, *Maurizio Gargiulo, Kristoffer Steen Andersen*

Development of pathways to achieve the SE4All energy efficiency objectives: Global and regional potential for energy efficiency improvements, *J. Gregg, O. Solér, O. Balyk, C. Cabrera Pérez, S. La Greca*

Methodology to estimate energy savings in buildings within ETSAP-TIAM, *Cristian Cabrera.*

Value of the interconnectors in the Nordic countries, *Jacopo Tattini, Maurizio Gargiulo.*

Cork, Ireland, May 2016

Energy efficiency and renewable energy modelling with ETSAP TIAM - challenges, solutions, and opportunities, *Jay Gregg.*

Modelling alternative fuel production technologies for Denmark, *Giada Venturini.*

ETSAP-TIAM collaboration - kick-off", *Kenneth Karlsson*

International Energy Workshop (IEW) 2016, Cork, Ireland.

The following contributions were presented at IEW 2016:

Integration of VRE in the Nordic Energy System, *Kenneth Karlsson,*

Madrid, Spain, November 2016

Methodology for incorporating modal choice behaviour in bottom-up energy system models, *Jacopo Tattini,*

National energy system modelling with TIMES - an MSc course in DTU, *Olexandr Balyk*

Table 2.2. Participants in ETSAP workshops from Danish Energy Agency and DTU Management Engineering.

Beijing June 2014	Kenneth Karlsson, Peggy Mischke DTU
Copenhagen, November 2014	Kristoffer Steen Andersen, Peter Bach, Sigurd Lauge Pedersen, Rikke Næraa, Danish Energy Agency, Olexandr Balyk, Cristian Cabrera, Subash Dhar, Poul Erik Grohnheit, Kenneth Karlsson, Peggy Mischke, Giovanni Pantuso, Stefan Petrović, DTU, Karsten Hedegaard, Ea Energy Analyses.
Abu Dhabi, June 2015	Kenneth Karlsson, XXX, DTU.
Sophia-Antipolis, France, October 2015	Kristoffer Steen Andersen, Olexandr Balyk, Cristian Cabrera, Jay Gregg, Kenneth Karlsson, Stefan Petrović,, Jacopo Tattini, Giada Venturini, Raffaele Salvucci, DTU.
Cork, Ireland, May 2016	Kenneth Karlsson, Giada Venturini, DTU.
Madrid, November 2016	Rikke Næraa, DEA, Olexandr Balyk, Kenneth Karlsson, Jacopo Tattini, DTU.

2.2 ETSAP projects workshops

Table 2.3. Danish participants in ETSAP project meetings, etc.

Cork, February 2014	Methodologies linking energy systems models and economic models	Peggy Mischke, Kenneth Karlsson, DTU, Lars Brømsøe Termansen, DEA
Copenhagen, Nov, 2014	Energy Modelling in Denmark	Table 2.2
Copenhagen, Nov, 2014	TIMES – CGE workshop	Table 2.2
Copenhagen, Nov, 2014	ETSAP – TIAM workshop	Table 2.2
Copenhagen, Nov, 2014	Electromobility EV Step workshop	Table 2.2
London, UCL, April 2015	BE4 Presentations	No Danish participation
London, UCL, April 2016	Workshop on Short term versus long term energy planning	Hans Ravn
Tokyo, December 2016	Workshop on Energy Modelling and Applications	No Danish participation

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. Four workshops was held in 2011-2012 under Annex XII, and the collaboration continued under ETSAP Annex XIII, with a special session during the ETSAP meeting in Copenhagen, and presentations in later workshops.

A proposal for ETSAP-TIAM Update and Re-calibration was submitted to ETSAP in November 2016. Due to the large number of applications the project was divided into two phases.

Project Deliverables Phase 1 -granted

1. Workshops involving ETSAP-TIAM users for determining needed areas to update in the model and e.g., the number of regions wanted in the model
2. Report with analysis of needed changes in the model
3. Updated data, energy balances, technology SubRES, macroeconomic outlook and trade matrixes

Phase 2 – application to next ETSAP meeting in 2017.

4. Re-calibration of the model and set up of a VEDA-BE database for results analysis, and documentation of ETSAP-TIAM. This includes also minimum two standard scenarios: Reference and a Policy scenario,

Integration of TIMES and CGE models.

The TIMES-DK model, which was initiated 2012 by the Danish Energy Agency is a part of . InterACT: Method for linking TIMES with a CGE. The project was presented at ETSAP meetings under Annex XII, a project meeting in Cork in February 2014 and in a special session during the ETSAP meeting in Copenhagen.

2.3 Nordic Energy Technology Perspectives

This study marked the first regional edition of the Energy Technology Perspectives series since its inception in 2006. The results allows 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 and later issues.

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. The results was presented in 2013.

The second study focuses on cities, flexibility and pathways to carbon-neutrality. Results of Nordic Energy Technology Perspectives 2016 was presented by five events in the Nordic capitals in May and June 2016, see <http://www.sys.man.dtu.dk/Research/Energy-Systems-Analysis/Research-projects/Nordic-ETP>

2.4 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. It is housed by the Danish Energy Agency. The project was initiated by the Danish Energy Agreement from 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 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 **Fejl! Hensyningskilde ikke fundet..**

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

2.5 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 PhD students and others from DTU management Engineering have taken part in the training.

2.6 ETSAP books

The ETSAP Book "Informing Energy and Climate Policies Using Energy Systems Models", Springer 2015, was launched at IEW2015 in Abu Dhabi. <http://www.springer.com/gp/book/9783319165394>

3. Utilization of project results

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

3.1 Danish PhD projects

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

- Representation of Renewable Energy Sources in Integrated Assessment Modelling of Energy and Climate Change Policies, Olexandr Balyk, completed 2015.
- Regional and Global Energy System Modelling with focus on China, Peggy Mischke, completed 2015.
- Geographical representations of renewable energy systems, Stefan Petrović, completed 2017.
- Modelling use of biomass and waste in future energy systems by Amalia Pizarro, 2014-2018.
- Modelling, transport fuels and future scenarios for the Danish energy system by Giada Venturini, 2015-2018.
- Modelling of transport systems in energy system modelling tools by Jacopo Tattini, 2015-2018.
- Integrated Energy and Macroeconomic Modelling by Kristoffer Steen Andersen, 2015-2018.
- Modelling the Effect of Emission Control Measures, by Christa Møllenbach Bregnbæk, 2015-2019
- Energy system modelling and integrated future scenario analysis of the Nordic energy and transport system, by Raffaele Salvucci, 2016-2019

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>.

3.2 ETSAP Annexes final reports

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

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 has 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

The literature review is completed and includes some 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. The report can be downloaded from the ETSAP website.

The report has been available from the ETSAP website since August 2015.

Reports on the projects on Danish participation in ETSAP Annexes.

A draft report "Global and national TIMES models: Use of IEA-ETSAP TIMES models in Denmark (ISBN 978-87-93130-32-6)" was available for the ETSAP community during the meeting in Copenhagen, November 2014. It has been updated, and a new version will be available from DTU Orbit:

<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 XIV. ETSAP meets twice a year for workshops. The first workshop under Annex XIV was held in Maryland USA, June 2017.

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ETSAP's website

www.iea-etsap.org

References

See Table 2.1. Selected Danish contributions to workshops within ETSAP Annex XIII.

Vaillancourt, Kathleen (Ed.), Policy Analysis Tools for Global Sustainability: E4 systems tools and joint studies. Final Report of Annex XII (2011 – 2013),

http://www.iea-etsap.org/finreport/ETSAP_Annex_XII_Final%20Report.pdf