

## **Technical-economic modelling with the TIMES model generator: Training course**

### **3<sup>rd</sup> Draft Program** (as of June 2, 2009)

Date: Friday June 12, Saturday June 13, Monday June 15, 2009  
Venue: ENEA, Calle delle Ostreghe 2434, San Marco

Trainers: Eng. Maurizio Gargiulo; [gargiulo.maurizio@gmail.com](mailto:gargiulo.maurizio@gmail.com); skype: gargiulomau  
Amit Kanudia; [amit.kanudia@gmail.com](mailto:amit.kanudia@gmail.com); skype: akanudia  
Ken Noble; [noblesoft@netspeed.com.au](mailto:noblesoft@netspeed.com.au); skype: ken.j.noble  
GianCarlo Tosato; [gct@etsap.org](mailto:gct@etsap.org); skype: gctosato1

### **Friday, June 12**

9.00-9.20	All participants Presentation of the program and round table
9.20-10.00	GianCarlo Tosato, IEA-ETSAP Presentation: Elements of Energy Technology Systems Analyses
10.00-11.00	Maurizio Gargiulo, ASATREM srl Hands-on: from an energy balance to final consumption split by end-use
11.00-11.20	Coffee break
11.20-12.00	GianCarlo Tosato, IEA-ETSAP Presentation: Linear Economic Models
12.00-13.00	Maurizio Gargiulo, ASATREM srl Hands-on: Installation of LEM software (GAMS, TIMES, ANSWER and VEDA)
13.00-14.00	Lunch
14.00-14.40	Maurizio Gargiulo, ASATREM srl Presentation: Overview of a simple TIMES model
14.40-15.40	Maurizio Gargiulo, ASATREM srl Hands-on: Building a tutorial TIMES model from scratch with VEDA-FE
15.40-16.00	Coffee break
16.00-16.30	GianCarlo Tosato, IEA-ETSAP Presentation: Scenarios
16.30-17.30	Maurizio Gargiulo, ASATREM srl Hands-on: Building scenarios for the tutorial TIMES model

### ***Saturday, June 13***

- 9.00-9.20 All participants  
Questions
- 9.20-11.00 Maurizio Gargiulo, ASATREM srl  
Hands-on: Building a tutorial TIMES model from scratch with ANSWERv6
- 11.00-11.20 Coffee break
- 11.20-12.00 Maurizio Gargiulo, ASATREM srl  
Presentation: The TIMES model generator, base components:  
Variables and equations
- 12.00-13.00 Maurizio Gargiulo, ASATREM srl  
Hands-on: Results analysis with VEDA-Back End
- 13.00-14.00 Lunch
- 14.00-14.40 Maurizio Gargiulo, ASATREM srl  
Presentation: Objective functions of TIMES: cost components and shadow prices
- 14.40-15.40 Maurizio Gargiulo, ASATREM srl  
Hands-on: Results analysis with VEDA-Back End (continuation)
- 15.40-16.00 Feedbacks

### ***Monday, June 15***

- 9.00-13.00 **Ken Noble**, Noble-Soft Systems, Pty Ltd, Canberra, Australia  
Presentation: The ANSWER-TIMES documentation  
Hands-on: Building a simple TIMES model with ANSWER
- 14.00-18.00 **Amit Kanudia**, KanORS Consultants, Delhi, India  
Presentation: The VEDA-TIMES support web-site  
Hands-on: Building a simple TIMES model with VEDA-FE

## Documentation

Before the training, please familiarise with the topics illustrated by the following references.  
 Priorities: **You must do**...; *I would do*...; You could do...

### Energy Systems Analysis, Linear Economic Models

1. **Nebojsa Nakicenovic (IIASA), Energy Primer, Excerpt from CLIMATE CHANGE 1995, Impacts, Adaptation and Mitigation of Climate Change: Scientific – Technical Analyses Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel for Climate Change, WMO – UNEP, Cambridge University Press, 1996, 878 pages, Chapter B., pages 75-92**
2. *Gargiulo M., 2008. Getting started with TIMES-VEDA. Draft 2.1., chapter 4: Getting Started with Problem, GC Tosato; [http://www.etsap.org/Docs/Files\\_Times\\_Tutorial.zip](http://www.etsap.org/Docs/Files_Times_Tutorial.zip)*
3. *Dorfman R., Samuelson P. A., Solow R. M.: Linear Programming and Economic Models, McGraw-Hill Book Company, New York 1958; Dover Publications, New York, 1987 (passim)*
4. Gale D.: The Theory of Linear Economic Models, The University of Chicago Press, Chicago and London, 1960, 1989

### The MARKAL/TIMES models generators

5. Loulou R., U. Remne, A. Kanudia, A. Lehtila and G. Goldstein. 2005. Documentation for the TIMES Model. Energy Technology Systems Analysis Programme (ETSAP).
  - Part I. 78 p. <http://www.etsap.org/Docs/TIMESDoc-Intro.pdf>  
**General description of the TIMES paradigm, general structure, economic significance, simplified mathematical formulation of TIMES, model options.**
  - Part II. 349 p. <http://www.etsap.org/Docs/TIMESDoc-Details.pdf>  
 Comprehensive reference manual intended for the technically minded modeller or programmer looking for an in-depth understanding of the complete model details, model mathematics, full description of the sets, attributes, variables, and equations of the TIMES model.
  - Part III. 20 p. <http://www.etsap.org/Docs/TIMESDoc-GAMS.pdf>  
 Description of the GAMS control statements required to run the TIMES model
6. *Gargiulo M., 2008. Getting started with TIMES-VEDA. Draft 2.1. Energy Technology Systems Analysis Programme 180 p. With contributions of Gary Goldstein, Amit Kanudia, Antti Lehtila, Uwe Remme, GC Tosato.*  
[http://www.etsap.org/Docs/Files\\_Times\\_Tutorial.zip](http://www.etsap.org/Docs/Files_Times_Tutorial.zip)  
 This very complete manual explains how to start building a technical-economic model of your energy system, and its possible developments over time, with TIMES-VEDA. This Users' Guide is intended for beginners who want to represent their energy systems with a TIMES model. It illustrates step-by-step how to build an energy model, from the simplest case with one commodity and one technology to a complex model encompassing the entire energy system with dozens of commodities and hundreds of technologies.
7. Specific notes<sup>1</sup>
  - Interpolation rules: <http://www.etsap.org/Docs/TIMES-Interpolate.pdf>
  - New VDA parameters: <http://www.etsap.org/Docs/TIMES-VDA.pdf>
  - Elastic demands: <http://www.etsap.org/Docs/TIMES-ED-Shaping.pdf>
  - Climate module: <http://www.etsap.org/Docs/TIMES-Climate-Module.pdf>

<sup>1</sup> Information on these topics is also available in the “Getting started” guide or in the MARKAL/TIMES documentation reports.

## Data management systems

“ANSWER-TIMES user manual” downloadable from <http://www.noblesoft.com.au/answer/ANSWERv6-TIMES-User-Manual.zip>

Getting Started TIMES-VEDA\_V2p7.pdf, downloadable from <http://www.etsap.org/documentation.asp>

VEDA training material at [www.kanors.com/vedasupport](http://www.kanors.com/vedasupport)

## Applications: models built with MARKAL-TIMES (non-exhaustive list)

### Global Models

<http://www.etsap.org/applicationGlobal.asp>

8. Labriet, M., R. Loulou, A. Kanudia. 2008. Is a 2 degrees Celsius warming achievable under high uncertainty? Analysis with the TIMES integrated assessment model. Cahier du GERAD, G-2008-30, 29 p. <http://www.gerad.ca/fichiers/cahiers/G-2008-30.pdf>  
Stochastic analysis of climate policies with ETSAP-TIAM (TIMES Integrated Assessment Model).
9. Drouet L., Vielle M., Labriet M. and R. Loulou. 2008. A master program that will drive the coupling of GEMINI-E3 and MARKAL/TIMES models. Working paper. <http://gemini-e3.epfl.ch/webdav/site/gemini-e3/shared/A%20master%20program%20that%20will%20drive%20the%20coupling%20of%20GEMINI-E3%20and%20MARKAL%20TIMES%20models>  
Discussion on the coupling of techno-economic MARKAL/TIMES model to a computable general equilibrium GEMINI-E3 model.
10. Vaillancourt, K., Labriet, M., Loulou, R. and J-P. Waaub. 2007. The Role of Nuclear Energy in Long-Term Climate Scenarios: An Analysis with the World-TIMES model. Cahier du GERAD, G-2007-29, 26 p. <http://www.gerad.ca/fichiers/cahiers/G-2007-29.pdf>  
Analysis of the future role of nuclear energy with the World TIMES model.
11. Syri S., Lehtilä A., Savolainen I. and T. Ekholm. 2007. Global energy and emissions scenarios for effective climate change mitigation - Modelling study with the ETSAP/TIAM model. VTT Technical Research Centre of Finland. [http://www.etsap.org/Applications/VTT\\_scenarioreport.pdf](http://www.etsap.org/Applications/VTT_scenarioreport.pdf)
12. International Energy Agency (Gielen D). 2006. Energy Technology Perspectives 2006, Scenarios & Strategies to 2050 (2008 version will be available on June 6<sup>th</sup>) <http://www.iea.org/Textbase/npsum/enertech2006SUM.pdf> (summary) <http://www.iea.org/Textbase/nptoc/enertech2006TOC.pdf> (table of contents)  
Use of MARKAL for policy analysis based on a detailed representation of technology options.
13. Biberacher M. 2006. Fusion in the global energy system – GIS and TIMES <http://www.etsap.org/Docs/Fusglob.pdf>  
Example of linkage between TIMES and a Geographic Information System
14. Labriet M. 2005. Greenhouse Gas Abatement: Techno-Economic Modeling of Global Cooperative and Non-Cooperative Scenarios. PhD Thesis, UQAM, Canada.  
Last chapter available at: <http://www.gerad.ca/fichiers/cahiers/G-2005-07.pdf>  
Full thesis available upon request.  
Example of linkage between the World integrated MARKAL and game theory in order to define globale climate policies.

**Regional Models** (<http://www.etsap.org/applicationRegional.asp>)

15. Pan European TIMES model (PEM) used within the New Energy Externalities Development for Sustainability (NEEDS) project. <http://www.needs-project.org/>  
<http://www.etsap.org/Applications/NEEDS-TIMES-PEM-summary-MB.pdf>
16. Alfstad T. 2005. Development of a least cost energy supply model for the Southern African Development Community region. Thesis, University of Cape Town.  
<http://www.etsap.org/Docs/ERC%20SADC%20energy%20supply%20model.pdf>
17. Mäkelä J. 2000. Development of an Energy System Model of the Nordic Electricity Production System. Thesis, Hlesinki University of Technology.  
<http://www.etsap.org/Docs/Times-Nordic-DiplArbeit-Jussi-1.pdf>

**National Models** (<http://www.etsap.org/applicationNational.asp>)

18. System for the Analysis of Global Energy Markets (SAGE) used by the Energy Information Administration, US Dept of Energy, for the International Energy Outlook. <http://www.eia.doe.gov/oiaf/ieo/>
19. Strachan N., Kannan R., and S. Pye. 2007. Final report on DTI-DEFRA scenarios and sensitivities, using the UK MARKAL and MARKAL-MACRO energy system models. Prepared for the Dept of Trade and Industry (DTI) and the Dept of Environment, Food and Rural Affairs (DEFRA). Policy Studies Institute & UK Energy Research Centre [http://www.ukerc.ac.uk/Downloads/PDF/U/UK\\_MARKAL\\_3rd\\_final\\_report\\_FINAL.pdf](http://www.ukerc.ac.uk/Downloads/PDF/U/UK_MARKAL_3rd_final_report_FINAL.pdf)
20. Labriet M, Cabal H., Caldés N. and Y. Lechón. 2007. Future Energy Policies in Spain given the European Energy and Climate Policy Framework. International Energy Workshop, Stanford, USA, June 25-27, 2007. <http://www.ciemat.es/portal.do?TR=A&IDR=1&identificador=2089>
21. Simões S., Cleto J., Fortes P. And J. Seixas. Estimate of CO2 Marginal abatement costs for Portugal using the TIMES\_PT model. <http://www.etsap.org/Applications/PortugalMAC.ppt>
22. Das A. and E. Ahlgren. 2007. Analysis of the impact of enhanced use of renewable and advanced fossil fuel technologies for power generation in Indonesia, Philippines and Vietnam and development of appropriate policies and institutional frameworks. Chalmers University of Technology, Sweden, 33 p.  
<http://www.etsap.org/Docs/Chalmers-EC-Asean-2007-summary.pdf>
23. Blesl M. 2006. The role of CHP and district heating in Europe (CASCADE-MINTS).  
[http://www.etsap.org/Applications/Blesl\\_Seoul-role-of-CHP-DH.pdf](http://www.etsap.org/Applications/Blesl_Seoul-role-of-CHP-DH.pdf)
24. Chen W. 2005. The costs of mitigating carbon emissions in China: findings from China MARKAL-MACRO modeling. <http://www.etsap.org/Applications/cwyEPMarkalMacro.pdf>
25. Barreto L. 2001. Technological Learning in Energy Optimisation Models and Deployment of Emerging Technologies. PhD. Swiss Federal Institute of Technology.  
<http://www.etsap.org/Docs/BARRETO-thesis.pdf>

**ETSAP Reports**

26. *Final Report of Annex X (2005-2008): Global Energy Systems and Common Analyses*,  
<http://www.etsap.org/index.asp> (passim)
27. Final Report Annex VIII (2002-2005): Exploring Energy Technology Perspectives  
[http://www.etsap.org/FinReport/ETSAP\\_Annex8\\_FinalReport\\_Rev5.pdf](http://www.etsap.org/FinReport/ETSAP_Annex8_FinalReport_Rev5.pdf)
28. Final Report Annex VII (1999-01): Contributing to the KYOTO Protocol  
<http://www.etsap.org/reports/annex7.pdf>