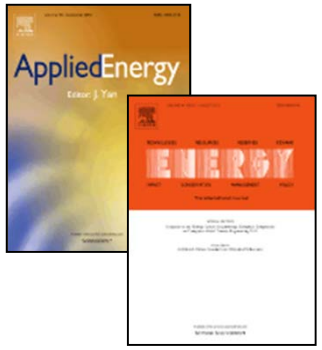
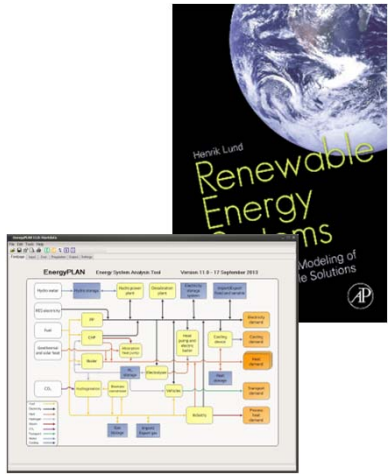
UNESCO sponsored conference
8th CONFERENCE ON SUSTAINABLE DEVELOPMENT
OF ENERGY, WATER AND ENVIRONMENT SYSTEMS
September 22-27, 2013, Dubrovnik, Croatia

Panel: How to write an archival paper that will be accepted in journals?

Validation of simulation models in scientific papers



Henrik Lund
EiC of ENERGY – the international journal
Professor in Energy Planning
Aalborg University, Denmark



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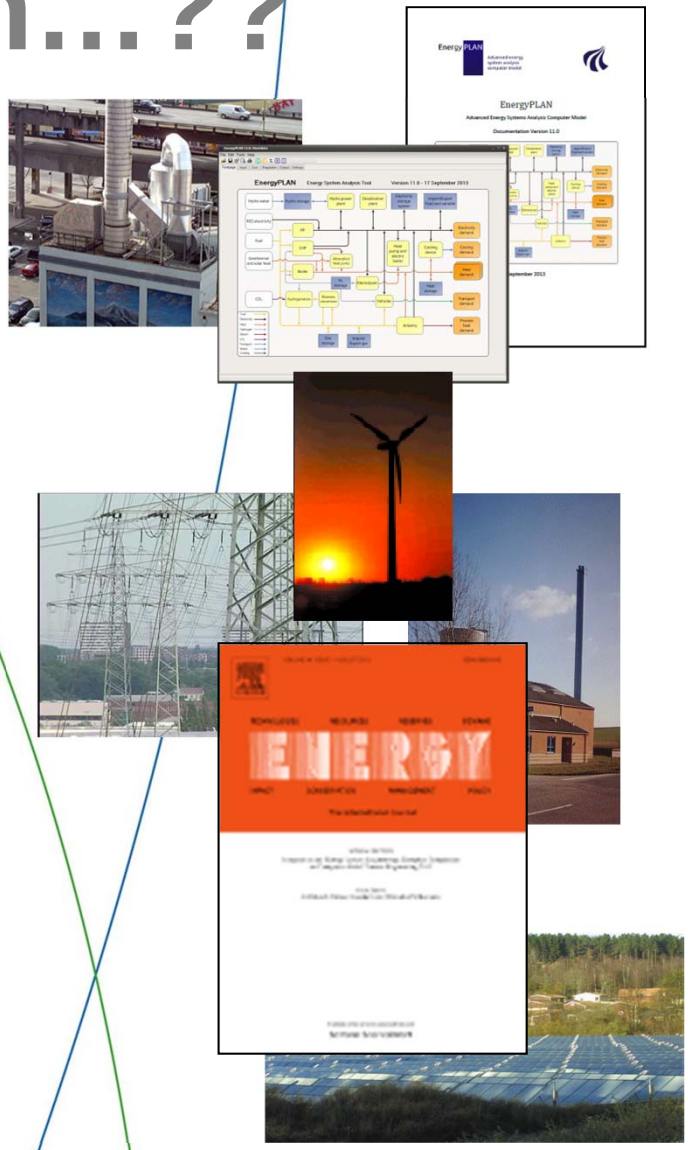
The problem…??

Scientists need complicated and advanced computer tools and models!

The scientific society (ie. Editors and reviewers) request validation!



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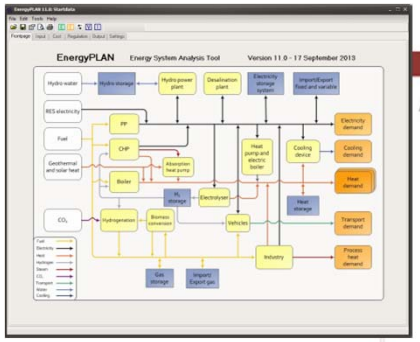
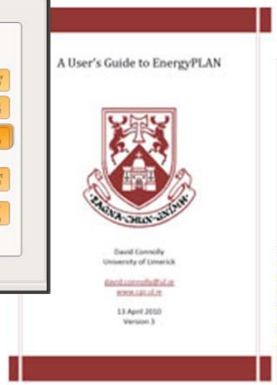
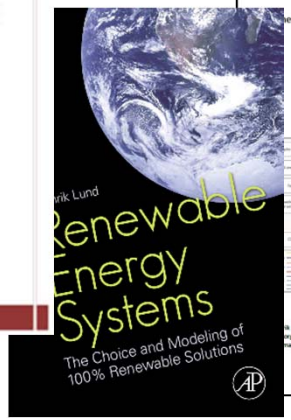
Focus today…

Case: The EnergyPLAN model

Problem: How to validate such a model..??







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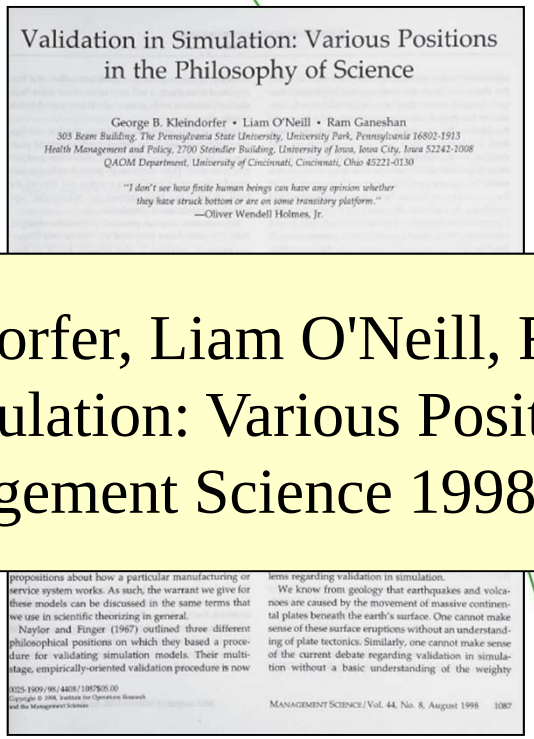
Background:



Validation in Simulation: Various Positions in the Philosophy of Science

George B. Kleindorfer • Liam O'Neill • Ram Ganeshan
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Health Management and Policy, 2700 Steindler Building, University of Iowa, Iowa City, Iowa 52242-1008
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"I don't see how finite human beings can have any opinion whether they have struck bottom or are on some transitory platform."
—Oliver Wendell Holmes, Jr.

propositions about how a particular manufacturing or service system works. As such, the warrant we give for these models can be discussed in the same terms that we use in scientific theorizing in general.

Naylor and Finger (1967) outlined three different philosophical positions on which they based a procedure for validating simulation models. Their multi-stage, empirically-oriented validation procedure is now

lems regarding validation in simulation.

We know from geology that earthquakes and volcanoes are caused by the movement of massive continental plates beneath the earth's surface. One cannot make sense of these surface eruptions without an understanding of plate tectonics. Similarly, one cannot make sense of the current debate regarding validation in simulation without a basic understanding of the weighty

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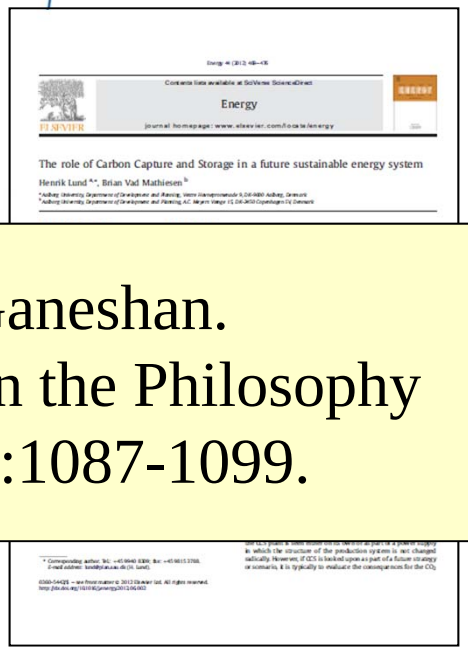
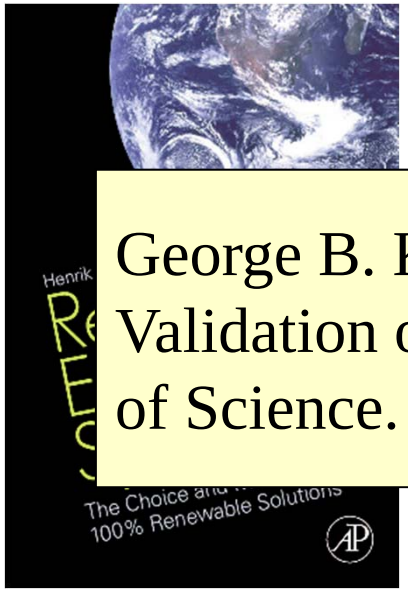


Energy

journal homepage: www.elsevier.com/locate/energy

The role of Carbon Capture and Storage in a future sustainable energy system

Henrik Lund *, Brian Vad Mathiesen



George B. Kleindorfer, Liam O'Neill, Ram Ganeshan. Validation of Simulation: Various Positions in the Philosophy of Science. Management Science 1998;44(8):1087-1099.

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"….. The validation problem in simulation is an explicit recognition that simulation models are like miniature scientific theories…."

"….. How can we infer from our observations (experience) of a system that the model we produce captures its essential structure and parameters? ...."

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"I don't see how finite human beings can have any opinion whether they have struck bottom or are on some transitory platform."
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There is still considerable doubt and even anxiety among simulation modelers as to what the methodologically correct guidelines or procedures for validating simulation models should be. Epistemically, the approaches one finds in the simulation literature run the gamut from objectivist to relativist with shades in between. At present in the philosophy of science, there appears to be a convergence toward a nonalgorithmic but discursive and nonrelativistic view of the argumentation involved in warranting scientific theorizing. The present paper attempts to give a description of the various philosophical positions as well as to summarize their problems and the kinds of evidentiary arguments they would each allow in arriving at defensible simulation models. From the debate, we attempt to set out a perspective that frees the practioner to pursue a varied set of approaches to validation with a diminished burden of methodological anxiety. Reciprocally this perspective does not let the modeler off of the hook but rather converts the validation problem into an ethical problem in which the practitioner must responsibly and professionally argue for the warrant of the model.
(*Simulation; Validation; Philosophy of Science; Hermeneutics*)

1. Introduction

The word "simulate" means to build a likeness, and, as such, the question of the accuracy of that likeness is never far behind. The validation problem in simulation is an explicit recognition that simulation models are like miniature scientific theories. Each of them is a set of propositions about how a particular manufacturing or service system works. As such, the warrant we give for these models can be discussed in the same terms that we use in scientific theorizing in general.

Naylor and Finger (1967) outlined three different philosophical positions on which they based a procedure for validating simulation models. Their multistage, empirically-oriented validation procedure is now included in most simulation textbooks (e.g., Law and Kelton 1991), and their oft-cited positions have come to be called the "historical" approaches to validation (Sargent 1992). We would like to revisit this subject. In our view, the limitations of the positions outlined by Naylor and Finger are the source of some of the current problems regarding validation in simulation.

We know from geology that earthquakes and volcanoes are caused by the movement of massive continental plates beneath the earth's surface. One cannot make sense of these surface eruptions without an understanding of plate tectonics. Similarly, one cannot make sense of the current debate regarding validation in simulation without a basic understanding of the weighty

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Objectivism versus relativism

- **Extreme objectivist believes** that model validation can be divorced from the model builder and its context. Validation is an algorithmic process which is not open to interpretation or debate

- **Extreme relativist believes** that the model and model builder are inseparable and validation is a matter of opinion


Validation in Simulation: Various Positions in the Philosophy of Science

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The court house metaphor

- The prosecutor does not have to prove the guilt in any foundationalist sense but rather ***”beyond reasonable doubt”***

- *”The model builder would be free to establish and increase the credibility of the model through any reasonable means. This process would also involve other stakeholders, such as model users and referees of journal articles”*


Validation in Simulation: Various Positions in the Philosophy of Science

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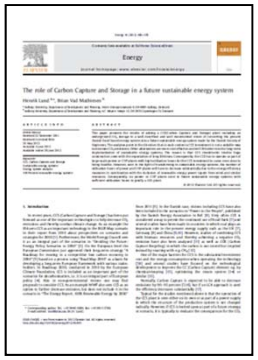
Validation in Simulation: Various Positions in the Philosophy of Science


Energy

The role of Carbon Capture and Storage in a future sustainable energy system

"Reasonable means"

Purpose becomes an essential benchmark

- … model of part of the world… how do we assure that is *"captures its essential structure and parameters?"*….
- …. things like choices, structure, limitations etc. should be measured against the purpose….

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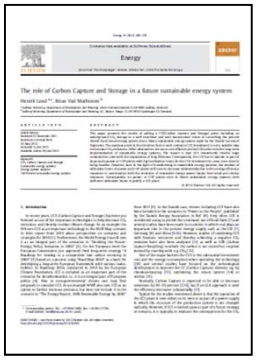
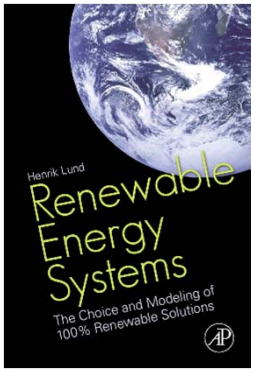
0. State purpose

- In the case of the CCS-study: The purpose of the model has been to calculate the consequences of adding a certain technology (CCS) to a strategy of transforming the present energy system into a future sustainable energy system



- In general: To assist in the design of national or regional energy strategies – in a situation in which radical technological change is in question.



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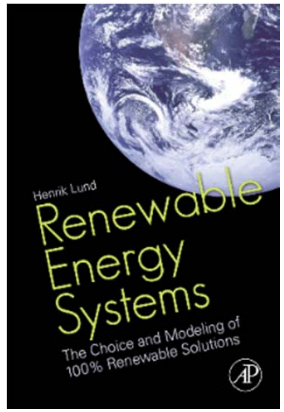
Some reflections



- The model should be able to make a consistent and comparative analysis of all alternatives in question as well as a reference
- The model should be able to analyse radical technological change
- The model should be able to provide suitable information for feasibility studies and the design of public regulation measures based on concrete institutional economics
- The model including methodology and results should be communicative
- Be able to explore a wide range of future options (speed of calculation)

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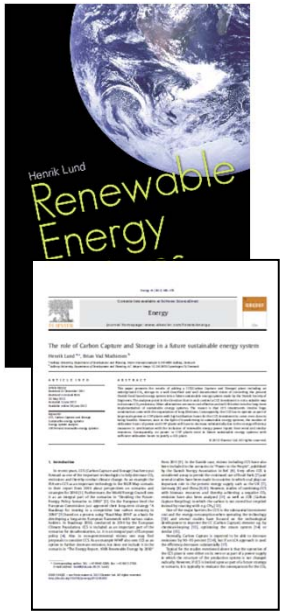
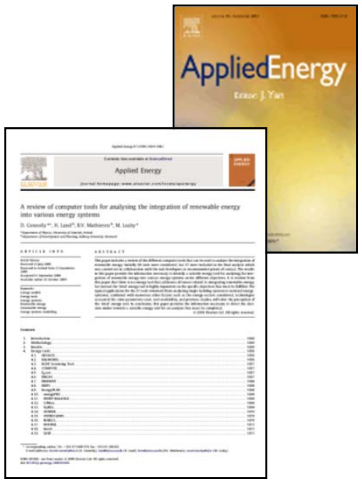
1. Choice of model

- Description of model. How does it work?
- Why did I chose and/or develop this model in this way?
- How does this model relate to other similar models….!





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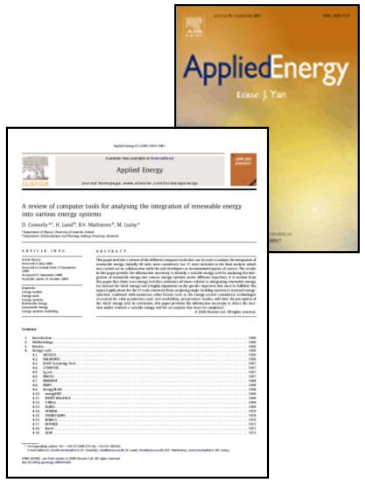
Tools versus Models



1. The terminology “tool” is used for e.g. energy system analysis computer tools such as EnergyPLAN,

2. while the terminology “model” is used for description of a certain energy system by use of the tool.

Sometimes the tool and the model is the same..!

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Definitions

1. A simulation tool simulates the operation of a given energy-system to supply a given set of energy demands. Typically a simulation tool is operated in hourly time-steps over a one-year time-period.
2. A scenario tool usually combines a series of years into a long-term scenario. Typically scenario tools function in time-steps of 1 year and combine such annual results into a scenario of typically 20–50 years.
3. An equilibrium tool seeks to explain the behaviour of supply, demand, and prices in a whole economy or part of an economy (general or partial) with several or many markets. It is often assumed that agents are price takers and that equilibrium can be identified.
4. A top-down tool is a macroeconomic tool using general macroeconomic data to determine growth in energy prices and demands. Typically top-down tools are also equilibrium tools (see 3).
5. A bottom-up tool identifies and analyses the specific energy technologies and thereby identifies investment options and alternatives.
6. Operation optimisation tools optimise the operation of a given energy-system. Typically operation optimisation tools are also simulation tools (see 1) optimising the operation of a given system.
7. Investment optimisation tools optimise the investments in an energy-system. Typically optimisation tools are also scenario tools (see 2) optimising investments in new energy stations and technologies.

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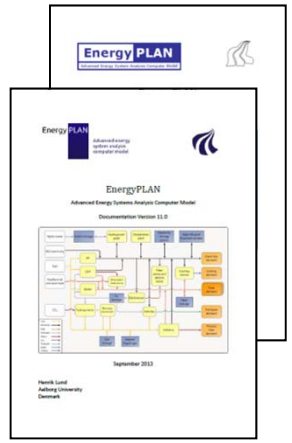
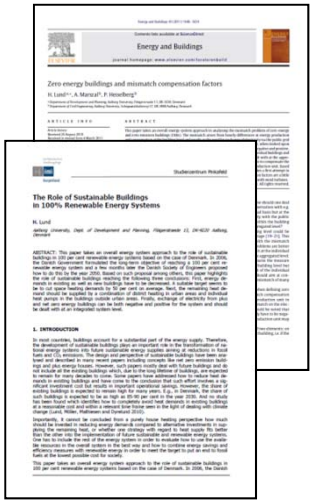
2. Documentation and proven ability

- Written documentation of the model exists. (as well as a user guide).
- A rather substantial group of users exists (3800 downloads - response and questions from time to time)
- The model has proven its ability to analyse national energy systems in among others Denmark, Romania, Ireland and China as well on the analysis of different technologies (more than 20 journal papers)





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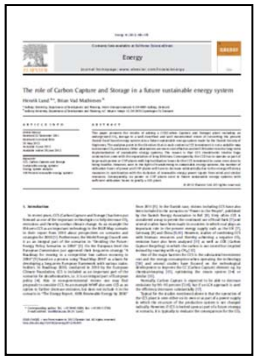
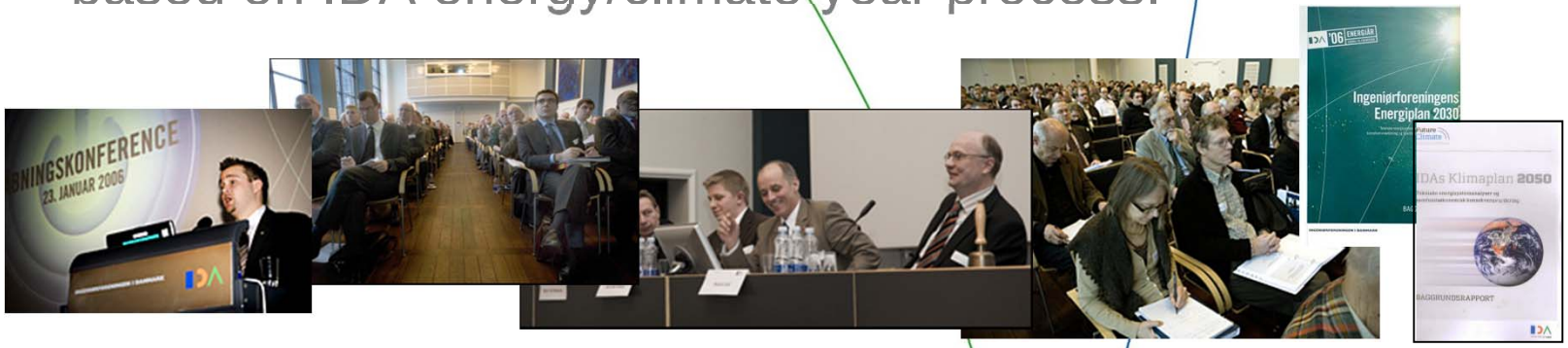
3. Data quality



- Modelling of the existing Danish energy system as well as the possible future sustainable system is based on IDA energy/climate year process.



- The results of the existing system and the reference scenario is calibrated against statistical historical data and the DEA reference scenario.

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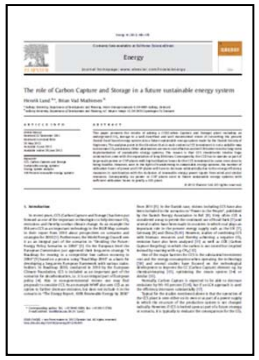
4. Description of CCS technology or similar



- CCS description based on the same expert input as in the case of the other technologies in the scenario

- Input for the future scenario created in a dialog among a number of experts within the Danish Society of Engineers (IDA).

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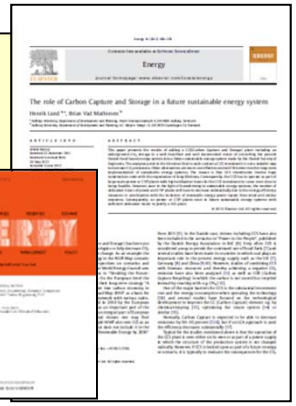
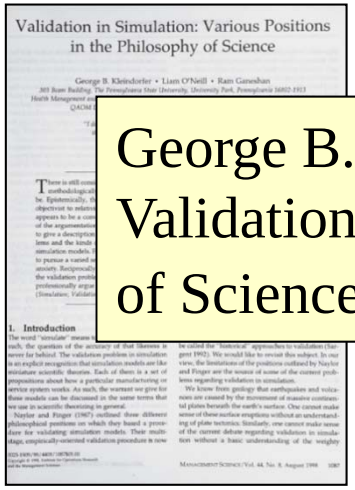
Lund, H. Mathiesen, B.V. *The role of Carbon Capture and Storage in a future sustainable energy system. Energy*, Vol 44, pp. 469-476, August 2012.





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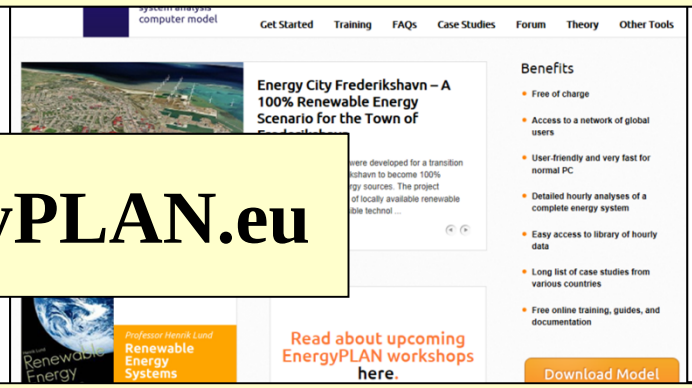
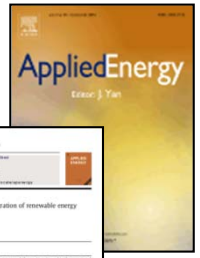


www.EnergyPLAN.eu



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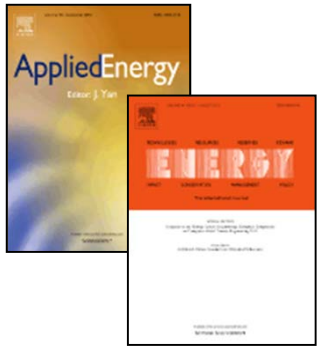

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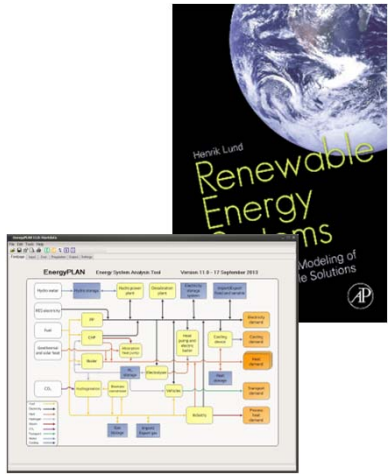

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