Analysis of the European energy system

under the aspects of flexibility and technological progress

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Deliverable

D3.1 Expert Workshop on Experience Curves

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Lead author(s):	Atse Louwen (UU), Martin Junginger (UU)
Reviewer(s):	Ulrich Reiter (TEP), Michael Krail (ISI)

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Document history

Version	Date	Author/Editor	Description
0.1	20.11.2017	Atse Louwen	Initial version, sent to reviewers
0.2	20.11.2017	Atse Louwen, Martin Junginger	Initial version after internal review
1.0	28.11.2017	Atse Louwen, Martin Junginger	Final version after review

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1. Short description of the event

1.1 WORKSHOP PLANNING

The Expert Workshop on Experience Curves was organised with several aims: 1) to disseminate and discuss preliminary findings of REFLEX WP3; 2) to discuss, with experts from the field, issues regarding the methodology and applications of experience curves; 3) to discuss, with experts from the field, the implementation of experience curves in energy models and 4) to present proposed methods to apply experience curves for (ex-ante) environmental impact assessment and 5) to gauge interest and involve experts for contributing to the publication of a book on experience curves (Deliverable D3.3 of the REFLEX project). The workshop was organized on November 8th, 2017 from 09:00 – 16:20 and was hosted by KIT-ITAS in Karlsruhe, Germany.

Invitations to the workshop were distributed by email to contacts of all REFLEX partners, and were sent to researchers in the fields of experience curves, energy modelling and environmental assessment. Furthermore, personal contacts from various stakeholder groups (business, policy) were invited. The invitation that was sent to the intended participants is shown in
Figure 1 below. When registrations were closed, over 40 people had registered for the workshop. Final attendance of the workshop was 34 persons, of which 20 participants from external organisations.

The workshop consisted of three parts: a plenary session in the morning (09:00-12:30) and parallel discussion sessions in the afternoon (13:30-16:00) and a wrap up presentations where key findings from the discussion sessions were presented (16:00-16:20). The agenda of the event is shown in section 4. On the evening of November 7th, a social dinner was organised for the speakers and participants to encourage networking.

1.1 PROCEEDINGS

The plenary session started with a presentation by Dominik Möst (TU Dresden) welcoming the participants and introducing the REFLEX project's organization and overall goals. Afterwards, Martin Junginger (Utrecht University) gave an overview of the aims and preliminary findings of REFLEX WP3.

After these introductory presentations, six presentations were given by a mix of project external and internal speakers. Oliver Schmidt (Imperial College London, external) presented his work on experience curves for electricity storage technologies. Ulrich Reiter (TEP Energy GmbH, internal) gave a presentation on the work of TEP Energy on experience curves and technological learning for demand side management (DSM) and other tertiary sector technologies. Uwe Remme (IEA, external) provided an overview of the work of IEA's ETP group on energy modelling and experience curves. Stephanie Heitel (Fraunhofer ISI, internal) showed a case study of applying experience curves in the transport model ASTRA. Atse Louwen (UU, internal) gave insights into his work on applying experience curves for environmental impact assessment of PV systems. Finally, Clas-Otto Wene (Chalmers, external) presented his work on "Quantum Modelling of the Learning Curve".

After the lunch break, three parallel discussion sessions focused on 1) the methodology and application of experience curves, 2) the implementation of experience curves in energy models, and 3) the application of experience curves for environmental impact assessment. In the first session, Noah Kittner (UC Berkeley, external) presented his

work on two-factor experience curves for energy storage technologies, and Thomas Martinsen (NMBU, external) provided an overview on the interaction between markets, spill-over, radical innovations, technological learning and experience curves. In the second parallel session, Steffi Schreiber (TU Dresden), Tobias Fleiter (Fraunhofer ISI), Katrin Seddig (KIT-IIP), and Christoph Fraunholz (KIT-IIP) all presented cases studies and experiences of implementing experience curves in energy models, respectively ELTRAMOD (electricity supply), FORECAST (buildings and industry), TE3 (transport) and PowerACE (electricity market). In the final parallel discussion session, Atse Louwen (UU) and Lei Xu and Mary Fuss (KIT-ITAS) gave presentations about ex-ante environmental impact assessment, respectively by using experience curves and updating of Lifecycle Inventories. In each of the parallel sessions, presentations were followed (and alternated) by open discussions with the participants.

Finally, the workshop concluded with a wrap-up session, where key findings and discussion points of the parallel discussion sessions were summarised and presented to all workshop participants, before closing of the workshop.

1.2 WORKSHOP OUTCOMES

The workshop succeeded in gathering together researchers and other stakeholders from many European countries and the US. The plenary talks and presentations in the discussion sessions showed state-of-the art work on experience curves, some of which have recently been published in high-impact journals. The open discussions of the parallel sessions resulted in clear identification of key issues and recommendations concerning experience curve methodology, model implementation of experience curves in energy models, and application of experience curves for environmental impact assessment.

Key arguments identified in the session about experience curve methodology were that is important to have clear definitions of system boundaries, and that using multi-factor experience curves can be helpful in explaining and describing exogenous impact factors like commodity prices, policy, R&D, market dynamics, bubbles, etc.). On the other side, it was also argued that factors such as deployment subsidies and R&D spending may be entangled, e.g. public deployment support may likely result in profits for companies, which may then spend these profits on private R&D. Ultimately, it was mentioned that a review study comparing one- versus multi-factor experience curves would contribute to the understanding of the benefits and drawbacks of both types of experience curves in different applications.

The parallel session on model implementation of experience curves also identified a number of key issues. One of the main issues discussed was the lack of emphasis on data collection for experience curve implementation, and the recommendation to improve this. Geographical scale of energy models raises the issues of how to integrate global technological learning in regional/local models. Scaling factors, (external) global scenarios were mentioned as possible solutions. For optimisation models, an issue is that the models tend to choose technologies with high learning rates, as these models by definition have “perfect foresight”. High initial production costs can only hardly be overcome in simulation models without accounting subsidies or incentives from governments. Hence, some technologies never get into the learning process and stagnate in end consumer prices.

In the final parallel session about experience curve it was discussed that although preliminary results indicate that using experience curves for ex-ante environmental impact assessment show promising results, further investigation is needed before general conclusions can be drawn. Further work will include an investigation of using

experience curves to update lifecycle inventories for future energy technologies, as well as an investigation of experience curves for non-energy impact assessment methods.

By bringing together researchers and experts from the fields of experience curves and energy modelling, interesting state-of-the-art presentations, and fruitful and helpful discussions were held. Many participants were very positive of the workshop contents and outcomes, and mentioned that they had struggled with many of the questions addressed, but had been missing a forum like this to discuss them.

Large interest has been raised among the participants present to contribute to REFLEX deliverable D3.3, a book on experience curves. Furthermore, important insights were acquired that will be applied in REFLEX WP3, both for deliverable D3.2 and the implementation of experience curves in the various energy models of the REFLEX project. The presentations of the workshop will be made available on the REFLEX project website.

2. INVITATION

The invitation (2nd version) emailed to the target group is shown in

Figure 1 below.

2nd WORKSHOP ANNOUNCEMENT and CALL FOR CONTRIBUTIONS

Technological Learning in the Energy Sector

Implementation of experience curves in energy system models for future cost estimations and environmental impact assessment

New technologies -- such as photovoltaics, electric vehicles, heat pumps, and batteries -- are entering the energy markets and systems at unprecedented rates. Questions arise such as: when will these technologies achieve which levels of maturity? And at what cost levels and which points in time can they be competitive in which market segments?

Experience curves are one possibility to assess the future cost of technologies. The REFLEX project is devising experience curves for a large number of energy technologies. These technologies include traditional and upcoming energy supply technologies, but also new technologies that enable high levels of flexibility in electricity grids. The devised experience curves will be implemented in a variety of energy systems models, covering various sectors such as energy supply and demand, transportation, and heat.

The REFLEX consortium is hosting an expert workshop on November 8th, where state-of-the-art experience curves will be presented and methodological issues of implementing experience curves in energy systems models will be addressed. Furthermore, the workshop will analyse the application of experience curves for prospective environmental impact assessment.

The REFLEX consortium is kindly inviting you to attend our workshop. Registration is free of charge. Please register via the link below before October 15th, 2017.

We are furthermore calling for experts in the field of experience curves, energy system modelling and related areas to contribute by means of oral presentations. If you would like to contribute, register via the link below before October 1st, 2017.

Register here:
https://goo.gl/forms/bXti1rnBKSTsrp2t2

Date

Wednesday November 8th 2017
from 09:00h - 17:00h

(on Tuesday November 7th at 19:30 we host a social dinner at own expense)

Location

Karlsruhe, Germany
(for more information see next page)

Programme

Morning Plenary talks

- *Experience Curves for Electricity Storage*
  Oliver Schmidt – Imperial College London
- *Experience Curves for Environmental Impact*
  Atse Louwen, Utrecht University
- *Experience Curves of Energy Efficiency and DSM*
  TEP Energy GmbH
- *Implementing experience curves in energy demand models and specific application in the ASTRA model*
  Tobias Fleiter & Stephanie Heitel, Fraunhofer ISI
- *(Title t.b.d.)*
  Uwe Remme, IEA - Energy Technology Perspectives
- More speakers to be announced

Afternoon Parallel discussion sessions

- Experience Curves: methodology and applications
- Implementation of Experience Curves in energy system models
- Experience Curves for future environmental impact assessment

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Figure 1: Invitation to workshop sent to the target groups

3. FINAL ATTENDANCE

Table 1 shows the list of participants at the event by name and affiliation. Project external participants are indicated with cursive font.

Table 1: Final attendees at the event

Name	Affiliation	Name	Affiliation
Alessia Elia	*UC Cork*	Katrin Seddig	KIT-IIP
Andreas Bublitz	KIT-IIP	Daniell Fett	KIT-IIP
Atse Louwen	UU	*Felix Lill*	*CDTM*
Carlos Blanco	*Leiden University*	*Steffen Fattler*	*FGE München*
Christoph Fraunholz	KIT-IIP	*Uwe Remme*	*IEA*
Clas-Otto Wene	*Chalmers University*		
Dominik Möst	TU Dresden		
Hans Böhm	*Energieinstitut an der JKU*		
Jannik Haas	*Uni. Stuttgart*		
Laurent Vandepaer	*USherbrooke/PSI*		
Manuel Wetzel	*DLR*		
Martin Junginger	UU		
Maryegli Fuss	KIT-ITAS		
Natalya Tsoy	*Leiden University*		
Kristina Nienhaus	*DLR*		
Noah Kittner	*UC Berkeley*		
Oliver Schmidt	*Imperial College London*		
Peter Radgen	*Uni. Stuttgart*		
Pinar Korkmaz	*Uni. Stuttgart*		
Sabrina Ried	KIT		
Simonas Cerniauskas	*Forschungszentrum Jülich*		
Steffi Weyand	*TU Darmstadt*		
Stephanie Heitel	Fraunhofer ISI		
Sven Peterhammer	*DLR*		
Martin Jakob	TEP Energy		
Thomas Martinsen	*NMBU*		
Dr. Thomas Schlegl	*Fraunhofer ISE*		
Lei Xu	KIT-ITAS		
Steffi Schreiber	TU Dresden		
Ulrich Reiter	TEP Energy		

4. AGENDA OF THE EVENT

Plenary Sessions **Wednesday, 8th November 2017, 09:00 – 12:30** **Room: 418** **Chair: Dominik Möst**	
Time	Topic
08:45	Registration
09:00	**Welcome and introduction** General introduction of the REFLEX project (Dominik Möst, TUD) REFLEX WP3 Overview (Atse Louwen/Martin Junginger, UU)
09:20	**Experience Curves for Electricity Storage Technologies** Oliver Schmidt (Imperial College)
09:50	**Experience Curves for DSM technologies** Ulrich Reiter or Martin Jakob (TEP Energy)
10:20	**From learning curves for current technologies to new & emerging technologies** Uwe Remme (IEA)
10:50	Coffee Break
11:20	**Case study: application of experience curves in the ASTRA transport model** Stephanie Heitl (Fraunhofer ISI)
11:50	**Experience Curves for Assessment of Environmental Impact** Atse Louwen (Utrecht University)
12:15	**Quantum Modelling of the Learning Curve – Achievements and Prospects** Clas-Otto Wene (Chalmers and Wenergy)

12:30	Lunch break

Parallel Sessions Wednesday, 8th November 2017, 13:30 – 16:20			
Time	**Experience Curves Methodology** Chair: Martin Junginger (UU)	**Model Implementation** Chair: Steffi Schreiber (TUD), Tobias Fleiter (ISI)	**Environmental Impact** Chair: Atse Louwen (UU)
13:30	**One vs Two-factor Experience Curves** Noah Kittner (UC Berkeley) **Markets, spillover and radical innovations** Thomas Martinsen (NMBU)	**Implementing experience curves in an optimisation model - the example of ELTRAMOD** Steffi Schreiber (TUD) **Implementing experience curves in simulation models - examples from the buildings and industry sectors** Tobias Fleiter (Fraunhofer ISI) **Implementation of experience curves in a system dynamics model using the example of TE3** Katrin Seddig (KIT-IIP) **Implementation of Experience Curves in the Electricity Market Simulation Model PowerACE** Christoph Fraunholz (KIT-IIP)	**Experience Curves for Future Environmental Impact Assessment** Atse Louwen (UU) **Lifecycle Inventory Updating for Future Environmental Impact Assessment** Mary Fuss / Lei Xu (KIT-ITAS)
14:30	**Coffee break**		
14:45	**Discussion**	**Discussion**	**Discussion**
16:00	**Wrap up and closing (UU)**		
16:20	**End of workshop**		