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Comparison of Results of OSeMOSYS with TIMES-PLEXOS Model

Modelling ambitious renewable energy targets for Ireland

15 January 2015

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Integration of Short-term Dynamics into Long-term Models

- Long-term energy system models cannot incorporate daily operation of power plants
- Related short term constraints may significantly impact longer term investments
- But constraints like ramping rates, start-up costs, minimum stable generation, etc., are usually not considered
- OSeMOSYS was enhanced to capture the impacts of variability on system adequacy and security requirements
- System adequacy: Endogenous calculation of capacity credit by OSeMOSYS





OSeMOSYS

Open Source Energy Modelling System

- Limited set of accessible energy systems models, often significant investments in human resources, training, software.
- OSeMOSYS is linear energy systems optimisation model, with no associated upfront financial requirements.
- "Lego block structure" allows easily adding elements. Every block consists of conceptual describtion, formulas, and code.







Comparison of Results of OSeMOSYS with TIMES-PLEXOS Model OSeMOSYS Model Enhancements

System Security – Operating Reserve

- Primary & secondary, upward & downward reserve
- Specific reserve contributions based on ramping rates can be defined for any technology, also demand-side
- Minimum stable generation levels considered
- Minimum level of spinning reserve can be defined
- Cycling constraints: changes of online capacity and generation from one time slice to another can be limited
- No mixed-integer programming introduced
- Model enhancements documented in detail







OSeMOSYS Model Enhancements

System Security – Selected Equations





Irish Case Study

Background – Irish Case Study

- Comparative UCC study using TIMES & PLEXOS
- Modelled Irelands 40% RE generation target for 2020
- Set up OSeMOSYS in a similar fashion as Irish TIMES model (12 time slices)
- Added detail taken from the Plexos model (8760 time slices), but maintained 12 time slices
- Compared results with TIMES/Plexos
- Publication: Deane, J.P., Chiodi, A., Gargiulo, M., Ó Gallachóir, B.P., 2012. Soft-linking of a power systems model to an energy systems model. Energy 42, 303–312.



Modelling elements of Smart Grids – Enhancing the OSeMOSYS (Open Source Energy Modelling System) code

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¹ Several supportive modeling tools are used for integrated resource phonois (16) Totascub an MSSGCE(2023), TMS [22] and MARAL(22) are derived from heilable-Mana approach [24] and show used for multi-regional models. Well among others, montanes a model share to beyondly applied in Artica [25,26]. ³ Excluding the alkily to model high point states of vasible derived triby groups.

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1. Introductio

1.1. Rationale

The Smart Grid concept islenged and covers there size electricity papely chain]— 14. It is characterised by the proposed is or factmologies to intelligently integrate the generation, transmission and occumulation of electricity [5]. Ultimizing the an ancient demotifs include lower core, improved invice quality and endote environmental impact [10]. In this paper, we hald on an electronic demotification include lower core, improved invice quality and endote environingelmed from Core (10). In this paper, we hald on an electronic distribution increased demotifs of options to match the objective spaceful above, increased demotifs on environmental constitution of the objective space of the objective spacement of the one-departchales generation combined with stratege options [11]. Since Grids may be composed of assume of generation, stock and technologies. Selecting the most assumption of the stack for environmental choices hand on multi-criteria decision making [16].

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Irish Case Study

Parameters

Parameters		Plexos	Enhanced	TIMES	
Technical	Installed capacity	✓	\checkmark	~	
	Input/output fuels	\checkmark	\checkmark	\checkmark	
	Heat rates/efficiencies	\checkmark	\checkmark	\checkmark	
	Min. stable generation	\checkmark	\checkmark		
	Up/down ramp rates/reserves	\checkmark	\checkmark		
	Min. up and down times	\checkmark	*		
	Maintenance rates/availabilities	\checkmark	\checkmark	\checkmark	
	Repair time	\checkmark			
Economic	Fuel costs	\checkmark	\checkmark	\checkmark	
	Emission costs	\checkmark	\checkmark	\checkmark	
	Variable O&M costs	\checkmark	\checkmark	\checkmark	
	Fixed O&M costs		\checkmark	\checkmark	
	Start-up costs	\checkmark	*		
Environmental	Emissions	\checkmark	\checkmark	\checkmark	



Irish Case Study

Background - Republic of Ireland

- 16% renewable energy target for 2020
- Translates to a 40% renewable generation target
- Technically feasible maximum wind penetration rates are expected to range between 60 – 80% of the load
- Extending the time horizon to 2050, greenhouse gas emission reductions of 80% below 1990 levels

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Modelling elements of Smart Grids - Enhancing the OSeMOSYS (Open Source Energy Modelling System) code

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1. Introduction

The Smart Grid concept inbread and covers the entire electricity supply chain[1-8] It is characteristical by the proposed use of techtopoles is in inframely integrate the generation, manufacture and contact technicity of contactivity, the manufacture and contact technicity of contactivity of the manufacture and contact technicity of the state manufacture and the state of the state specificality, we focus on the ability of Smart Grids to enable insurated angenes and hole for the state of the s

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0360-54425 - we from maker © 2012 Elswier Izd. All rights reserved http://dx.doi.org/101016/jenergy2012.08.087 and stranging (e.g., [2–18]). Commercially are lable analytical into have developed organizatily over datade, gaining inmaturity along with complexity.³ With the energence of some popular (2–10) an eventuality with a differentiation and address has been as the opply such took. Only a small solver of energy modelines in an address and the distance of energy modelines into the most their modeling media. This is, however, a preveation when animation to the outer barries and address and labor to meet their modeling media. This is, however, a prerequired to understand the detaction barbon barbon in iteration defau-shell solverse. While many aspects of modeline modely competitional and

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Scenarios

OSeMOSYS Simple:

Built on core code of OSeMOSYS, similar to the stand-alone TIMES model.

OSeMOSYS 70% Wind:

Draws on external, detailed wind availability assessment. Enabled a more accurate consideration of the 70% wind generation limit.

TIMES-PLEXOS Simple:

Increased temporal resolution (hourly intervals), no additional operational constraints.

OSeMOSYS Enhanced:

Considers increased operational detail (operating reserve requirements, max. contribution of power plants to meeting these reserves, minimum stable generation)

TIMES-PLEXOS Enhanced:

Increased operational detail (start-up costs, minimum stable generation, ramping rates, and operating reserve requirements)



















Results for 2050

Deviation of capacities, discounted costs and emissions from enhanced OSeMOSYS model

OSeMOSY S Simple	Unit	2020	2025	2030	2035	2040	2045	2050	
Total capacity	%	0.0	4.0	4.6	3.8	3.3	-2.1	-14.1	
Σ Plant capacity deviations Capacity OSeMOSYS Enhanced	%	0.0	4.0	17.4	20.3	15.1	19.8	23.5)
Discounte d costs	%	-9.0	40.5	-11.3	-4.0	-5.8	-21.5	-14.3	
Emissions	%	-1.3	-7.6	-14.4	-5.4	0.0	0.0	0.0	
OSe MOSYS 70% Wind	Unit	2020	2025	2030	2035	2040	2045	2050	
Total capacity	%	0.0	0.0	-1.4	-1.3	-1.2	-6.4	-7.8	
Σ Plant capacity deviations Capacity OSeMOSYS Enhanced	%	0.0	0.0	7.3	12.8	9.4	14.1	13.0	
Discounted costs	%	-2.3	-1.9	-0.2	-3.0	-9.1	-15.2	-3.9	



Conclusions

- Long-term energy systems models which omit short-term constraints: Simple OSeMOSYS model: 21.4% of yearly generation in 2020 assigned to different power plants than in enhanced model.
- **Soft-linking:** two separate models have to be set-up ٠ and maintained; no overall optimisation across the two models -> identified capacity investments may not present the economically most efficient pathway
- Integrating operational aspects into the long-• term models: 95.0% of the dispatch results of the enhanced OSeMOSYS model matched those of an interlinked model with a 700 times higher temporal resolution.

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Modelling elements of Smart Grids - Enhancing the OSeMOSYS (Open Source Energy Modelling System) code

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1. Introduction 11. Rationak

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E-mol address: manual.welads@energy.kth.ae(M. Widath) 0360-54425 - we from mater @ 2012 Elswier lzd. All rights reserved http://dx.doi.org/101016/jenergy2012.08.087

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Conclusions

- Integrating operational aspects into the longterm models: In conventional model, up to 23.5% of <u>total capacity in 2050</u> assigned to different power plants than when considering operating reserves.
- Approach presented for OSeMOSYS, but can as well be implemented in other long-term models.
- M. Welsch, M. Howells, M. Hesamzadeh, B. Ó Gallachóir, P. Deane, N. Strachan, et al. *Ensuring Supporting Security and Adequacy in Future Energy Systems – The need to enhance long-term energy system models to better treat issues related to variability.* minor revisions.
- M. Welsch, P. Deane, F. Rogan., M. Howells, B. Ó Gallachóir, H.H. Rogner, et al. Incorporating Flexibility Requirements into Long-term Models – A Case Study on High Levels of Renewable Electricity Penetration in Ireland. under review.



Modelling elements of Smart Grids – Enhancing the OSeMOSYS (Open Source Energy Modelling System) code

M. Welsch A*, M. Howells *, M. Bazilian ^b, J. DeCarolis ^c, S. Hermann *, H.H. Rogner ^d *200 logic between effectively closely and the set *200 logic between effectively closely and the set *200 logic between effectively closely and the set *200 logic between effective effective effective effective effective *200 logic between effective effective effective effective *200 logic between effective effective effective *200 logic between effective effective effective *200 logic between effective effective *200 logic between effectiv

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1. Introduction

1.1. Rationale

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decision making by hulping to characterize tested energy policies and strategies (e.g., [12–18]). Commercially an ability and total have developed organically over decades, gaining in macrity look have developed organically over decades, gaining in macrity families of modelling tooks and supportive capacity building (e.g., [27–31]) an incomisity wide and international audience has learnt to apply auch tooks, tody a small subset of energy modelines adapt it to merch international audience. This is, however, a personulate them animizes to extravel concepts before they are integrated into off-their subseture.

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RENEWABLE ENERGY INTEGRATION

PRACTICAL MANAGEMENT OF VARIABILITY, UNCERTAINTY, AND FLEXIBILITY IN POWER GRIDS



Long-Term Energy Systems Planning: Accounting for Short-Term Variability and Flexibility CHAPTER

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1. Introduction

According to the International Energy Agency (IEA), the world continues to diverge from a pathway toward meeting internationally agreed climate change targets. Global average temperatures are expected to increase by 2.8-4.5 °C by 2100 if no countermeasures are taken [1]. This calls for a major transformation of our energy systems, in which renewable energy technologies play an important role to mitigate climate change.

The electricity production of renewable energy sources, such as wind and solar power, is variable as a function of the availability of the renewable resource at hand. Variable renewables certainly provide secure quantities of energy when considered over longer time periods, but they do not guarantee the secure delivery of power as and when needed [2]. The variability they introduce adds to the overall fluctuations in power systems. For example, on the supply side, these may be due to outages in conventional power plants, and on the demand side, they may be due to the time dependency of loads. As the shares of renewable electricity generation rise, future power systems need to be increasingly flexibility to cope with such fluctuations to balance supply and demand. Energy policies and strategies are required that facilitate the transformation to such increasingly flexible power systems.

Energy models have successfully proven their use in informing the development of energy policies and strategies from the early 1980s on [3–6]. They commonly serve as test-beds to investigate developments or system configurations that would be impractical, too expensive or impossible to test in real-world



Thank you for your attention