Tools Linking approaches

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Background

WP3: Develop a methodology on how to find and evaluate suitable combinations of tools in order to support energy policy making for the transition of Europe towards a low carbon society.

Output of this WP:

"the models which are appropriate for answering a policy question depend heavily on the policy question itself, meaning that the "best available" models are a function of the question to be answered."

Background

WP5: To validate the selected tools from WP3 using the data identified by WP4.

Approach:

- Choose a number of models that appeared in different combinations in the analysis of WP3 -> models that appeared in the top combinations and were available to the project partners.
- Formulate a linking scheme approach for these models.

Focus on model couplings that were not done in the past by examining the soft linking possibilities between them.

Models/Tools

TIMES, EU wide, technology rich bottom-up optimization model of the whole energy system.

COMPETES, EU-wide power sector model, optimal unit dispatch, power trade flows between countries, congestion per connection, system load and RES curtailment.

Climate Bonus, individual based CO_2 emissions calculator

RESolve-E, focus on the RE part of the electricity system, capacity and production projection per technology, cost developments, full assessment of specific support measures

IER-Transmission, optimal investment plan for power generation and transmission, an extension for storage is under development.

MECHanisms tool focused mainly on energy efficiency projects/programs, major function is to guide and assist project managers through critical decisions in the development of the project.

Model Linking

The ideal model should be **technologically explicit**, **offer microeconomic realism** and **macroeconomic completeness**.

A soft linking approach offers a more detailed representation but fails to address the simultaneous equilibria in both markets (energy and economy).

- The time resolution used in models can be quite different, depending on the specific focus on the model.
- The issues of convergence and stability of the linking process of heterogeneous model are not simple either.

In the linking scheme a CGE or MGM model is not included - > this work has been already performed successfully in the past.

Model Linking – Data

Common Database:

- covers the need for maximum possible data consistency
- highest available geographical granularity and time scale, to allow extraction of data at the level desired by each model.

Remaining data input for each model is stored in independent, dedicated databases.

Specific independent databases for each model can be found in the report of WP4.

COMMON DATABASE				
	Input Parameter Name	**Input Parameter Description**	**Units**	**MODELS**
				1: TIMES, 2:IER-TRANSMISSION, 3: COMPETES, 4: RESOLVE-E, 5: CLIMATE-BONUS
GENERAL	TS	Split of the year in time segments	%(fraction of year)	1,
	Discount	Discount factor for the computation of the NPV	%	1,
REGIONS	Inter_Cap	Interconnection capacity between regions	Unit of capacity	1,3,
SECTORS	Energy balance	Table of the energy balance of a country	Unit of energy	1,
	Fuel_prices + CO2 price	Fuel prices per sector and energy carrier	m€/PJ	1,2,3,4,
	Import_prices	Import prices per energy carrier	m€/PJ	1,
	Export prices	Export prices per energy carrier	m€/PJ	1,
	Demand_sec_ts	Split of demand for useful energy per sector and time segment	PJ	1,

ATEST

DEMANDS	Demand drivers			1,
	GDP	Gross domestic product	m€	1,
	GDP growth	Growth of GDP	%	1,
	Value_added	Value_added per sector	m€	1,
	IPI	Industry production index per (sub)sector	Units produced	1,
	Population			1,
		Socio-professional classes of households		1,
		Budget share for Energy goods and services		1,
	Number of persons per household			1,
	Demand_evol	Evolution of demand per (sub)sector and end-use	PJ	1,

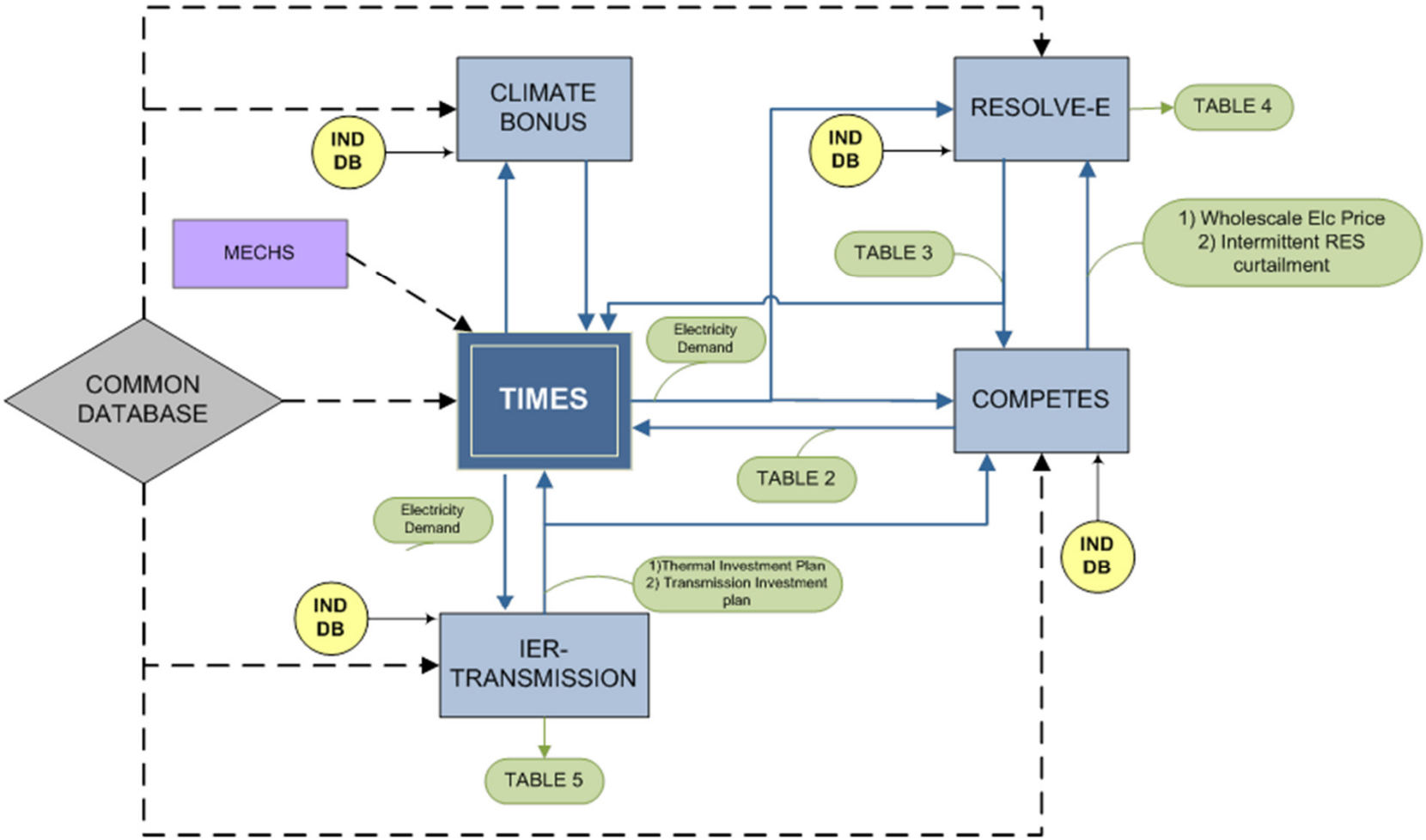
TECHNOLOGIES	Life	Technical lifetime of investment	Years	1,
	AF	Availability factor of technology(annual or seasonal)	%	1,3,
	INVCOST	Investment cost per technology	€/(unit of installed capacity)	1,2,4,
	Upper limit	Upper limit of technology penetration or upper limit of activity of a technology	% or absolute	1,
	Lower limit	Lower limit of technology penetration or upper limit of activity of a technology	% or absolute	1,
	Fixed limit	Fixed limit of technology penetration or fixed limit of activity of a technology	% or absolute	1,
	Eff	Efficiency of technology	%	1,3,
	E_stock	Existing stock per technology	Unit of installed capacity	1,
	CF	Capacity factor per technology(obligatory only for end-use demand technologies)	%	1,
	FIXOM	Fixed operation and maintenance cost per technology	€/unit of capacity	1,4
	VAROM	Variable operation and maintenance cost per technology	€/unit of energy	1,3,4,

Model Linking

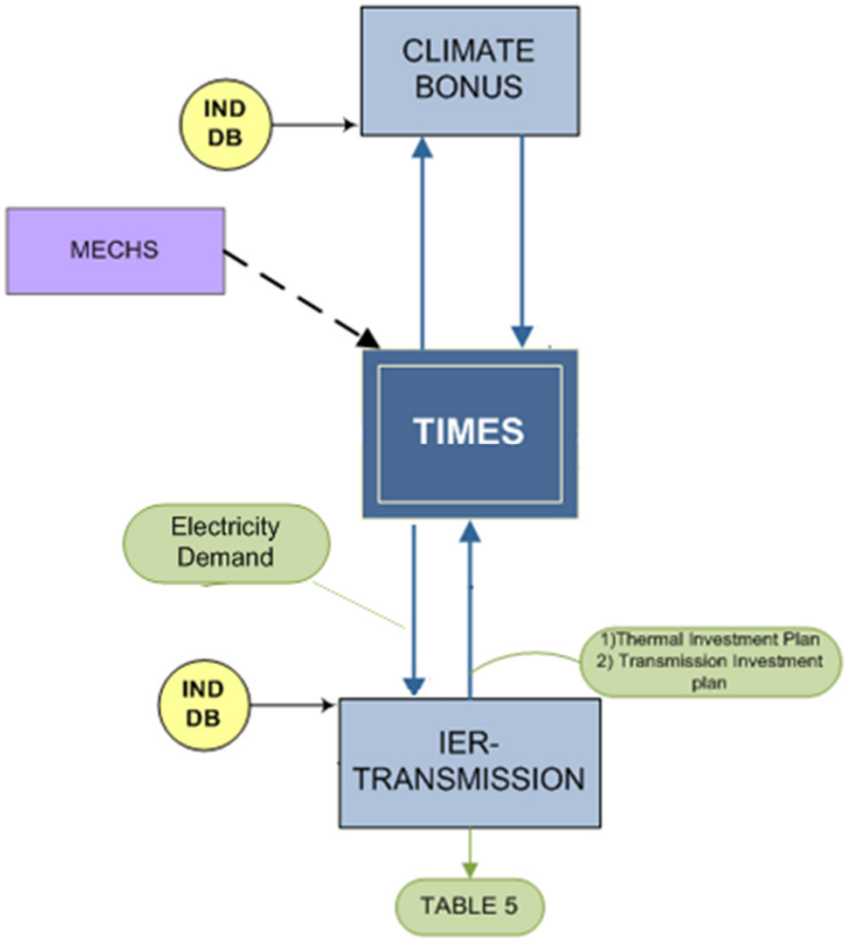
Policy questions in which these models were involved (what we try to achieve with the help of these tools).

- “How to achieve a low cost and low emissions energy mix?”
- “Which are the most competitive low carbon technologies in the medium and long term?”
- “Where should new energy installations be best located?”,

Model Linking – Scheme



Model linking Scheme - 1

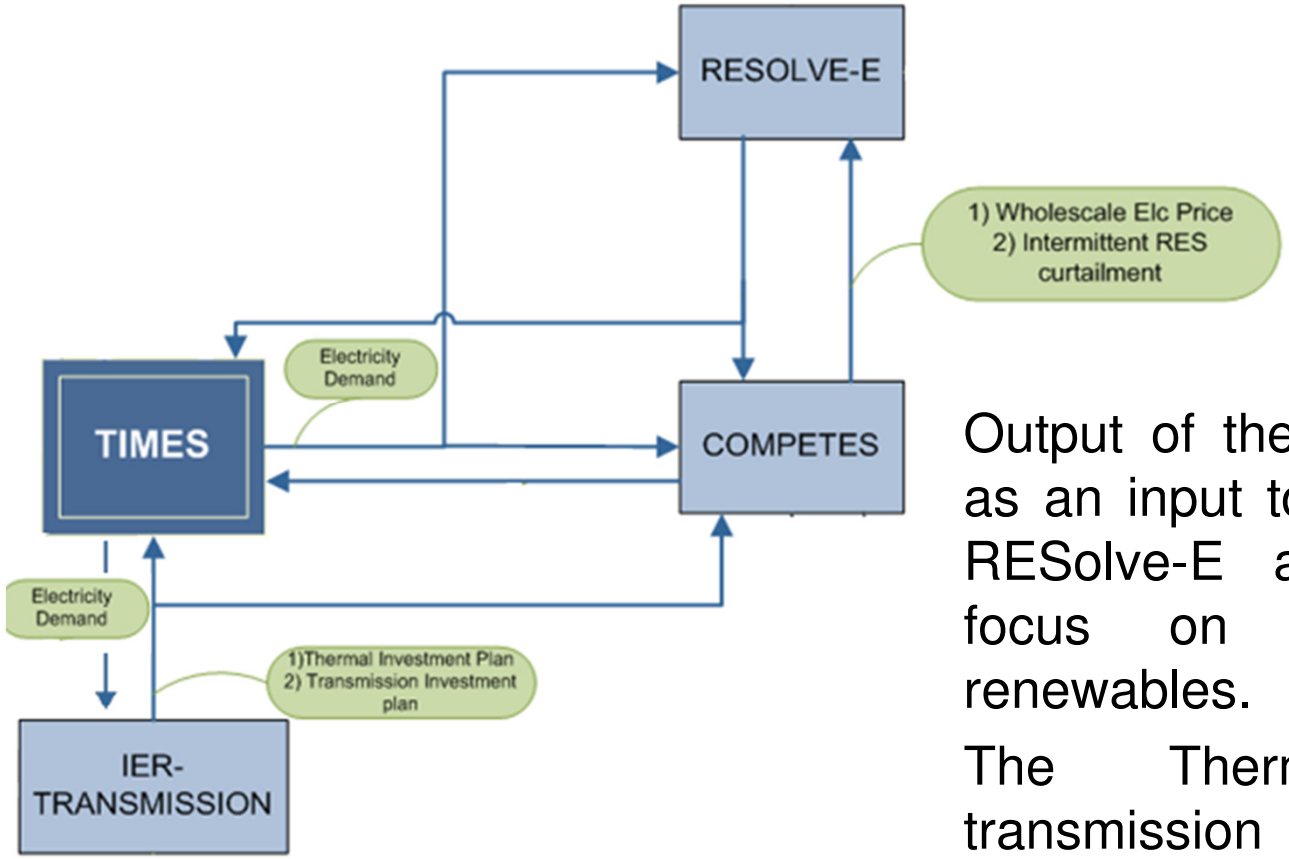


A systemic model covering the whole of the energy system like TIMES is run with input from: Climate-bonus, Mechanisms.

The electricity demand from TIMES is used as an input to IER-Transmission which optimizes both thermal generation and transmission capacity expansion simultaneously

(At the moment only a detailed version for Germany exists). The output is forced in TIMES.

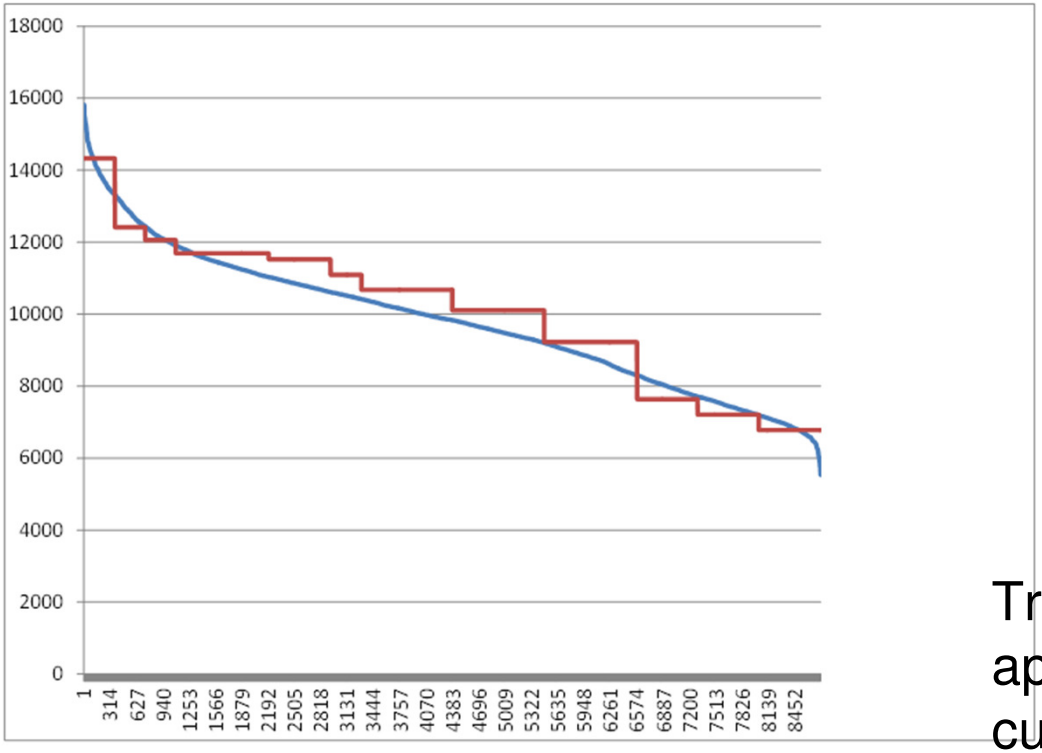
Model linking Scheme - 2



Output of the systemic model used as an input to the iteration between RESolve-E and COMPETES that focus on the electricity and renewables.

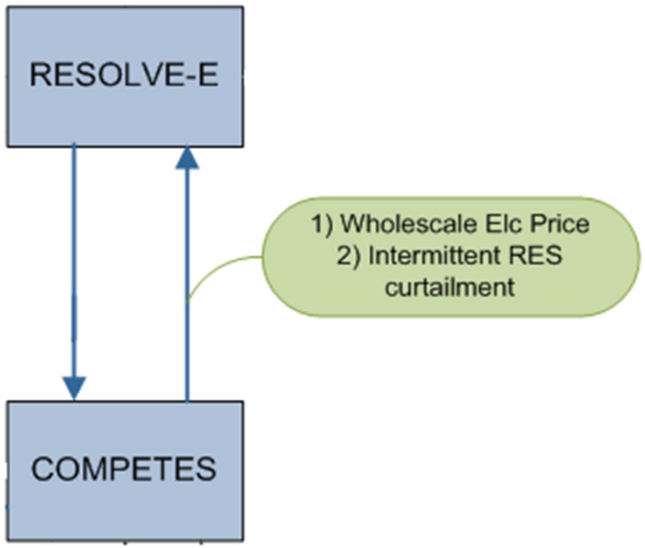
The Thermal system and transmission is optimised in IER transmission.

Model linking Scheme Electricity Demand transformation



Transformation of the stepwise approximation of the annual load curve to the continuous curve necessary for models analysing the electricity sector in detail like COMPETES.

Model linking Scheme – 3a



RESOLVE-E is run first.

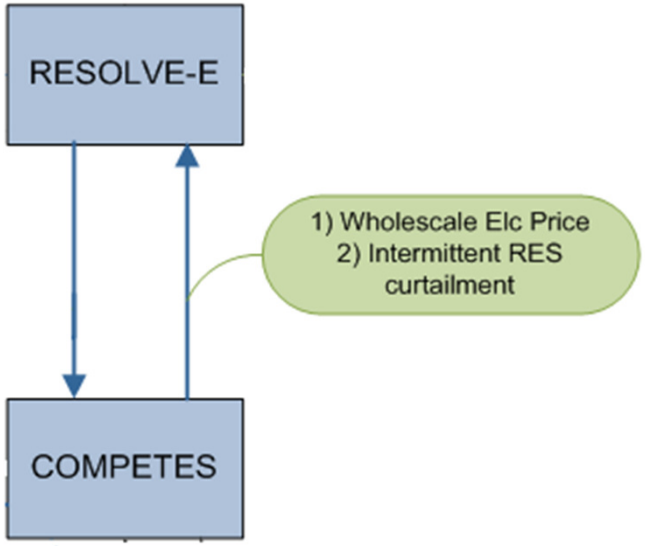
Inputs:

- wholesale electricity price, (the marginal price of electricity derived with TIMES can be used).
- support schemes for RES
- fuel prices
- technical and economic characteristics of RES technologies.

Then COMPETES can be run using

- RES capacity development,
- RES electricity production taken from RESOLVE-E,
- Total electricity demand taken from TIMES,
- Thermal generation investment plan and the transmission investment plan taken from TIMES, shaped by the output of IER-Transmission.

Model linking Scheme – 3b



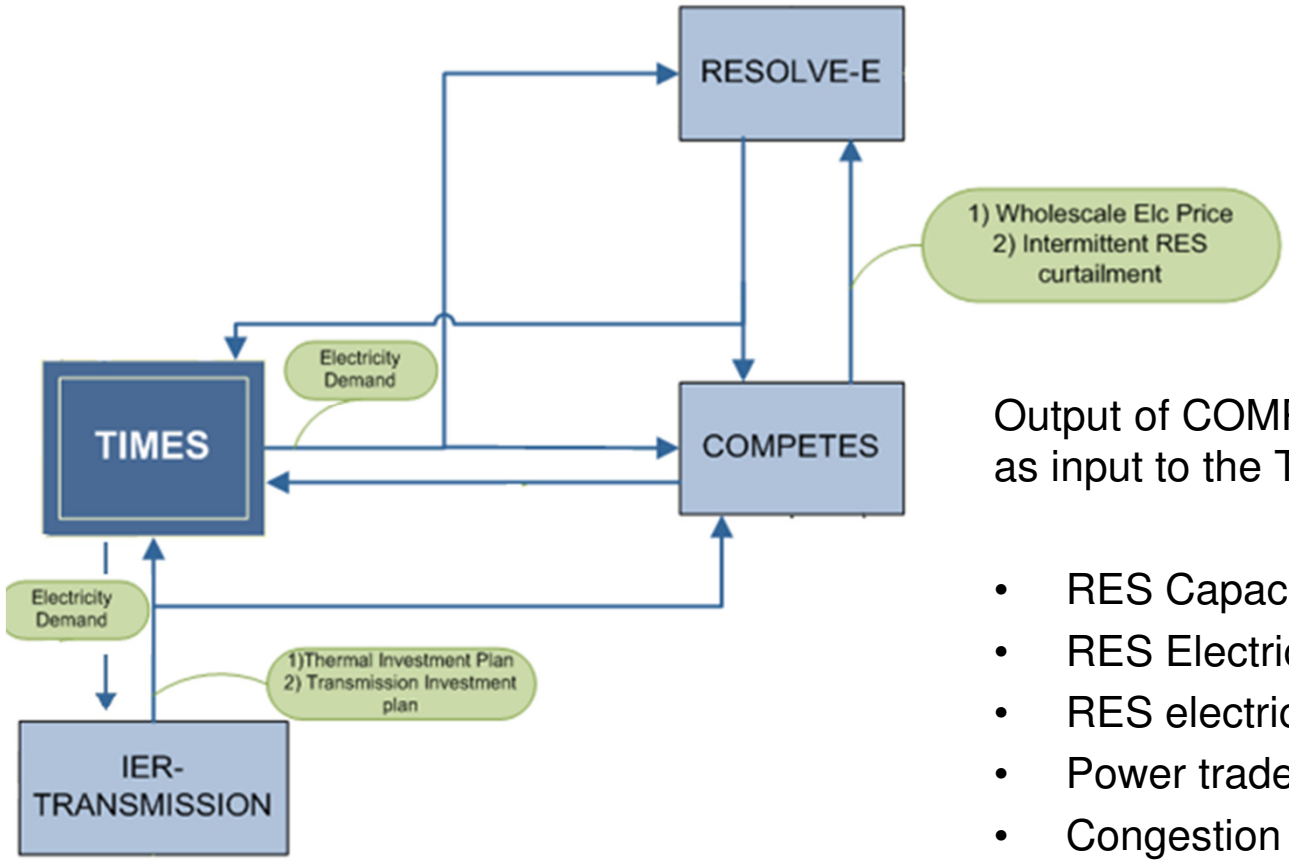
COMPETES outputs used in RESOLVE-E:

Wholesale electricity price (calculated from an hourly simulation, taking into account operational issues like ramp up/down constraints, unit-commitment complexity as well as transmission constraints and the relevant congestion implications).

Expected **load curtailment** and **RES production curtailment** due to RES production intermittency and grid constraints.

The final results will come from RESOLVE-E, where it is necessary to correct the RES production according to the curtailment levels given by COMPETES.

Model linking Scheme – 4



Output of COMPETES+RESOLVE-e used as input to the TIMES model:

- RES Capacity development
- RES Electricity production
- RES electricity curtailment
- Power trade flows
- Congestion price (Marginal price of the transmission capacity).

Model linking Scheme

Convergence formula between models: the iteration between the model runs will result to a shift of the optimal points in each model. Need to define a kind of “confidence intervals” between some key exchange variables.

Linking between TIMES, RESOLVE-E, COMPETES and IER-Transmission:

TIMES gives the final electricity demand to RESOLVE-E, COMPETES and IER-Transmission, RESOLVE-E returns cost development indications about RES, COMPETES provides the wholesale electricity price to RESOLVE-E, IER-Transmission provides the thermal power and transmission grid development

Model linking Scheme

- This iteration will converge when ———— ,
  where is the final electricity demand in the i-th iteration of the TIMES run and is the user specified confidence interval.

- The **optimality of the solution** in such an iteration is **not guaranteed**, and it should be closely monitored and empirically verified.

Conclusions

- Common database: useful for the consistent input to all models.
- Proposed Linking scheme: a first analysis was performed on possible interactions between models.
- Actual exercise should be performed to check the proposal. Extension of some models required to cover the whole of EU.

- **Convergence** and **optimality** of the final solution is an open issue and should be further analysed.