Soft-linking of the TIMES-Italy model to a power and gas system model

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Agenda

- **Context**
  - RSE models for scenario analysis
  - Why do we need a new tool?
- **Methodology**
  - The new power and gas model
  - Soft linking methodology
- **Case study**
- **Conclusions and next steps**

Context: RSE models for scenario analysis

RSE Ricerca Sistema Energetico

1) National Energy Model

TIMES_RSE

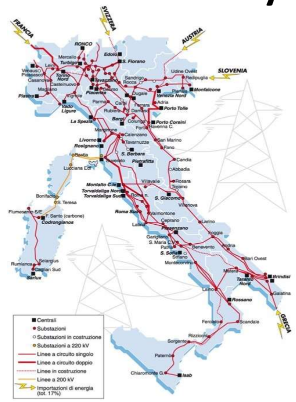
- Italy as 1 node
- Time horizon until 2060-2100
- 12 times slices (*)
- A new climate-zones module

2) Multiregional Energy Model

TIMES_MONET

- 20 regions
- Used to regionalise national results

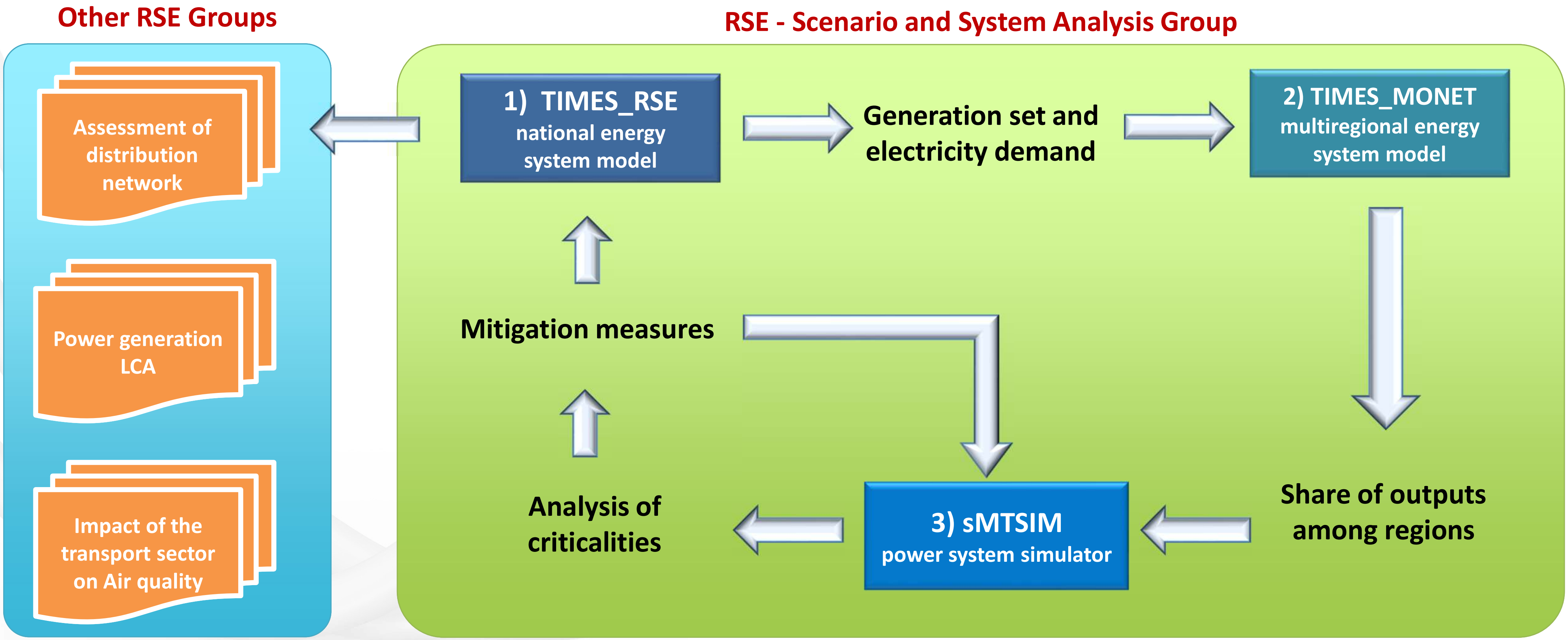
3) Market & Power System Simulator



sMTSIM

- 6 power market zones
- Time horizon: 1 year; 8760 hours
- Unit commitment, power dispatch model

Context: RSE models for scenario analysis



Context: Why do we need a new tool?

Low carbon scenarios envisage future energy systems with high variable renewable energy sources and frequent periods of overgeneration → sector coupling and PtX technologies using excess electricity will be crucial to decarbonisation.

The deployment of PtX plants increases the interconnection between electricity and gas systems → need for appropriate modeling tools that explicitly consider this coupling with bidirectional energy conversion.

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Methodology: the new power and gas model

	TIMES_RSE	Power and gas model (*)
Model type	Linear optimisation (perfect foresight version)	Linear optimisation (perfect foresight)
Language	GAMS + CPLEX	GAMS + CPLEX
Scope	Whole energy system	• Electricity system (transmission grid) • **Gas system** • **H_2 system**
Spatial resolution	Single region	User-definable. For Italy: • 6 power market zones • 1 gas market zone (**)
Temporal resolution	12 time-slices (4 seasons, 3 intraday time-periods)	8760 h/yr

(*) Developed by RSE and Università degli Studi di Bergamo

(**) Because there are no congestion issues in Italy. If relevant, it’s possible to model n° gas market zones with a gas network topology.

Methodology: the new power and gas model

Power sector

Demand: exogeneous hourly net loads for each power market zone

Supply: gas power plants, hydro dams (capacity, efficiency, ramp rates, spinning reserve)

e-storages: pumped hydro and grid batteries (limits for power production, storage level, efficiency, charge/discharge mutually exclusive in any given hour)

Transmission network: lower and upper transmission limits

Constraints for the power system:

- load balance constraint in every zone and every hour;
- spinning reserve level in every zone and every hour provided by thermal plants and e-storages.

Methodology: the new power and gas model

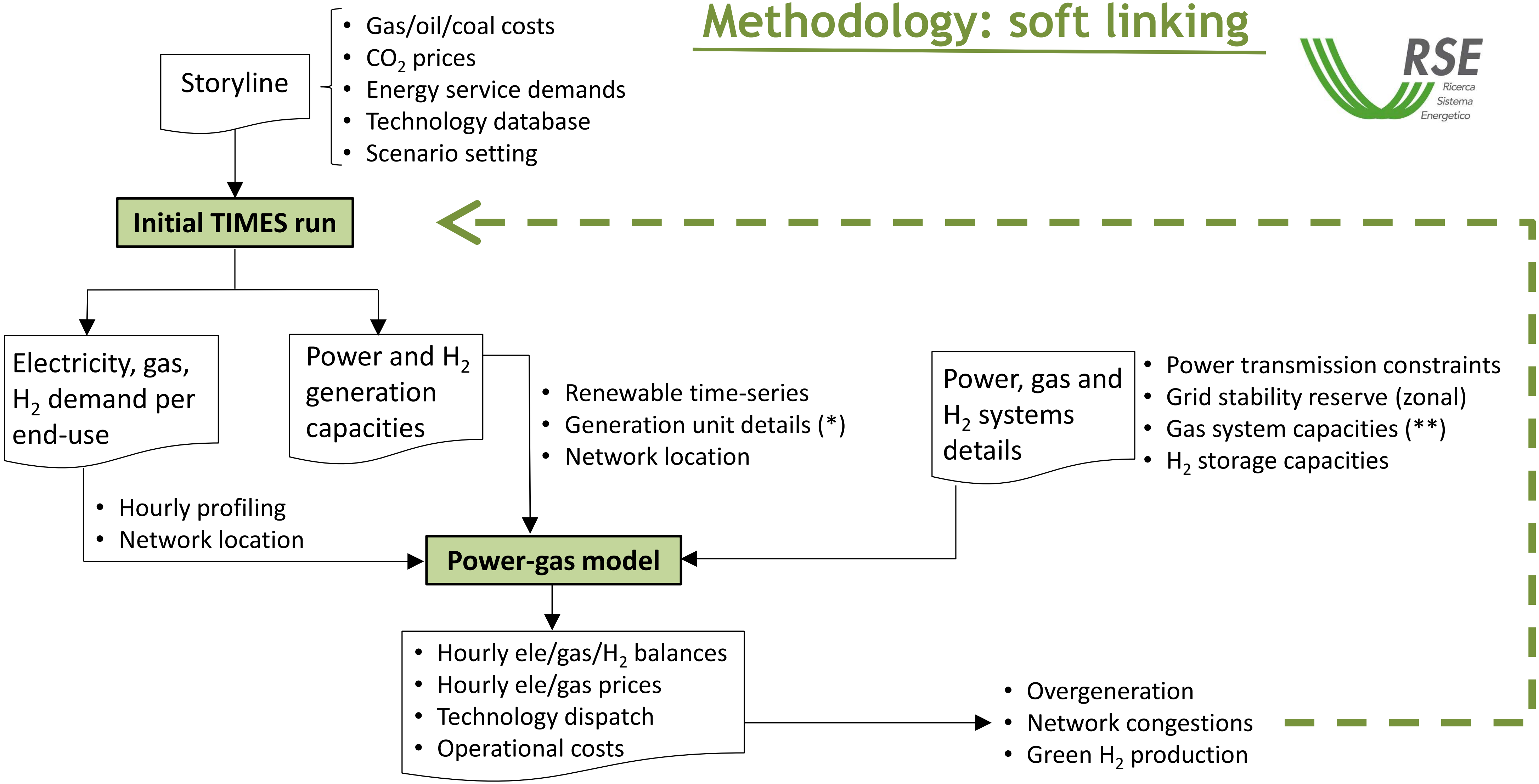
Gas and hydrogen sectors

- **Demand**: exogeneous hourly demand for final consumptions (natural gas, synthetic CH_4, H_2).
- **Gas system**: gas sources (imports and domestic production), gas storage plants, gas pipelines with capacity transmission limits between the gas market zones (if relevant).
- **Hydrogen system**: electrolysers, H_2 storages, methanator for synthetic methane production. (synthetic CH_4 can be used to supply the exogenous demand or injected in the gas network).

- Gas and hydrogen **balance constraints** in every zone and every hour.

Objective function: min OPEX

Methodology: soft linking



(*) Capacity, efficiency, ramps. (**) Supply (import, production) and storages

Methodology: identification of green H_2 production

- National hourly demand for electrolytic hydrogen in an exogenous input.
- In the model, hydrogen can be produced only by electrolysers. Electrolysers can use electricity from any source, not just from renewables.
- However, the emission intensity of H_2 produced from fossil-based electricity is higher than the emission intensity of H_2 produced from natural gas in conventional SMR plants.

→ Need to identify actual green H_2 production from hourly and zonal power and H_2 results

23rd May 2022: the EC published the new EU Draft regulation that sets out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin *(Article 4 - Rules for counting electricity taken from the grid as fully renewable)*

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Case study

Using the TIMES_RSE model, we generated a ***Green Deal* scenario for Italy** starting from the *National Energy and Climate Plan* and imposing the following changes:

- National GDP and population projections were revised downward
- Increased climate ambition: overall constraint of -51% of GHG emissions by 2030
- CAPEX projections for electrolysers were revised downward, assuming the large-scale manufacturing by 2030

→ The *Green Deal* scenario presents the first hydrogen applications by 2030:

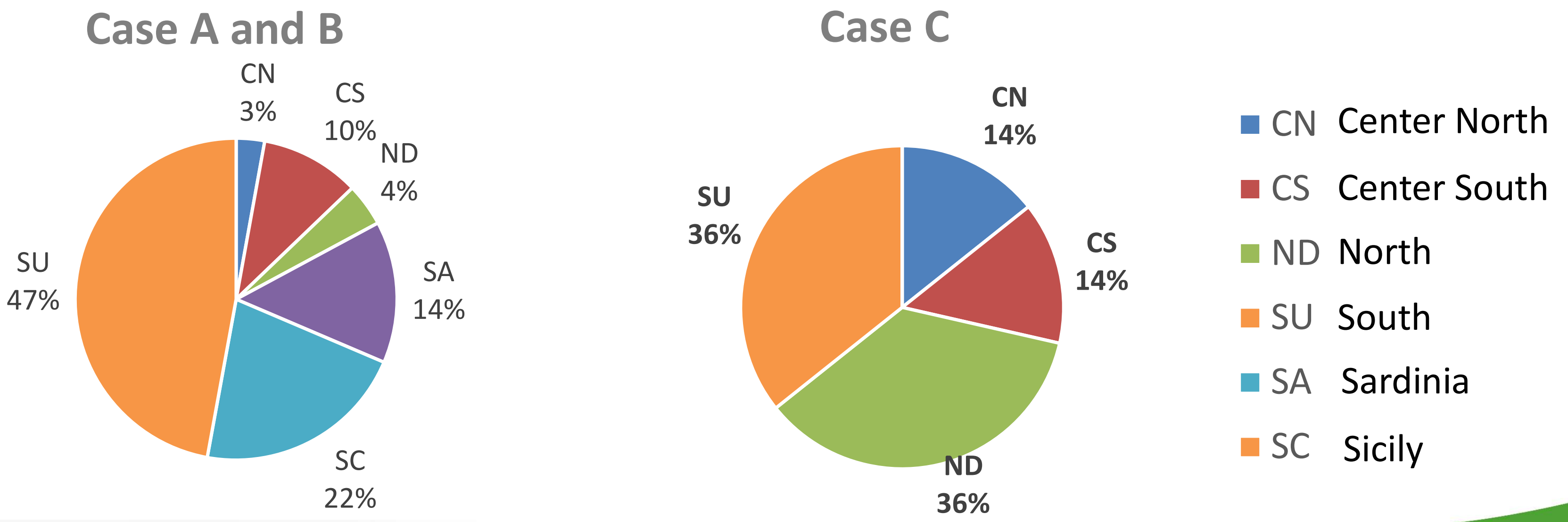
- total demand for transport and industry ≈ 0.5 Mtoe
- total PtH_2 capacity from the TIMES_RSE model = 3.6 GW_{el}

Case study

3 simulations with the **power & gas system model** varying the installed capacity of electrolysers and e_storage systems:

- **Case A:** 3.6 GW of electrolysers located to facilitate the integration of VRE into the power system
- **Case B:** 7.0 GW of electrolysers located to facilitate the integration of VRE into the power system
- **Case C:** 7.0 GW of electrolysers located near possible hydrogen demand centres (NRR Plan)

Electrolysers capacity allocation between the power market zones:



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The capacity for PtH_2 and e_storage systems is determined considering different evaluation criteria:

1. Provide the desired amount of green H_2;
2. Minimize the use of electricity from gas power plants for H_2 production;
3. Allowing the highest possible load factor for PtH_2 plants;
4. Minimize the thermoelectric production;
5. Contain renewable overgeneration.

Case study

	Assumptions		Results			
	PtH_2 capacity (GW_{el})	Additional e_storage capacity (GW_{el})	Power cons. for green H_2 (TWh el)	Power cons. for "black" H_2 (TWh el)	Over-generation (TWh el)	Comments
TIMES_RSE	3.6		8	-	-	
Case A	3.6	+6 (as in the NECP)	**5**	**3**	1	Not able to supply the green H_2 demand
Case B (serving power syst.)	7	+2	7	1	0.4	Ok for the power sector, but difficult H_2 logistics
Case C (serving H_2 dmd)	7	+2	**5**	**3**	1.9	Not able to supply the green H_2 demand, but ok for the H_2 logistics

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Conclusions and next steps

- A new dispatching optimization model of electricity-gas sectors with potential bi-directional energy conversion.
- Sensitivity analysis is important to minimize the use of electricity from gas power plants for H_2 production.
- Higher shares of green H_2 could be obtained by increasing H_2 storage capacities and assuming more flexible H_2 demand profiles.

Possible model developments:

- Power sector: more technical constraints (e.g. minimum load for power plants, explicit representation of 1st, 2nd, 3rd reserve power)
- Additional sector coupling options: H_2 blending, PtHeat, PtL
- EU scenarios to test the version with different gas market zones

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