Università degli studi di Napoli Federico II

Scuola Politecnica e delle Scienze di Base

Corso di Laurea Magistrale in Ingegneria per l'Ambiente e il Territorio

Tesi di laurea:

LOW-CARBON STRATEGIES AND TRANSMISSION CAPACITIES FOR EUROPEAN ENERGY SYSTEMS

Relatori:

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Candidato:

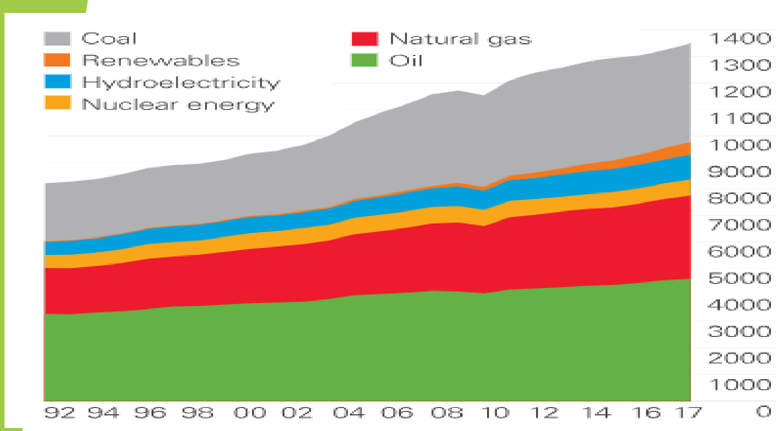
Federica Di Donna M67/350

Outline

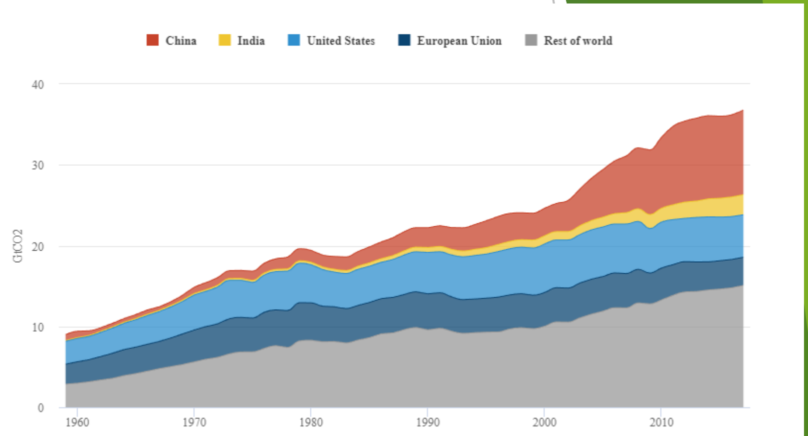
- Energy Overview
- Methodology and tool
- Modelling the Italian energy system
- Modelling the South East Europe energy system
- Interaction between energy system

Global Energy Trends and Global warming

Primary energy world consumption (Mtoe)



C02 emissions from fuel combustion (Gt of CO_2)



Primary energy consumption is increasing:

- +1,2% in 2016
- +2,2% in 2017

- The average temperature rise of the Earth surface is almost linearly proportional to the cumulative emissions of CO_2.
- The surface Earth temperature has increased of 1,5°C with respect to the preindustrial value.

Global Strategies For Mitigation

UNFCCC

1992

UNFCCC was signed by the **United Nations Conference on Environment and Development**, in Rio de Janeiro, an international treaty whose goal was the reduction of greenhouse gas emissions not imposing mandatory limits.

1997

"**Kyoto Protocol**" was adopted, implementing the aim of the UNFCCC to fight global warming by reducing GHG concentrations in the atmosphere. The Protocol fixes the obligation to reduce current emissions in developed countries

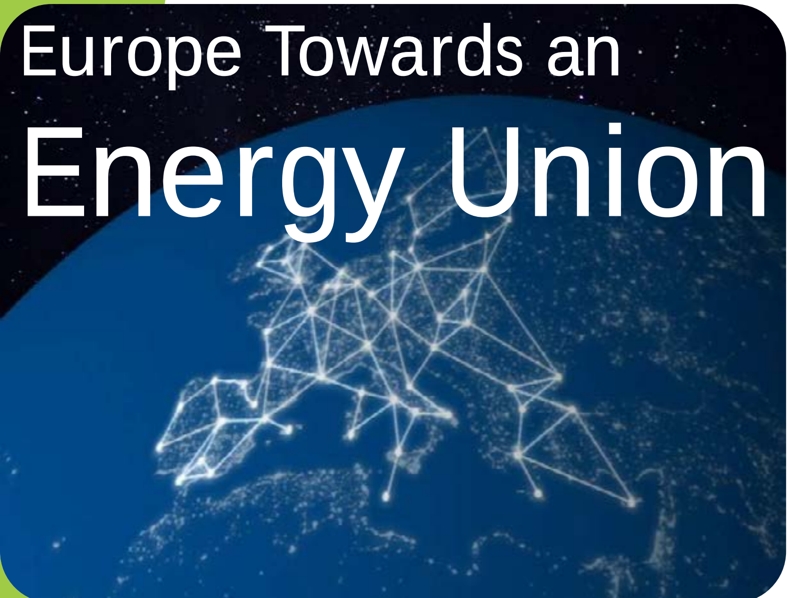
2015

Paris Conference saw a unanimous agreement on significant reduction of the use of fossil fuels, influencing the strategies that will be implemented in the coming decades and reiterating the urgency of choices that would go towards the decarbonization of energy consumption in order to reduce GHG emissions.

2018

COP24

EU strategies



5 dimensions:

- Energy Security and Solidarity
- Internal Energy Market
- Decarbonisation
- Moderation of demand
- Innovation and Competitiveness

2020

-20% GHG emissions | 20% Renewable Energy | 20% Energy Efficiency | 10% Interconnection

2030

- 40% GHG emissions | 27% Renewable Energy | 30% Energy efficiency | 15% Interconnection

Integrated European grids are indispensable for making the energy transition a success

2050

The roadmap to a low carbon economy predicts that by 2050 the EU will reduce its GHG emissions by 80% compared to 1990 levels

Aim of the work

In this work we study the interaction between Italian energy system and SEE countries

Italian transmission grid is interconnected to the rest of UCTE Power System by means of 22 interconnection lines: with France, Switzerland, Austria, Slovenia, Greece, and one additional cable between Sardinia and Corsica.

Table 1-Existing linee

	Capacity (MW)
Italy-France	3150
Italy-Switerzland	4240
Italy-Austria	315
Italy-Slovenia	730
Italy-Greece	500

Table 2- Development plan

	Capacity (MW)	Status
Italy-Slovenia	1000	Concept/early planning
Italy-Croatia	1000	Concept/early planning
Italy-Albania	1000	Concept/early planning
Italy-Montengro	600	Under construction

The work is composed in two step:

EnergyPLAN Advanced energy system analysis computer model

Modelling scenarios

- Reference scenarios (2015)
- Future scenarios (2030-2040-2050)

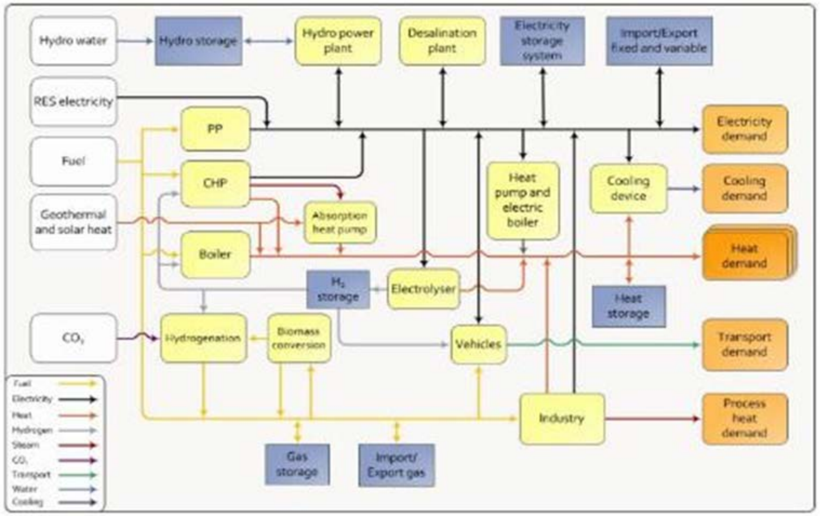
MultiNode

Analysing the interaction

- Italy-Slovenia
- Italy-Greece
- Italy-Croatia
- Italy-Montenegro
- Italy-Albania

Energy PLAN
Advanced energy system analysis computer model

II software: EnergyPLAN



- **Deterministic model**
- **Optimizes the operation, by an hourly quasi-static simulation**

Data

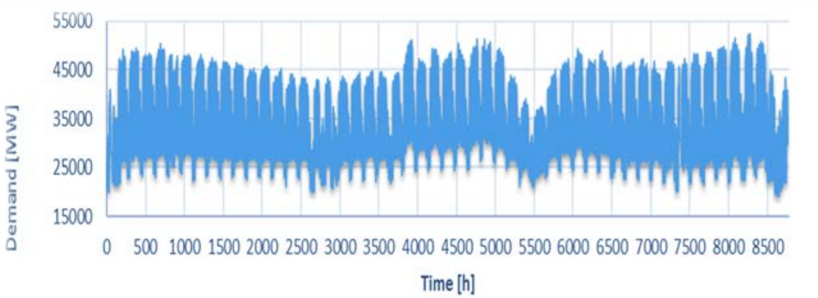
- Demand
  - Electricity
  - Heating
  - Cooling
  - Transport
  - Industry
- Supply
  - Heat and Electricity
  - Renewable Energies
  - Heat Only
  - Waste

Italian energy system modelling: Reference sccenario

Demand Section:

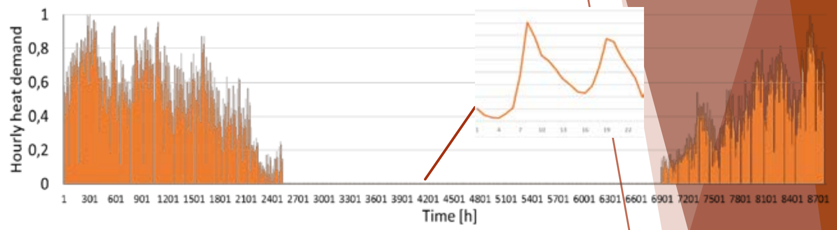
Electricity

Total electricity demand was equivalent to 309 TWh and 85.9% was covered by national production



Individual Heating

Hourly heat demand was evaluated using the heat degree days (HDD) of 5 cities. The aggregated distribution curve is a weighted average of the 5 individual ones, considering the population of each zone.

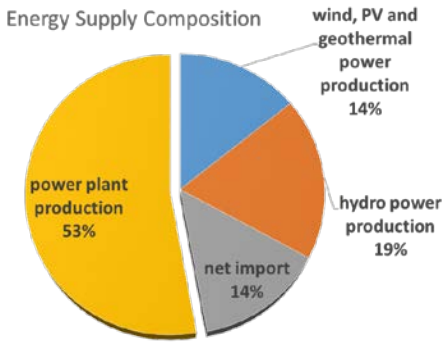


Transport

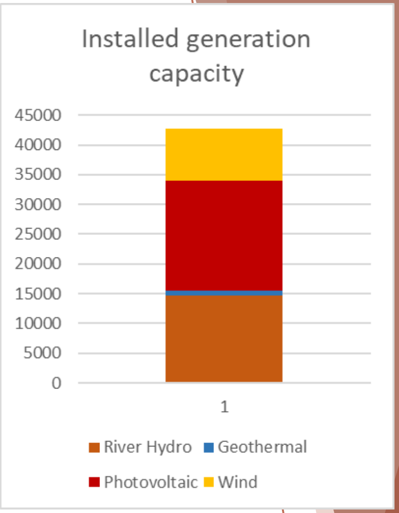
	[Mtoe]	[TWh]
Jet fuels consumption by transport	3,722	43,287
Diesel consumption by transport	22,773	264,853
Gasoline consumption by transport	8,495	98,792
Gas consumption by transport	1,072	12,469
LPG consumption by transport	1,718	19,985
Electricity consumption by transport	0,900	10,464
Biofuel consumption by transport	1,065	12,391

Italian energy system modelling: Reference sccenario

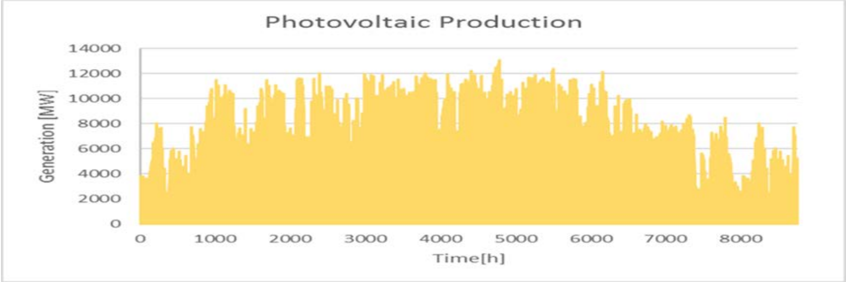
Supply Section: Electricity Only

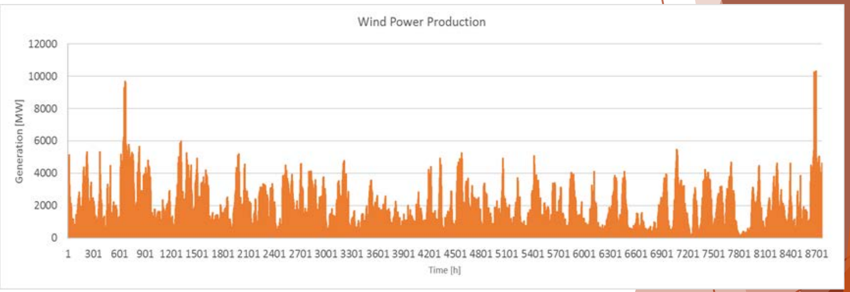


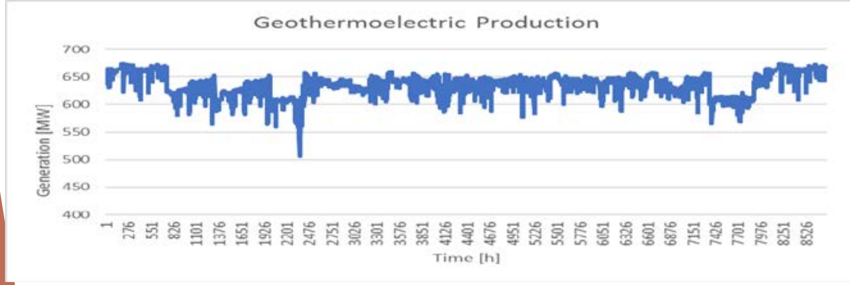
	Installed generation capacity [MW]	Production [TWh/y]
River Hydro	14641	58,54
Geothermal	821	5,9
Photovoltaic	18609	22,3
Wind	8703	15,18

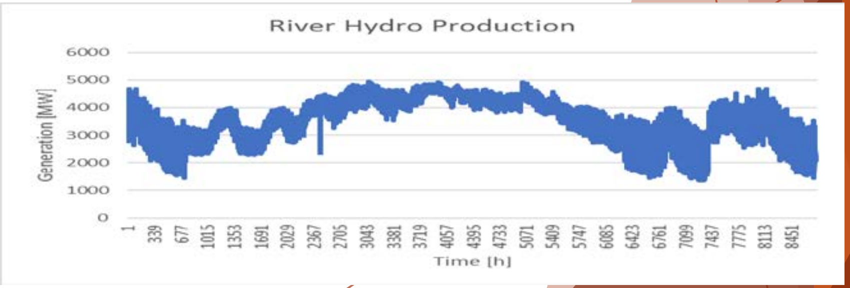


Hourly distribution:



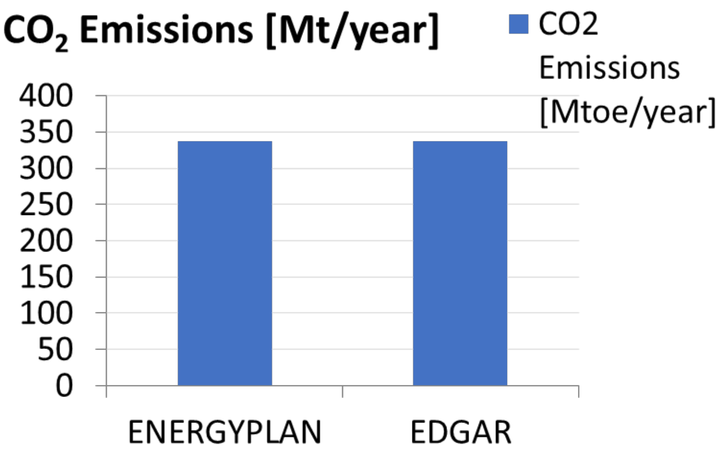


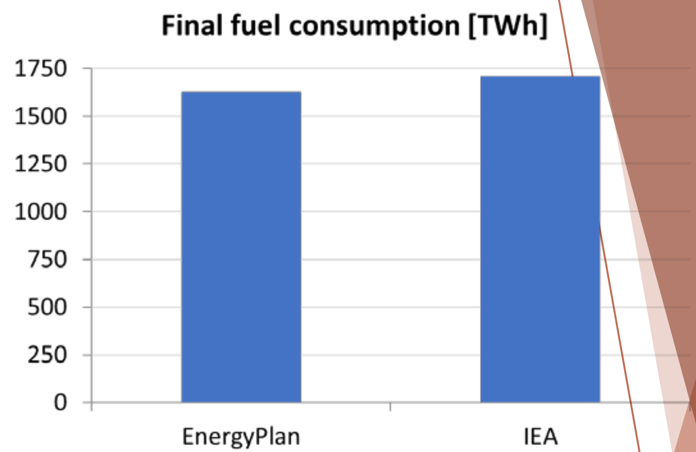




Italian energy system modelling: Reference sccenario

The Results





EnergyPLAN output value is 337,66 Mtoe
EDGAR value is 337,61 Mtoe

EnergyPLAN output is 1630 TWh
IEA value is 1707 TWh

Differences are < 5%

Future Scenario (2030 2040 2050)

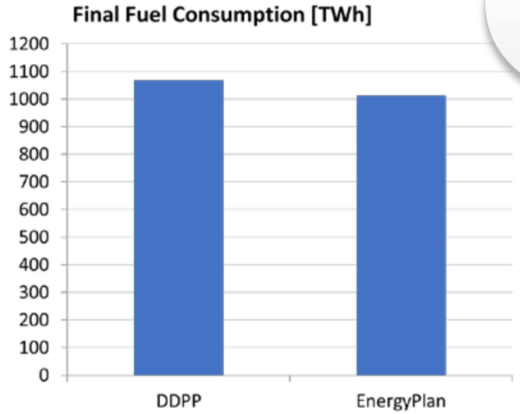
ENTE PER LE NUOVE TECNOLOGIE, L'ENERGIA E L'AMBIENTE

DDPP DEEP DECARBONIZATION PATHWAYS PROJECT

Main drivers of deep decarbonization are:

- Improvements in energy efficiency
- Almost total decarbonization of power generation
- High level of electrification of heating and transport
- Large share of electricity from renewable energy sources
- Modal shift and consumers' attitude towards public transport

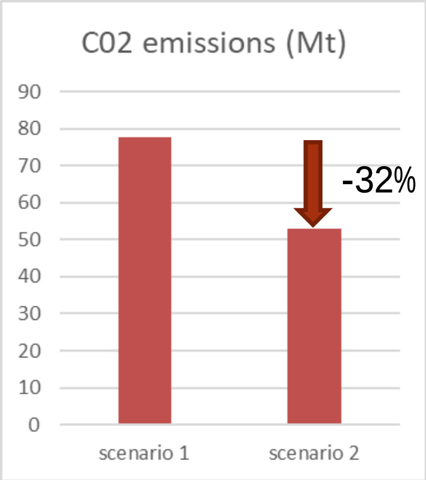
Results and Critical Issues



	CO_2	Final Consumption
EnergyPLAN	77,6 Mt	1014 TWh
ENEA	81,6 Mt	1070 TWh

Alternative scenario: 2050

- A greater electrification of transport was considered
- Coal and Oil have been completely replaced by Natural gas in the Industry and Fuel section
- The vehicle to grid technology has been added



South East Europe energy system modelling

Reference scenario: 2015

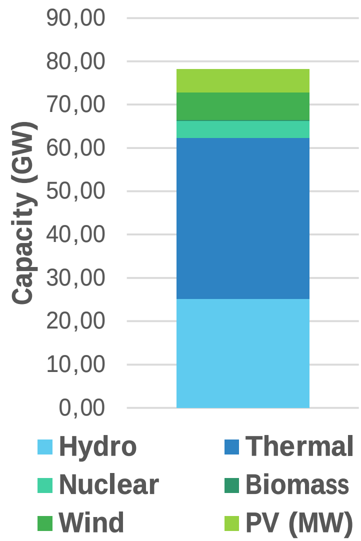
Demand section : Electricity

	Electricity demand (TWh)
Albania	7,28
B&H	13,5
Bulgaria	38,66
Croatia	18,19
Greece	61,49
Macedonia	8,16
Montenegro	3,52
Romania	59,57
Serbia	37,39
Slovenia	15,05
Kosovo	6,25
Tot	269,06

Reference: IEA

Supply section

Installed generation capacity in SEE:



	Hydro(MW)	Thermal(MW)	Nuclear(MW)	Biomass(MW)	Wind(MW)	PV (MW)
Albania	1798	0	0	0	0	1
B&H	2141	1590	0	0	0,3	10,9
Bulgaria	3219	6613	2000	34	700	1029
Croatia	2208	1681	348	25	418	48
Greece	3392	9741	0	2	2091	2604
Macedonia	658	800	0	0	37	17
Montenegro	656,07	208	0	0	0	2,7
Romania	6730	9460	1300	104	3130	1326
Serbia	3022	4642	0	0	10,4	12
Slovenia	1295	1495	348	30	5	238
Kosovo	43	885	0	0	1,35	0,102
tot	25162,07	37115	3996	195	6393,05	5288,702

Validation of the models

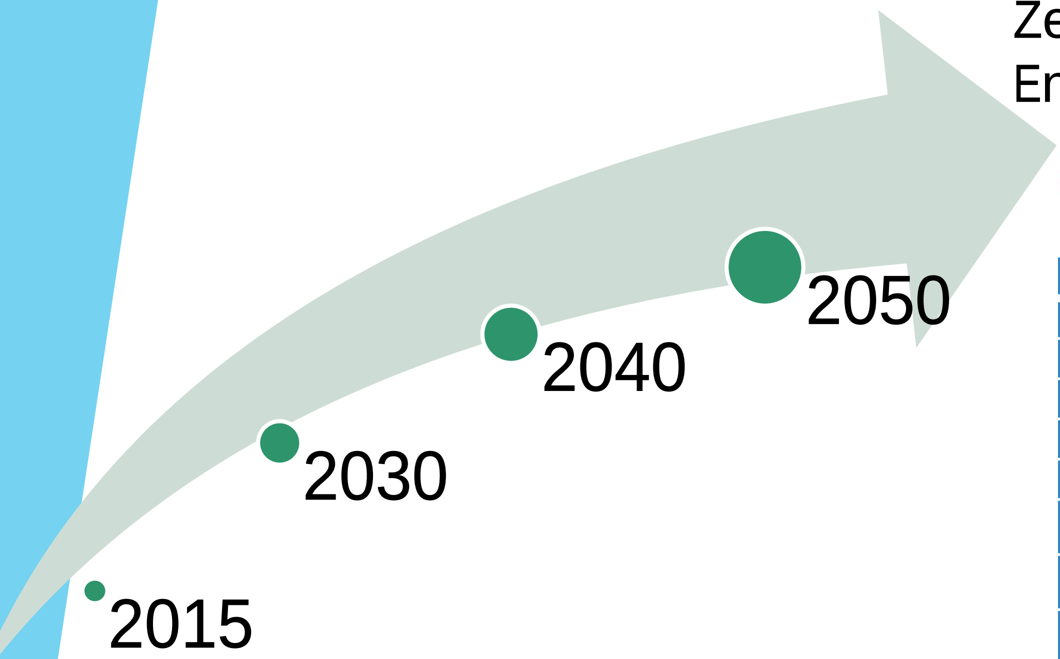
The reference scenarios are validated through a comparison between the results and the data available on IEA. The differences are accettable.

International Energy Agency

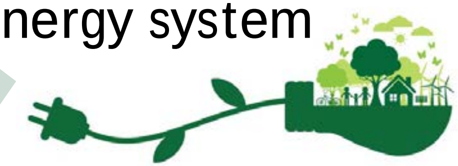
Electricity production:

	Model (Gwh)	IEA (GWh)	%
Albania 2015	5900	5895	-0,08
Bosnia and Herzegovina 2015	15640	15629	-0,07
Bulgaria 2015	51760	49228	-4,89
Croazia 2015	11160	11403	2,18
Grecia 2015	54810	51874	-5,36
Kosovo 2015	6120	6119	-0,02
Macedonia 2015	5700	5646	-0,95
Montenegro 2015	2900	3003	3,55
Romania 2015	71810	66296	-7,69
Serbia 2015	40250	38298	-4,85
Slovenia 2015	15250	15100	-0,98

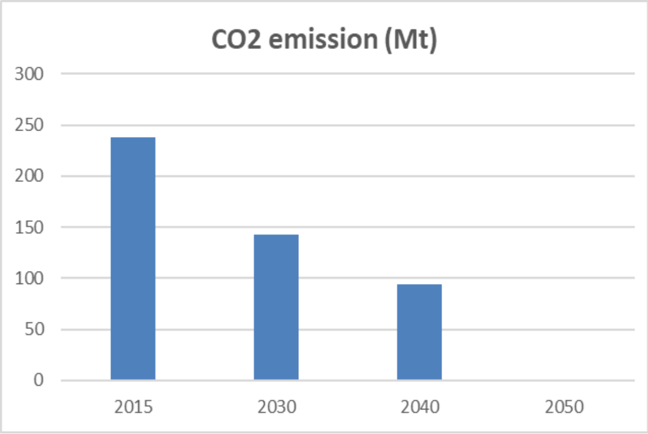
Future scenario and comparison

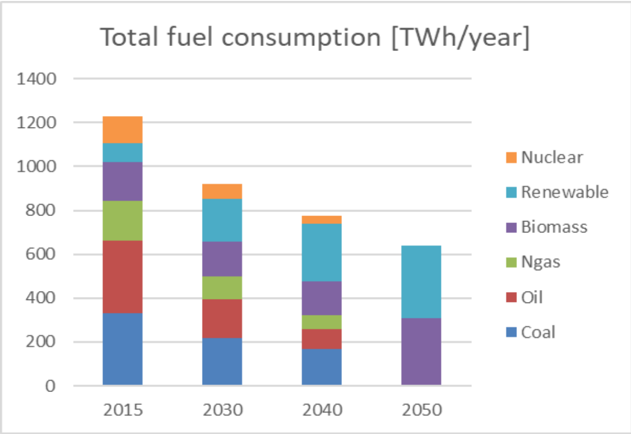


Zero-carbon
Energy system



	2015	2030	2040	2050
CO2 [Mt]	238,35	143,073	94,3	0
TPES [TWh/year]	1226,89	921,5	773,31	702,86
Coal [TWh/year]	329,74	216,44	166,77	0
Oil [TWh/year]	333,58	177,67	90,31	0
Ngas [TWh/year]	179,21	106,04	64,5	5,5
Biomass [TWh/year]	177,17	158,18	154,61	308,73
Renewable [TWh/year]	87,99	195,15	263,06	388,63
Nuclear [TWh/year]	119,2	68,03	34,06	0

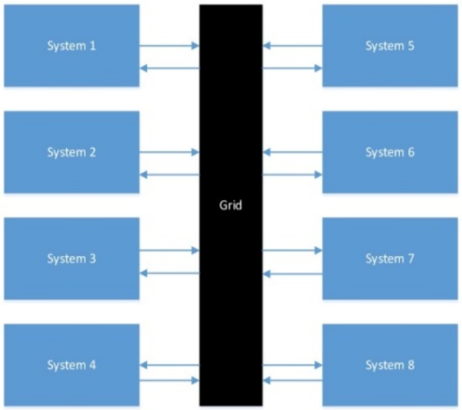


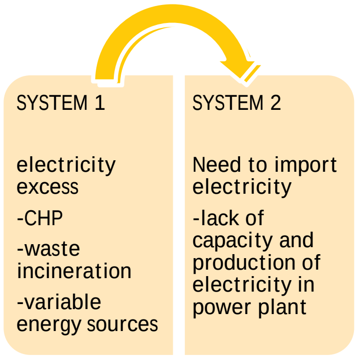


In 2050 TPES is reduced by 42.7%

Interaction between Italy and SEE

- The tool: **MULTINODE**





- Four different scenario are analyzed:

	Capacity (MW)
Scenario 1	1230
Scenario 2	1830
Scenario 3	2230
Scenario 4	4830

The results

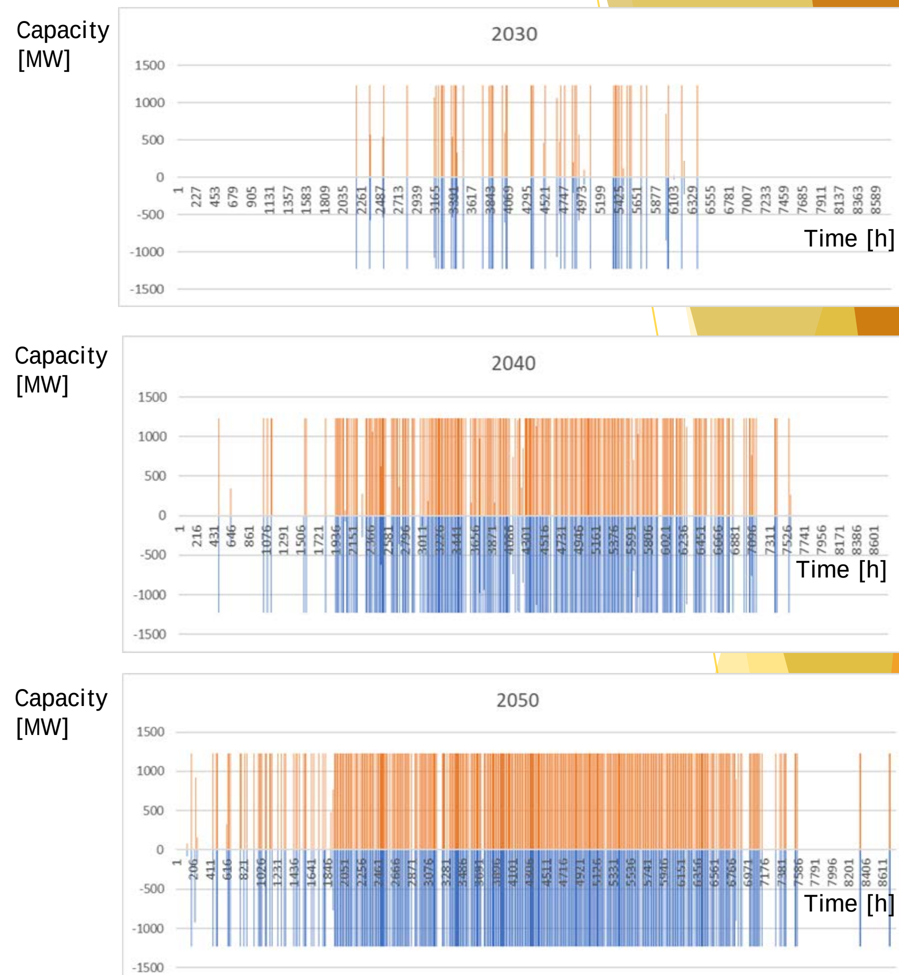
Scenario 1
Transmission capacity: 1230 MW

Total annual demand:

	Import /export (TWh/year)	
	Italy	SEE
2030	-0.15	0.15
2040	-1.18	1.18
2050	-1.96	1.96

	N° of hours in which import/export takes place	N° of congested hours
2030	149	103
2040	1011	907
2050	1639	1560

Import/export distribution:



The results

Results

Scenario 4
Transmission capcity: 4830 MW

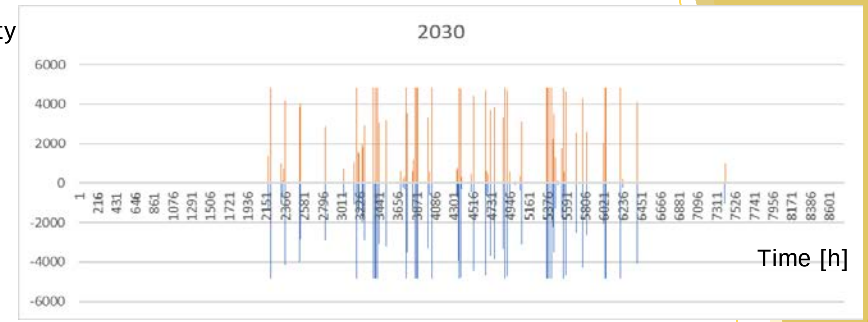
Total annual demand:

	Import /export (TWh/year)	
	Italy	SEE
2030	-0.46	0.46
2040	-4.02	4.02
2050	-7.15	7.15

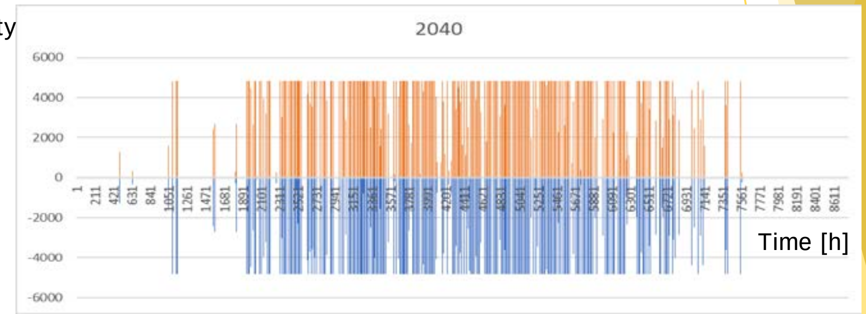
	N° of hours in which import/export takes place	N° of congested hours
2030	182	34
2040	1012	664
2050	1645	1328

Import/export distribution:

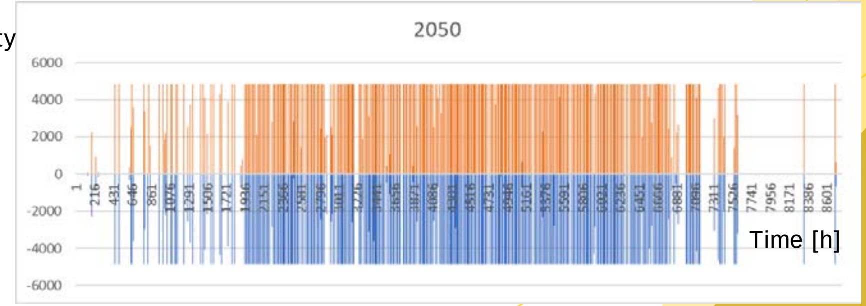
Capacity [MW]



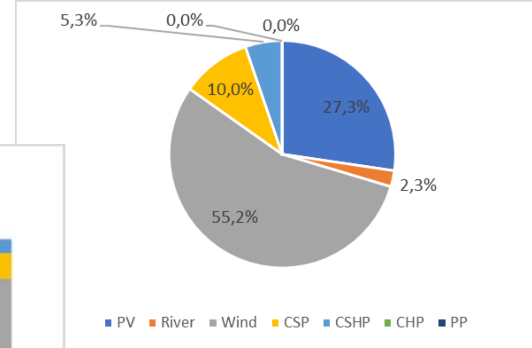
Capacity [MW]

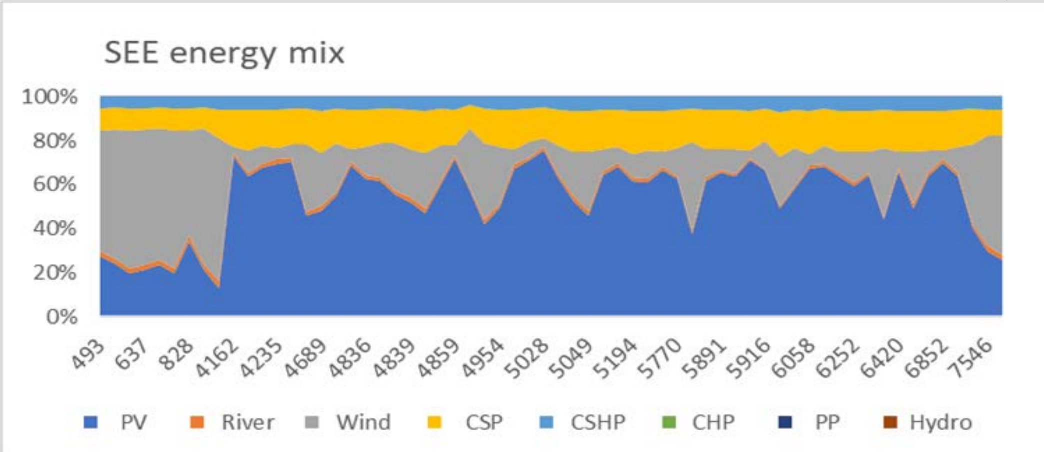


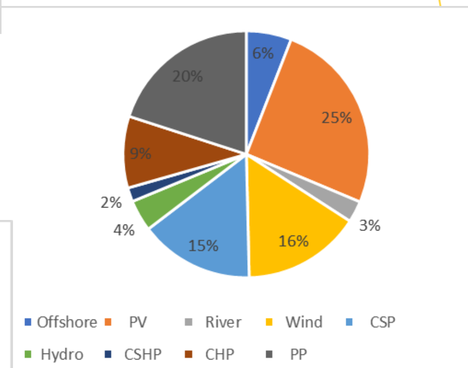
Capacity [MW]

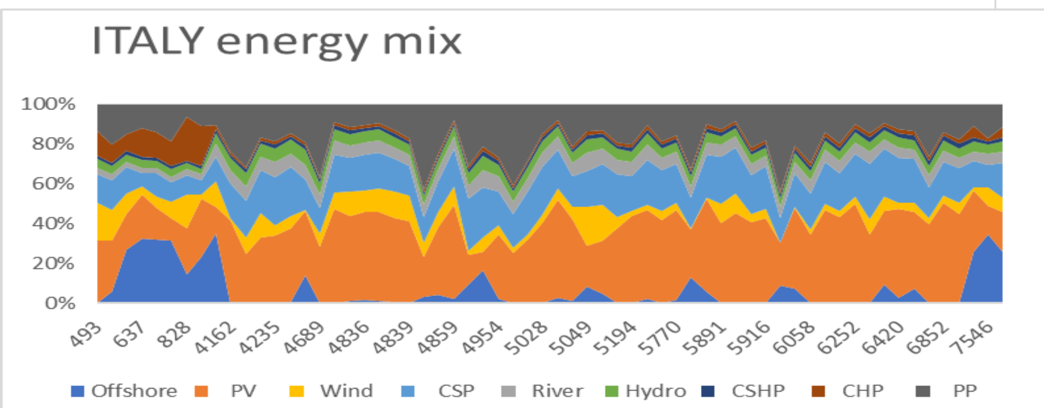


The results









SEE always transfer only renewable to Italy

Energy overview | Methodology and tool | Modelling Italian energy system | Modelling South East Europe energy system | Interaction between energy system

Conclusion

- In order to achieve the deep decarbonization goals a drastic transition is needed.
- Renewable sources and a strong electrification of heating and transport services should progressively replace fossil fuel consumption.
- This requires the upgrade of the electric grid, (increasing the interconnection of market areas, reinforcing the ability to transport electricity).
- Italy could benefit from future excess of renewable energy of SEE countries.
- The transmission capacity value between the two systems could still be increased.

Thank you for your attention