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South-East Europe Electricity Roadmap

Economic Assessment of a hypothetical interconnector RO-BG

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REKK

SEERMAP Electricity Network Assessment workshop

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REKK FOUNDATION

Outline

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- Introduction
- Economic vs financial focused assessment
- Verification of investment cost
- Social welfare calculation
- ENS, Loss change, RES and CO_2 impacts
- NPV calculations

Cost-Benefit Analysis 1

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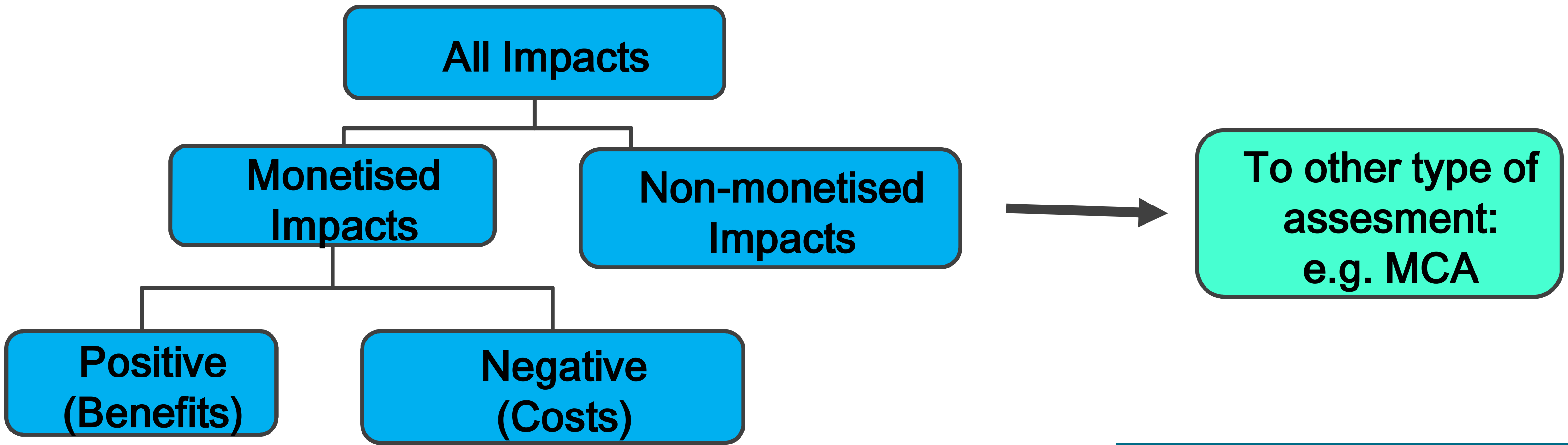
A cost-benefit analysis (CBA) is a technique to systematically compare the benefits and and revenues with the costs over the life span of an investment project.

- Project evaluation from the view point of different stakeholders is called Cost Benefit Analysis
- The cost-benefit analysis assesses all possible costs and benefits of a project – but not all could be monetised!
- Costs and benefits to be included in the CBA need to be quantified and monetised – so some impacts should be left out:
- Additional qualitative criteria can be considered outside a CBA (second stage analysis)



Source: EnC PECI assessment WGM 2014

Cost-Benefit Analysis 2

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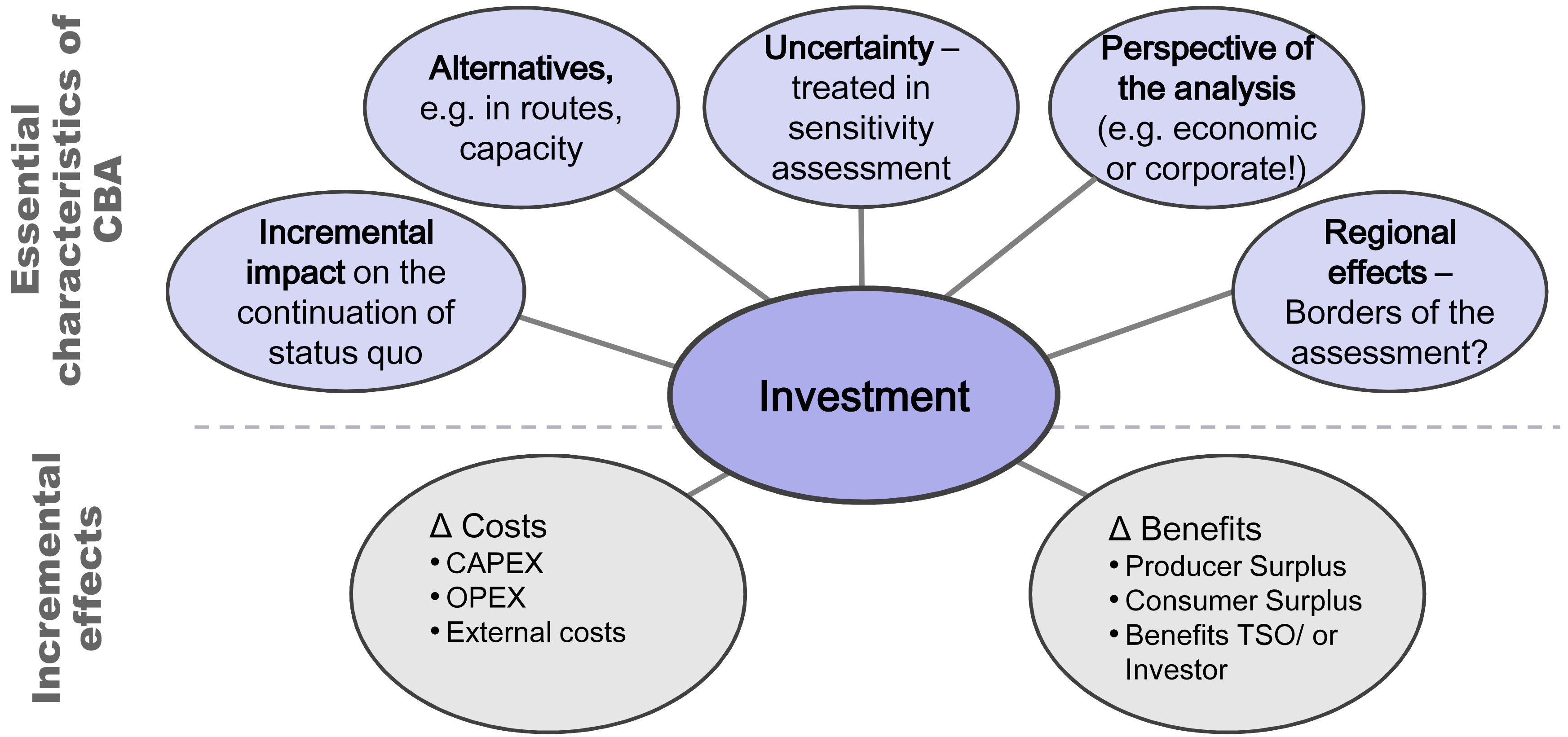
CBA has been increasingly used by policy makers for evaluation of new investments in important projects.



Source: EnC PECI assessment WGM 2014

Economic assessment 1

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Generally two types of assessment is carried out:

- Economy wide assessment – including the whole electricity sector – consumers, generators, network companies.
  - Main questions:
    - Is it beneficial for the country/region to build up the new line?
    - Who are the winners and losers in the new situation?
- TSO focused assessment: covering costs and benefits related to the TSO only. In this type of assessment interested parties:
  - TSO, Financing institutions (e.g. EBRD), Regulator
  - Main questions:
    - Is the TSO able to finance the project?
    - How much consumers have to pay more for this line?
    - How much tariffs will increase due to the new line?

Verification of project cost

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- There are important benchmarking reports on investment cost of high voltage electricity transmission line.
- Most important:
  - ACER Unit Investment Cost report (2015) http://www.acer.europa.eu/Official_documents/Publications/UIC_Electricity_History/UIC%20Report%20%20-%20Electricity%20infrastructure.pdf
  - Gives unit cost to transmission lines (per Km), by:
    - Type (overhead, underground, subsea cables)
    - Voltage level (220 to 400 kV)
    - 1- 2 circuits
  - And to associated equipments, e.g. to AC substations, individual transformers by capacity.

ACER Unit Investment Cost ranges

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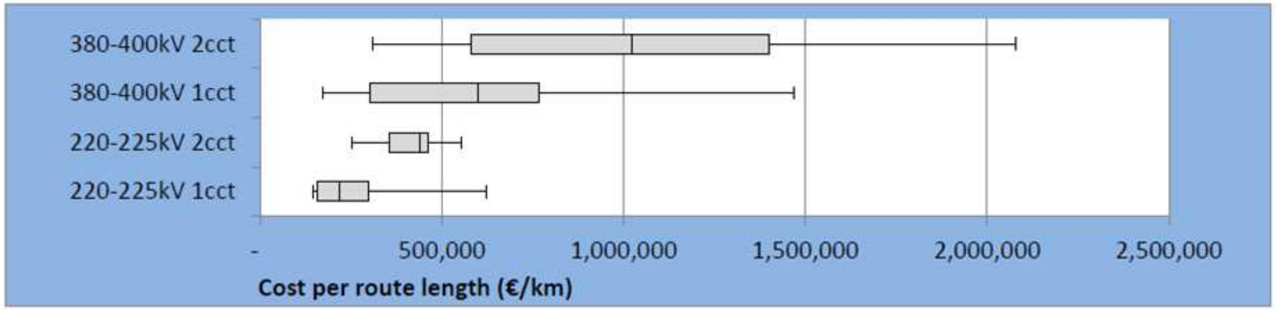
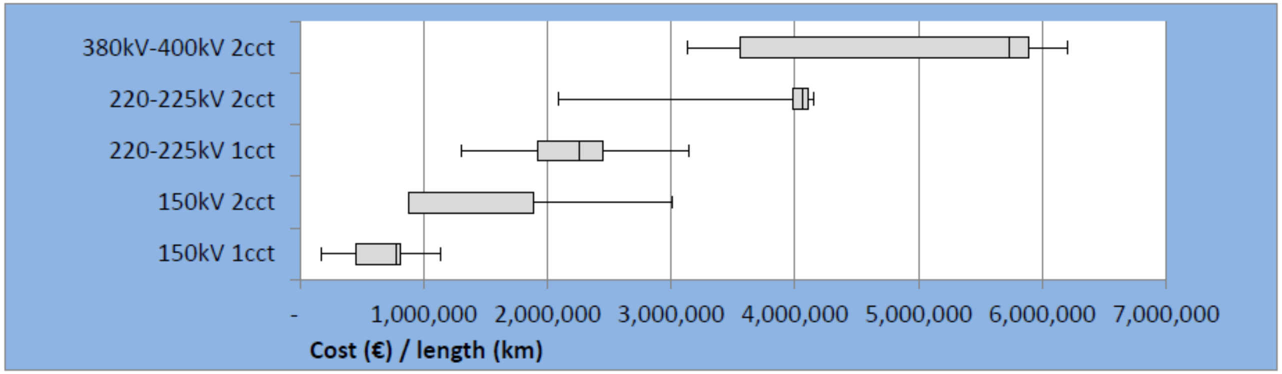
- Overhead lines:

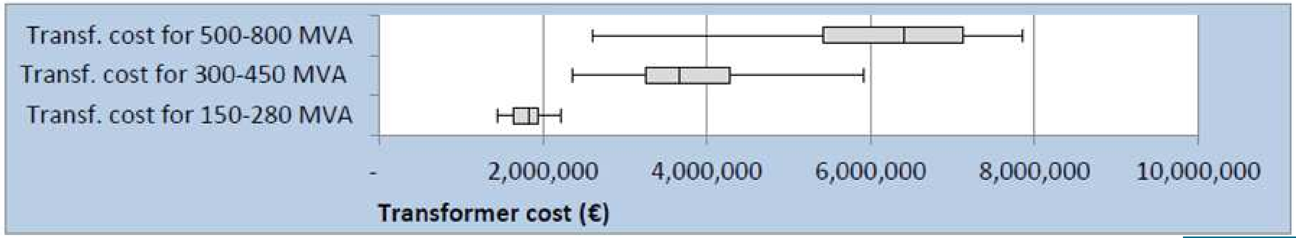


New vs, refurbishment line cost significantly differ!

- Underground cables:



- Transformer costs



Source: ACER UIC Report 2015

Calculation of Social Welfare components

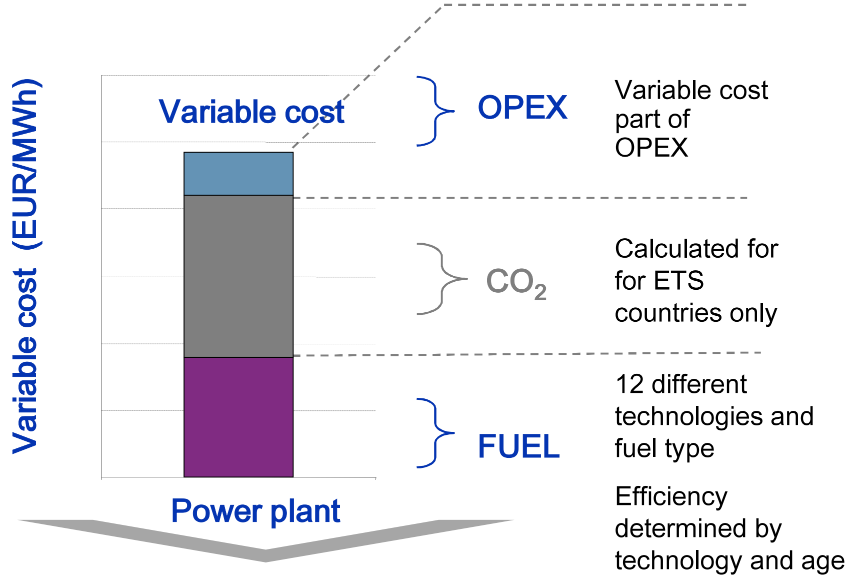
Economic assessment 2

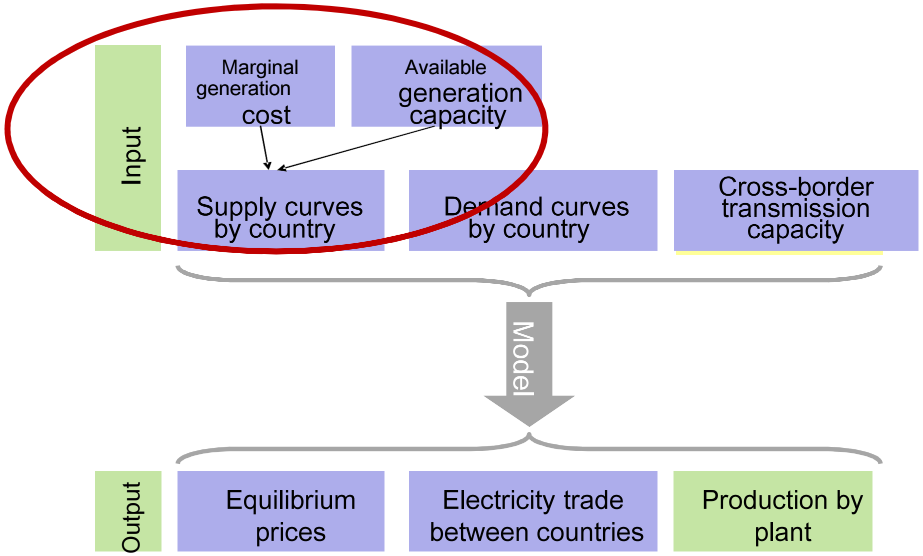
Social welfare change is the main component in economic CBA.

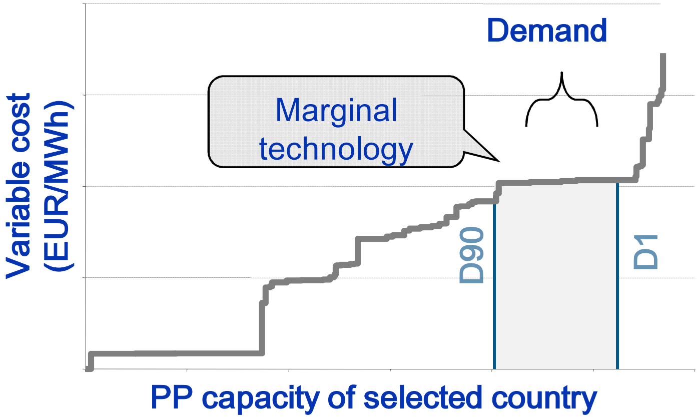
It needs input from both network and economic models:

- From technical network model:
  - NTC
- From economic model:
  - Price changes (baseload and peakload)
  - Socio-economic impact calculation

Supply Side: Calculation of Variable Costs and Merit Order







MERIT ORDER

- Power plants with increasing marginal costs are ordered next to each
- The merit order as supply curve shows the competitiveness of different technologies/power plants in a given country
- Marginal power plant set by the actual demand determines the power price
- Due to the cross-border capacities and import/export between the countries, foreign power plants could set the domestic power prices in a given moment

Cross Border Trade and Demand Side

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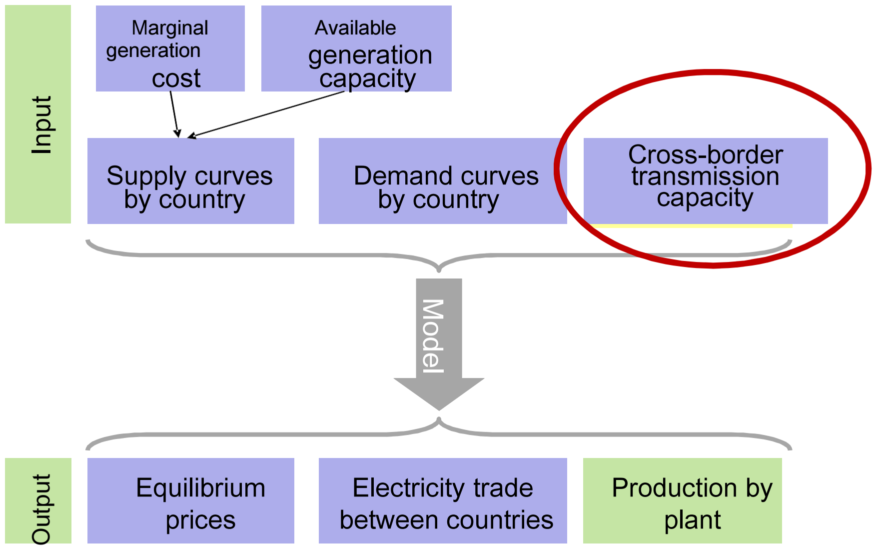
Cross border trade

- Based on Net Transfer Capacity (NTC) values
- Non-satisfied demand for capacity results in price differences amongst regions

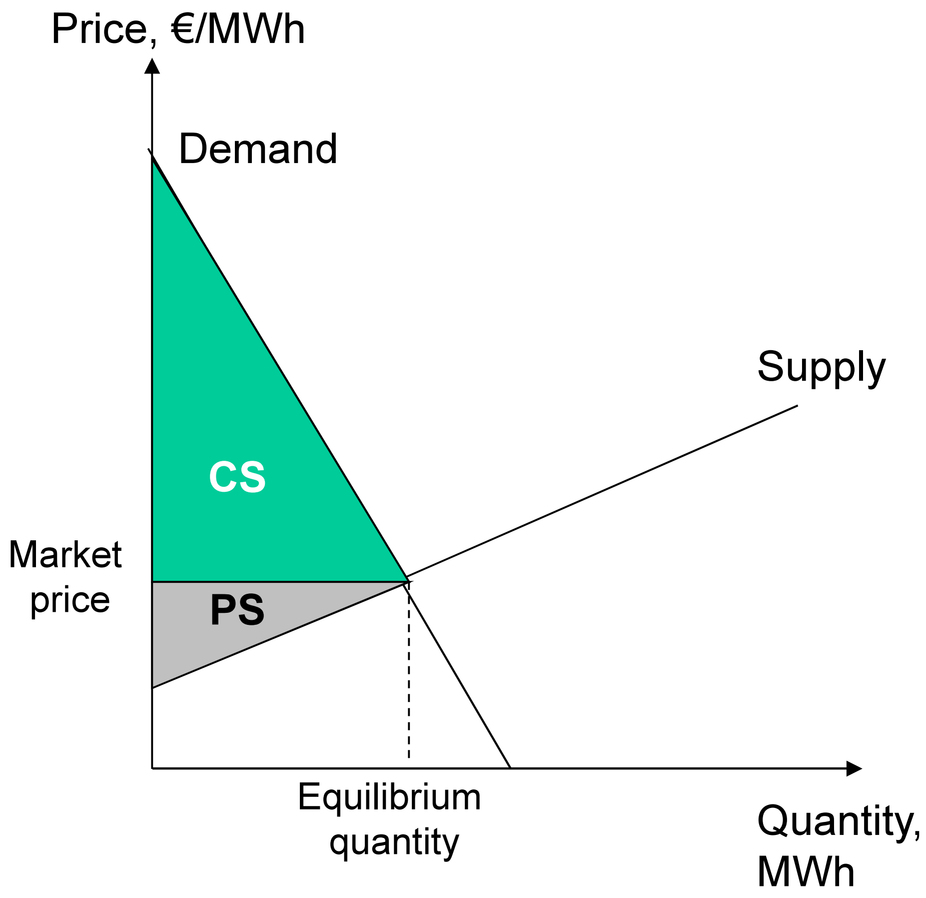
	Country A	Country B
Generation capacity	1000	500
MC	50	100
Consumption	400	400
Price	**50**	**100**
1.Case: 0 MW NTC	**50**	**100**
2.Case: 50 MW NTC	**50**	**100**
3.Case: 200 MW NTC	**50**	**50**



Demand side

- Based on hourly modelling
- 90 representative hours, weighted to cover the year:
  - calculates baseload and peakload prices,
  - welfare effects

Welfare Components



Consumer surplus (CS):

Consumer surplus is the difference between the maximum price a consumer is willing to pay and the actual price they do pay.

Producer surplus (PS)

Market price multiply by the equilibrium quantity decreased by the total variable cost of production

Rent

Price differentiate between two market multiply by the traded quantity

Total welfare

CS+PS+RENT

Network and economic modelling in CBA

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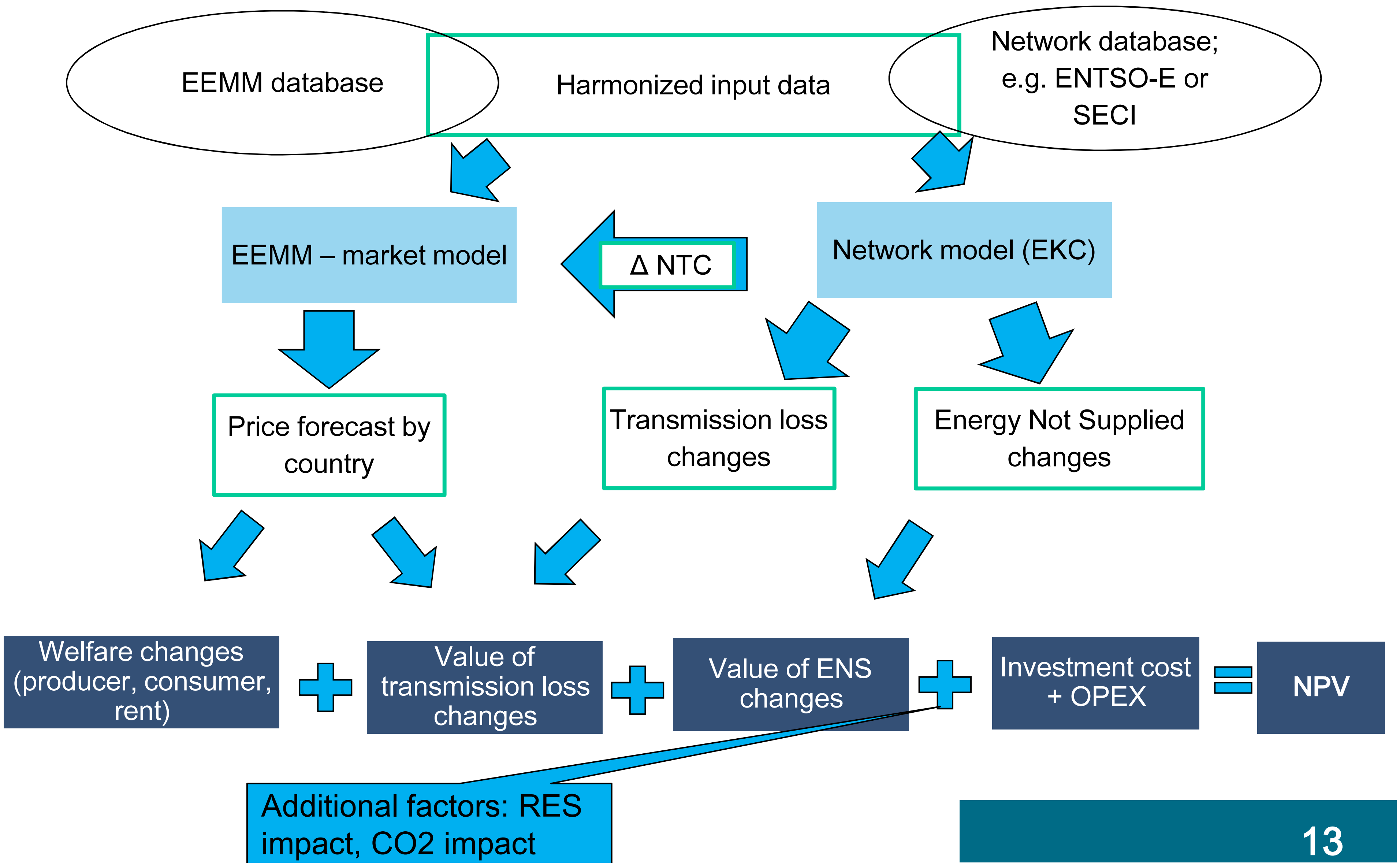

Description of Electricity Dummy Project (BG-RO new OHL line)

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The dummy project: a new 400kV OHL between Romania and Bulgaria

- Capacity: the new OHL increases the NTC by 1000 MW in both directions
- Commissioning year: 2020
- Investment costs:
  - BG: 10 m€ in 2018; 20 m€ in 2019, 20 m€ in 2020
  - RO: 10 m€ in 2018; 20 m€ in 2019, 20 m€ in 2020
  - Operation cost: 0.5 m€/year in both countries from 2020
- Transmission loss and EENS changes are assumed to be the followings (in the assessment these values will come from the network modelling):
  - Loss change: +100 GWh/year in BG, -50 GWh/year in RO
  - EENS change: 0.3 GWh/year in BG; 0.6 GWh/year in RO
- We assume that ETS will be fully introduced in EnC Countries from 2020 -> CO_2 costs are taken into account within the optimization of the market model

Parameters of the Cost-Benefit Analysis

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- Components of Net Present Value (NPV) calculation
  - NPV = CS + PS+ Rent + Value of losses +EENS – OPEX - Investment cost
    - CS: Consumer surplus change in the countries of the area of analysis
    - PS: Producer surplus change in the countries of the area of analysis
    - Rent: Rent change in the countries of the area of analysis
    - Value of losses: Value of loss change in the countries of the area of analysis
    - EENS: Value of Expected Energy Not Supplied change
    - OPEX: Operation and Maintenance cost change due to the project
    - Investment cost: verified investment cost
- When calculating the NPV, we apply the 25 years of assessment period and a residual value of zero are applied → ENTSO-E methodology (assuming the same period length allows comparability)
- Values between 2016-2030 are modelled by EEMM; after 2030 values are kept constant → harmonized with ENTSO-E methodology
- Real social discount rate: 4 % → ENTSO-E methodology

Reference case and regional coverage

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First question: **What should be the reference network case?**

E.g. include in the assessment the planned, but not yet realised projects?

- Methods:
  - PINT: Put in one at time
  - TOOT: Take out one at time
- As the lines have impact on each other these methods results in different values: PINT in overestimation of benefits!
  - Their interaction can help to detect lines with higher interaction!

Second question: **What is the reference region?**

  - Shall we measure the benefits on the two countries only, or also on the neighbouring countries?
  - Or shall we widen the assessment to the whole ENTSO-E?
  - Regional scope can change the picture quite dramatically!

EEMM Modelling Results: Price Changes Due to Dummy Project in 2030, €/MWh (TOOT vs PINT approach)

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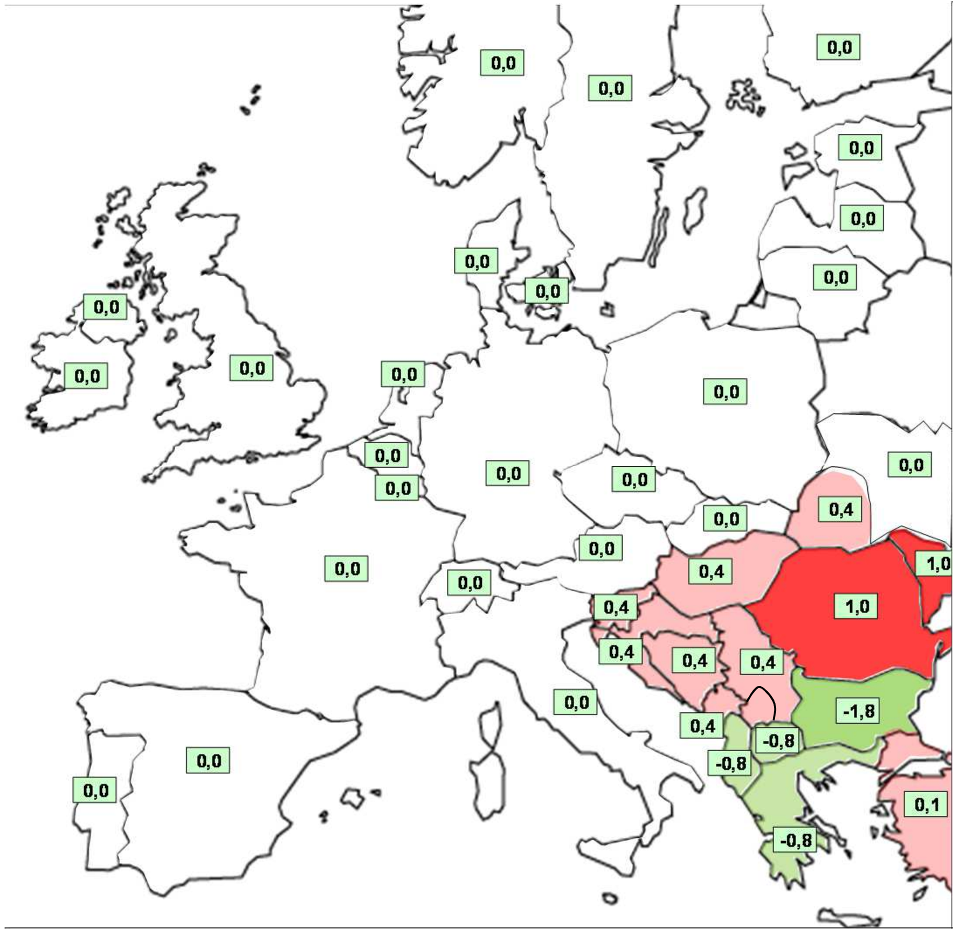
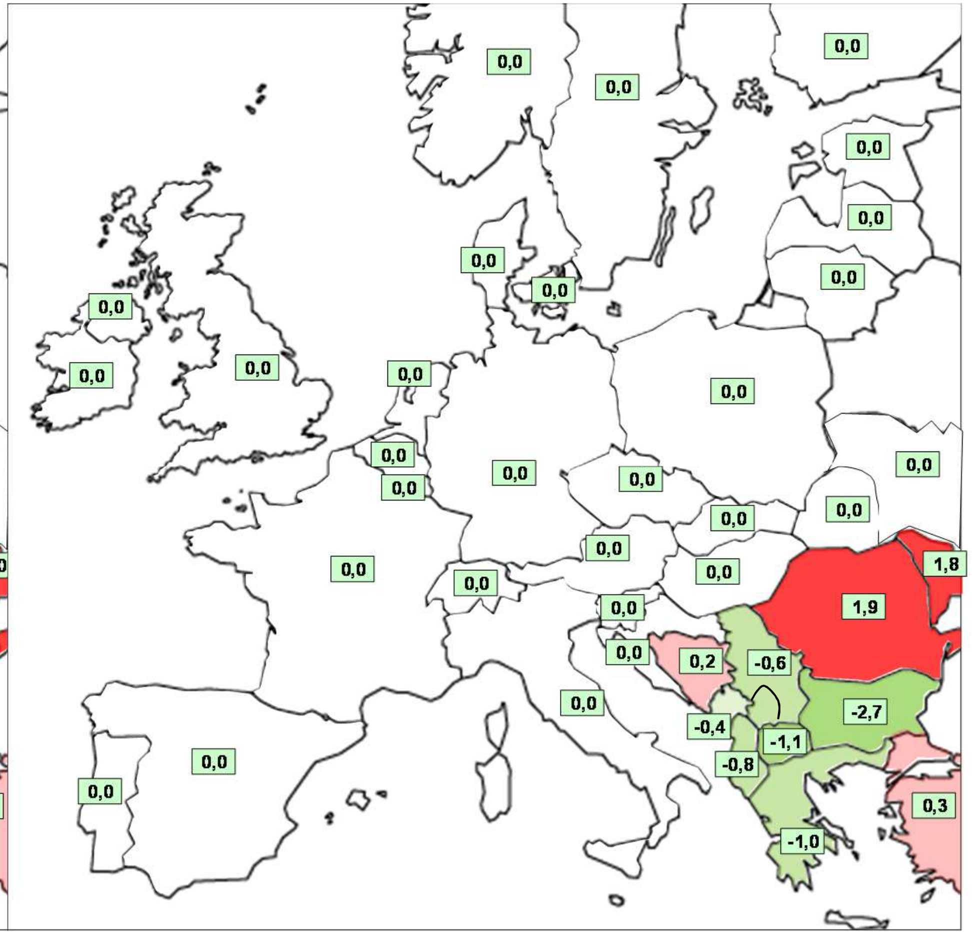
TOOT approach



PINT approach



Social Welfare Effects in BG and in RO in TOOT Methodology

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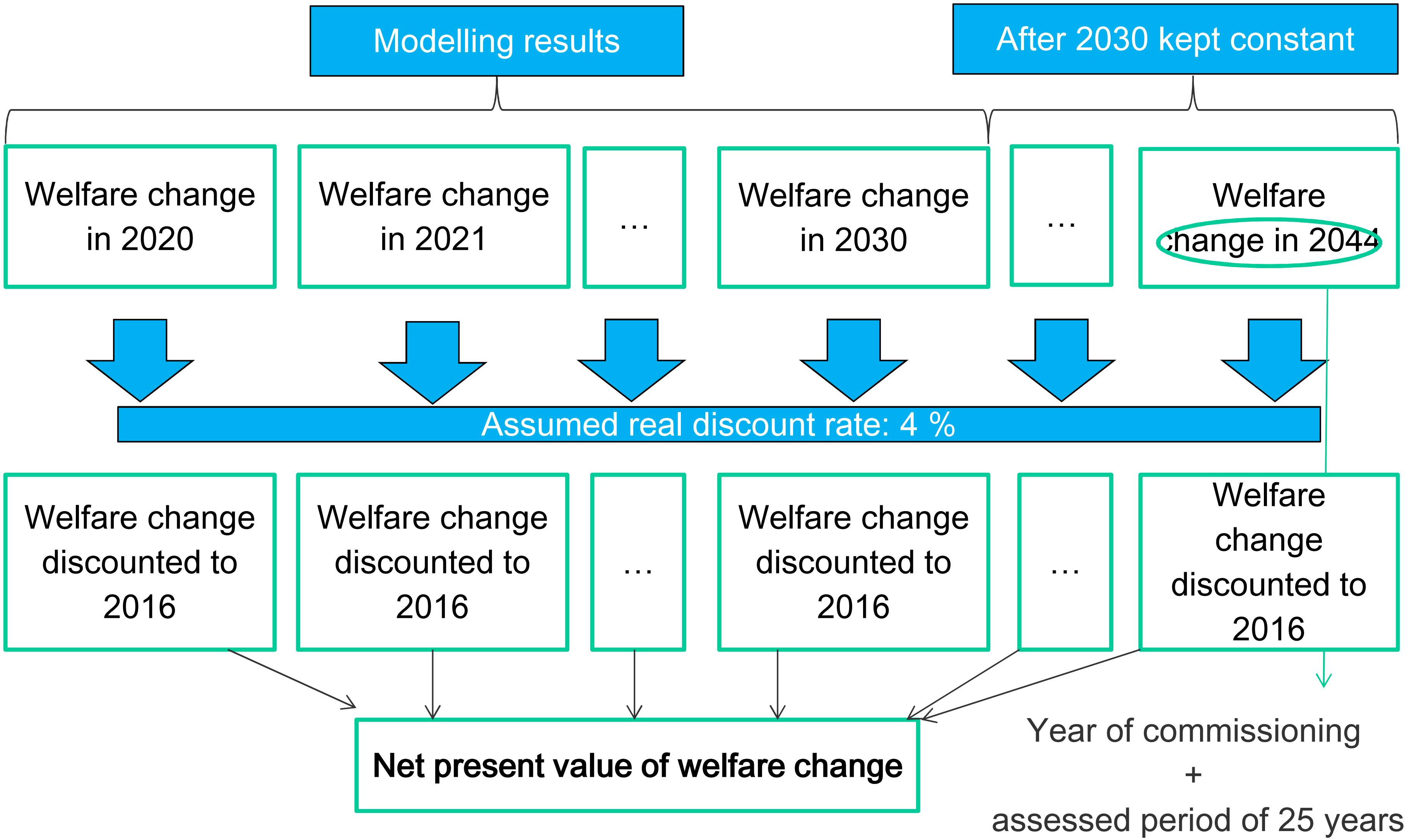
- Due to the new OHL, wholesale price increases in Romania and reduces in Bulgaria
- Price reduction in BG results in a consumer welfare gain, but producers loose
- Price increase in RO results in a producer welfare gain, but consumers loose

	Unit (M€)	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
BG	Consumer welfare change	8.4	14.1	29.6	58.6	153.5	359.6	410.5	65.8	56.1	78.2	75.9
	Producer welfare change	-8.3	-13.8	-27.2	-53.9	-91.4	-187.2	-207.2	-57.3	-49.6	-65.7	-62.7
	Rent change	-0.1	-1.1	-2.8	-6.1	-25.6	-71.7	-84.5	-1.0	1.9	0.8	1.5
	Total social welfare change	**-0.1**	**-0.9**	**-0.3**	**-1.5**	**36.5**	**100.7**	**118.8**	**7.5**	**8.4**	**13.3**	**14.8**
RO	Consumer welfare change	-2.5	-4.4	-14.4	-19.9	-36.6	-46.8	-43.1	-33.5	-29.7	-36.8	-65.8
	Producer welfare change	2.8	5.1	18.7	26.6	50.4	60.6	55.7	42.2	38.1	50.5	85.8
	Rent change	-1.1	-1.9	-4.4	-8.1	-12.0	-30.8	-32.2	-3.4	-0.2	-2.9	-1.0
	Total social welfare change	**-0.7**	**-1.2**	**0.0**	**-1.4**	**1.8**	**-17.1**	**-19.6**	**5.2**	**8.2**	**10.8**	**19.0**

Calculating the Net Present Value of Social Welfare Changes



Net Present Value of Total Social Welfare Changes in TOOT method, M€

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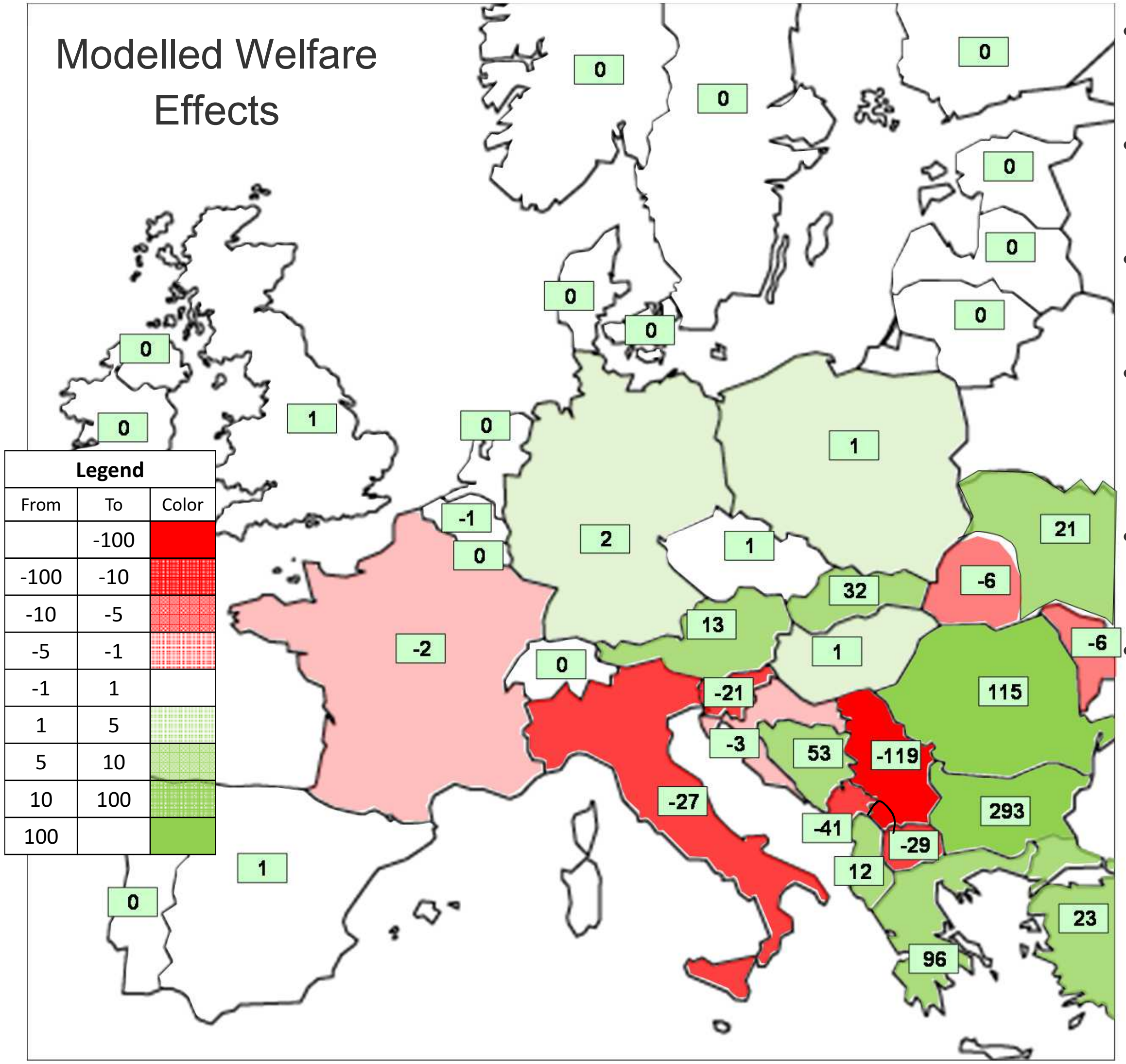

Legend		
From	To	Color
	-100	
-100	-10	
-10	-5	
-5	-1	
-1	1	
1	5	
5	10	
10	100	
100		

- Total welfare change in modelled countries in **TOOT** method: **407 M€**
- Total welfare change in modelled countries in **PINT** method: **546 M€**
- Total welfare change in **BG+RO** in PINT method: **491 m€**
- Total welfare change in **EnC+Neighbouring** countries in PINT method: **562 M€**
- Total welfare change in **EnC countries** PINT method : **-84 M€**
- **Geographical coverage matters! Recommendation:**
  - **calculation to be based on EnC + neighbouring EU members or**
  - **whole ENTSO-E**

Calculation of other elements:

ENS, loss changes, RES impacts, CO2 impacts

Monetization of Transmission Loss Changes

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- Transmission loss change monetization steps:
  - 1. step: Determine the volume of transmission loss changes due to the project -> result of network model
  - 2. step: Calculate the yearly baseload price -> result of the market model, this price serves as a basis for valuing the loss changes
  - 3. step: Calculate the net present value of the yearly cost of transmission loss changes
- 1. step: Assumed transmission change is:
  - +100 GWh/year in BG; -50 GWh/year in RO
- 2. step: Baseload price between 2016-2030 -> result of the model; after 2030 the baseload price will be kept at the 2030 level
- 3. step: Same method as in social welfare change: **NPV=48.5M€**

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	…	2044
Baseload price, €/MWh	BG	40.3	42.6	47.0	49.3	56.7	61.0	64.7	64.2	67.6	69.9	75.1	…	75.1
	RO	40.1	42.4	46.1	48.2	52.3	54.0	57.4	60.3	62.7	64.1	68.2	…	68.2
Monetization of transmission loss changes, M€	BG	4.0	4.3	4.7	4.9	5.7	6.1	6.5	6.4	6.8	7.0	7.5	…	7.5
	RO	-2.0	-2.1	-2.3	-2.4	-2.6	-2.7	-2.9	-3.0	-3.1	-3.2	-3.4	…	-3.4
	Total	**2.0**	**2.1**	**2.4**	**2.5**	**3.1**	**3.4**	**3.6**	**3.4**	**3.6**	**3.8**	**4.1**	**…**	**4.1**

Monetization of Changes in Energy not Supplied

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- **EENS change monetization steps**:
  - 1. step: Determine the volume of EENS due to the project (in MWh) -> result of network model
  - 2. step: Monetize the EENS value by using the average yearly GDP figures of the EnC countries (GDP/electricity consumption, based on Eurostat Unit:€/kWh)
  - 3. step: Calculate the net present value of the yearly cost of EENS changes

Proposed values in calculations:

- 1. step: Assumed EENS change is (it will come from network modelling in the assessment):
  - 0.3 GWh/year in BG; 0.6 GWh/year in RO
- 2. step: ~1.04 € /KWh based on latest Eurostat figures
- 3. step: NPV calculation of benefits over 25 years: **NPV (BG)= 4.33 M€; NPV (RO)= 8.67 M€**

EENS unit values

- In Expected Energy not Supplied, it is an important decision what is the monetary value of one kWh electricity not served:
- Three approaches:
  - Use the price of electricity as proxi: would result in underestimation (Value: approximately 0.06-0.2 Euro/kWh)
  - Calculating it by using the GDP/Electricity consumption value as a proxy for VOLL, as it is region specific and based on more reliable data. E.g. for the EnC countries, it is around 1 Euro/kWh
  - Use willingness-to-pay or willingnes-to-accept assessment to evaluate them. They are region and time specific. Not readily available for most countries. E.g. Bath University estimates: 4-40 Euro/kWh for developed regions.

Monetisation of RES and CO2 impacts

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New cross-border lines could help in **RES deployment** as well, e.g.:

- Can help to increase production share in one country, that can trade this electricity to other countries, less endowed with RES resources.
- Also it can help the connection of more RES generators in the area of the line.

- But question arises what portion of this benefit should be attributed to the cross-border line and what portion to the RES generators?

CO2 impacts:

- If the economic model includes carbon pricing, impact should not be calculate again as it would mean double counting of the impact

Net Present Value of Investment Cost and OM Cost

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- Investment cost:
  - BG: 10 m€ in 2018; 20 m€ in 2019 ; 20 m€ in 2020
  - RO: 10 m€ in 2018; 20 m€ in 2019 ; 20 m€ in 2020
- The operation cost is 0.5 m€/year in both countries from 2020
- Net present value of investment cost:
  - Discounted each CAPEX value to 2016
  - **NPV** of investment cost is **-90.7 M€ (BG+RO)**
- Net present value of OM cost:
  - OM costs occur between 2020-2044 (assessment period of the project is 25 years)
  - Discounted OPEX costs value to 2016
  - **NPV** of OPEX cost is: **-13.8 M€ (BG+RO)**

Summary of Cost-Benefit Analysis of Dummy Project, M€

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		Welfare change				Investment cost	OM cost	Trans. loss change	EENS change	**Total net present value**
		Consumer	Producer	Rent	Subtotal					
Modelled countries	TOOT	-40	850	-403	407	-91	-14	49	13	**364**
	PINT	-221	1305	-538	546	-91	-14	49	13	**503**
EnC + Neighbours	TOOT	746	56	-416	385	-91	-14	49	13	**342**
	PINT	1445	-383	-499	563	-91	-14	49	13	**520**

This NPV value can determine the decision on the line or can go into Multi-Criteria Assessment (MCA)

Conclusions

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Main issues:

- Is a simple rule like: benefits > costs is sufficient to decide?
- How should we treat non-monetised benefits and costs (e.g. ecosystem costs that are difficult to quantify, or system flexibility/robustness ?

Treatment of uncertainty:

- One more straightforward solution is to carry out sensitivity assessment on crucial factors. On factors like:
  - Carbon price
  - Investment cost
  - Fuel costs
- The other solution is to make the modelling stochastic.