Economic Assessment of a hypothetical interconnector RO-BG

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Outline

- Introduction
- Economic vs financial focused assessment
- Verification of investment cost
- Social welfare calculation
- ENS, Loss change, RES and CO2 impacts
- NPV calculations
A cost-benefit analysis (CBA) is a technique to systematically compare the benefits and revenues with the costs over the life span of an investment project.

- Project evaluation from the viewpoint 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
CBA has been increasingly used by policy makers for evaluation of new investments in important projects.

**Essential characteristics of CBA**
- Alternatives, e.g. in routes, capacity
- Incremental impact on the continuation of status quo
- Uncertainty – treated in sensitivity assessment
- Perspective of the analysis (e.g. economic or corporate?)
- Regional effects – Borders of the assessment?

**Incremental effects**
- Δ Costs
  - CAPEX
  - OPEX
  - External costs
- Δ Benefits
  - Producer Surplus
  - Consumer Surplus
  - Benefits TSO/ or Investor

Source: EnC PECI assessment WGM 2014
Economic assessment 1

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

• There are important benchmarking reports on investment cost of high voltage electricity transmission line.

• Most important:
  ‣ ACER Unit Investment Cost report (2015)
  ‣ 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

- **Overhead lines:**

  ![Overhead line cost graph](image)

  New vs, refurbishment line cost significantly differ!

- **Underground cables:**

  ![Underground cable cost graph](image)

- **Transformer costs**

  ![Transformer cost graph](image)

Source: ACER UIC Report 2015
Calculation of Social Welfare components
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
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
In the new situation in Country A, some producers will be substituted by cheaper import, shown by the orange area.

- Consumer surplus (CS) will increase, while producer surplus (PS) will reduce.
- Country B will be able to increase production, however price there will increase due to the new CBC.
- These effects will be calculated dynamically in an economic model (e.g. EEMM).
Network and economic modelling in CBA

- Harmonized input data
  - EEMM database
  - Network database; e.g. ENTSO-E or SECI

- EEMM – market model
  - Price forecast by country

- Network model (EKC)
  - Transmission loss changes
  - Energy Not Supplied changes

- Welfare changes (producer, consumer, rent)
- Value of transmission loss changes
- Value of ENS changes
- Investment cost + OPEX

- Additional factors: RES impact, CO2 impact

- Δ NTC

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

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 -> CO₂ costs are taken into account within the optimization of the market model**
Parameters of the Cost-Benefit Analysis

- 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

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)
Social Welfare Effects in BG and in RO in TOOT Methodology

- 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

<table>
<thead>
<tr>
<th>Unit (M€)</th>
<th>2020</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
<th>2024</th>
<th>2025</th>
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Calculating the Net Present Value of Social Welfare Changes

- Modelling results
- After 2030 kept constant

Welfare change in 2020 → Welfare change in 2021 → ... → Welfare change in 2030 → ... → Welfare change in 2044

- Assumed real discount rate: 4%
- Net present value of welfare change

Year of commissioning + assessed period of 25 years

Welfare change discounted to 2016 → Welfare change discounted to 2016 → ... → Welfare change discounted to 2016 → ... → Welfare change discounted to 2016
Net Present Value of Total Social Welfare Changes in TOOT method, M€

- 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

• 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€

<table>
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<th>Baseload price, €/MWh</th>
<th>2020</th>
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<th>2022</th>
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<td>3.8</td>
<td>4.1</td>
<td>...</td>
<td>4.1</td>
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</table>
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 proxy: 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 SEE countries, it is around 1 Euro/kWh
  - Use willingness-to-pay or willingness-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.
Monetization of Changes in Energy not Supplied

• 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: \( \text{NPV (BG)} = 4.33 \text{ M€}; \text{NPV (RO)} = 8.67 \text{ M€} \)
Monetisation of RES impacts

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

1. Can help to increase production share in one country, that can trade this electricity to other countries, less endowed with RES resources.

2. Also it can help the connection of more RES generators in the area of the line.

• Only incremental gains should be accounted for! E.g. if new RES generators can connect, only the difference in connection cost and production cost should be accounted for!
Montenegrin example: new 400 kV transmission line allows connection of cheap hydro generation
But question arises what portion of these benefit should be attributed to the cross-border line and what portion to the new RES generators?

E.g. the arising cost savings in the range of 20-25 Euros/MWh should all be attributed to new line, or should be equally split between OHL and RES generators?

What is the right sharing methodology?
Monetisation of CO2 impacts

CO2 impacts:

- If the economic model includes carbon pricing, impact should not be calculated again as it would mean double counting of the impact.
- So if the welfare calculation uses carbon pricing no extra calculation is needed.

- But in some cases (e.g. when no NTC change appear) some external calculations might be needed.
  - E.g. if OHL has high impact on transmission losses (positive or negative) - than reduction/extra CO2 emission increase due to the production/reduction of electricity to cover losses should be accounted for in the ratio of the average emission factors of generation.
Net Present Value of Investment Cost and OM Cost

• 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)**
|                      | Welfare change |                        |                  |                  |                  |                  |                  |                  | Total net         |
|----------------------|----------------|------------------------|------------------|------------------|------------------|------------------|------------------|------------------| present value     |
|                      | Consumer       | Producer               | Rent             | Subtotal         | Inv. cost        | OM cost          | Trans. loss      | EENS change      |                  |
|                      |                |                        |                  |                  |                  |                  | change           |                  |                  |
| 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)
Issues to be covered

- The main questions:
  - If social/economic benefits outweigh the cost for the TSO – how to set up the right tariff scheme to give the TSO sufficient incentives to undertake the project?
  - Tariff setting: should set the level to compensate sufficiently the TSO, but do not give way to ‘gold-plating’ (overinvestment) in CBC line. This will be elaborated more in details in the financial assessment presentation.
  - If benefits appear inequally some type of compensation scheme is desirable between affected countries
  - All these issues are made even more complex, as very long time frame is involved (over 30 years), so there is high uncertainty in calculated welfare impact
Distributional effects

- Example shows uneven distribution of costs and benefits for the assessed project.
- Although on overall level project economic benefit is positive, there is a high risk that project will not be realised if no compensation mechanism is put in place. Even if both countries developing the line are better off.
- Regulator might be concerned with highly negative consumer surplus change, which means significant price increase for end consumers.

<table>
<thead>
<tr>
<th>Unit: k€</th>
<th>Country1</th>
<th>Country2</th>
<th>Country (3) affected</th>
<th>Sum</th>
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<td>-1 100</td>
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Conclusions

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.
Thank you very much for your attention!

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