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STRIDE Smart grid workshop

Lecture 6

Cost benefit analysis of smart grid projects

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Cost benefit analysis of smart grid projects

General information

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Cost-Benefit Analysis

- Economic based tool for project analysis
- Cost-Benefit Analysis (CBA) is one of the most acknowledged tool for assessing the financial viability of industrial projects
- Cost-Benefit Analysis (CBA):
  - seeks for **an optimal resource allocation** in which the **monetary benefit outclass costs**
  - seeks for the **most profitable** investment alternative
    - Makes an incremental analysis with respect to a **reference scenario**
    - Produces easy-to-read economic indicators:
      - Net Present Value (NPV): net benefit produced
      - Internal Rate of Return (IRR): discount rate value that makes the NPV equal to zero
      - Cost Benefit Ratio (CBR): the ratio of the present value of benefits and costs

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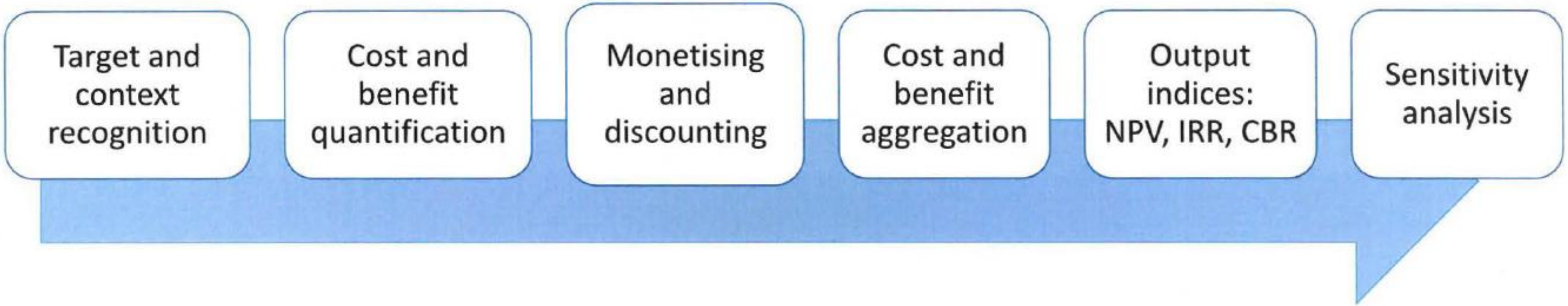
Cost-Benefit Analysis

- Steps of CBA



- Several regulatory frameworks **require a positive** CBA for approving the project

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Cost-Benefit Analysis

CBA for societal decision-making

- Government bodies have devised Sector-specific CBA guidelines
- CBA of large infrastructural projects that involve public interests is not fully acknowledged
- Societal project assessment highlights the weaknesses of CBA. The monetary-based tools show several conceptual flaws when intangible impacts are involved:

Quantifying → Intangible impacts are **not clearly quantifiable**

Often, only a qualitative assessment is possible

Monetizing → Monetization techniques **misrepresent the point of view** of individuals on intangible impacts

Discounting → Discounting of intangible impacts appears unsound because it leads to an **increased burden on future generations**

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Cost-Benefit Analysis

CBA for societal decision-making

- Private sector
  - Involve people as **customers**
  - Goods and services are exchanged within a market
  - **Tangible impacts** are majoritarian
  - Investor target: **maximise the profits**

- Public sector
  - Involve people as **citizens** (and/or taxpayers)
  - Goods and services **does not have a market**
  - **Intangible impacts** are not negligible
  - Investor target: maximise the **efficiency** and the **effectiveness** of investment costs

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Cost-Benefit Analysis

CBA for smart grids

- Key issues:
  - Obtain an effective classification of impacts
  - High risk of double counting
  - Obtain a multiplicity of feasible future scenarios
  - Forecast the price trend of technologies related to smart grids
  - Identify and consider the synergy of different smart grid assets
  - Generalise methods and results on different countries

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Cost-Benefit Analysis

Current analytical frameworks

- Most **smart grid assessment frameworks** descend from EPRI approach
- EPRI (Electric Power Research Institute) (Faruqui, A., Hledik, R.), 2010. “Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects”, Palo Alto, CA: EPRI. 1020342.
- EPRI Guidebook for Cost/Benefit Analysis of Smart Grid Demonstration Projects
  - Understanding the costs and benefits of Smart Grid applications requires an in-depth assessment of the technical and economic performance of the applications as well as the interoperable communications networks that support them.
  - To support such assessments, a report jointly funded by the Department of Energy and EPRI entitled, “Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects (EPRI 1020342),” provides a framework for estimating benefits and costs associated with Smart Grid projects.

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Performing cost/benefit analysis on Smart Grid system

- Performing cost/benefit analysis on Smart Grid systems poses interesting and challenging problems in measuring physical impacts and estimating economic benefits from them.
- However, when the Smart Grid systems are part of first-of-kind or demonstration projects, there are additional challenges to producing meaningful cost/benefit analysis.
- **How is Cost/Benefit Analysis for Smart Grid Projects Different?**
  - While neither entirely new nor unique, the need for public enumeration of the economic benefits of utility investments is often not necessary, especially in the electric distribution area.
  - Utilities regularly invest large sums in utility equipment devoted to public service in pursuit of their regulatory or charter obligations to serve.
  - The benefits of extending service into newly developed areas, for instance, and planning for continued growth are generally accepted and implicit in the regulatory imperative/obligation
  - Many Smart Grid investments are in this new category that requires going beyond utility-cost minimization.
  - Besides their novelty, Smart Grid applications offer new benefits beyond basic service or lower cost. They may improve service reliability and quality beyond currently accepted levels.
  - They may provide customers with choices they have never had before.

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Challenges in Cost/Benefit Analysis for Smart Grid Projects

- Several attributes of Smart Grid investments make conducting cost/benefit analysis more challenging than for traditional utility investments.
- **Technology Diversity**. The scope of the technologies involved can be quite broad and can range from the generation bus to the devices that customers use, and all of the communications devices in between. Many of the technologies are flexible systems that open a broad array of possible techniques and uses that have yet to be imagined. They can facilitate the integration of new technologies into dispatch operations and into wholesale electricity markets. They can facilitate the integration of distributed electricity generation installed at various locations on the system.
- **Scale of technologies**. The scale of technologies can range from small, isolated parts of the grid to expansive projects that span several stages of the delivery system.
- **Scope of markets and market participants**. Smart Grid investments can have impacts across customer classes, utility markets, market participants (including customers, utilities, and energy service companies), states, and regional market operators and reliability organizations such as Independent System Operators/Regional Transmission Operators (ISO/RTOs).

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Estimating project impacts, costs, and benefits

- Estimate physical impacts from measurements
- Monetize estimates of physical impacts
- Estimate costs incurred by customers per year for baseline and project
- Estimate utility costs by function/classification for baseline and project
- Summarize Costs and benefits

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Overview of the CBA process

- A basic definition of Cost/Benefit Analysis (CBA) is analysis that seeks to determine whether the benefits of a project or decision outweigh its costs.
- However, CBA analyzes costs and benefits from a particular point of view, which may range from broad and societal (public perspective) to narrow and focused (private perspective).
- General economic analyses take a societal perspective, determining whether a project is a good allocation of societal resources, without regard to the distribution of benefits.
- CBA methodology that is compatible with societal or customer-oriented approaches to weighing costs and benefits.
- This concept fits most comfortably with fully integrated utilities, in that costs and benefits align easily and all are contained within one corporate envelope

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Estimating project impacts, costs, and benefits

- Scoping a Cost/Benefit Analysis
  - A CBA is usually an extrapolation into the future, a representation in monetary terms of a plan of actions and their impacts. It is not necessarily a representation of the experimental conditions as discussed above, or an evaluation of the costs and benefits of the experiment.
  - Rather, it is an analysis *informed* by the results of experiments, cast to be representative of realistic implementation of a Smart Grid project beyond the demonstration framework.
  - Scoping the CBA—determining what is to be included and what time frame it is to be analyzed in—is important for making sure that the proper physical observations are taken during the experimental demonstration phase.

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Estimating Project Impacts

- In some cases project impacts may be measured directly, but as discussed above, in many cases the impact must be estimated, *even for the period of the experiment*, owing to the lack of a true baseline measurement. Further, often the true impact of interest is located well beyond the boundaries of the project, and estimation is the only tool.
  - For instance, reductions in losses of energy consumption are of economic interest because they save fuel and reduce emissions, both of which are physical impacts occurring potentially distant from the point of energy savings.
- While various methods can be used to estimate impacts associated with the experimental conditions, a CBA for long-lived investments must include estimated costs and benefits extrapolated for many years into the future.
- The grounds for extrapolation of impacts must be examined, but frequently no science will be found on which to provide accuracy. In the best circumstances, experimental data can verify model results, which can provide a closer look at impacts that are difficult to measure, e.g., line losses. Models run using typical planning forecasted loads can be used to estimate impacts informed by the experimental results, with the proviso that planning estimates are subject to uncertainties as well.

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Cost and Benefit Categories for Cost/Benefit Analysis

- The physical impacts that are interesting from a cost/benefit analysis perspective are those that cause economic benefits or costs. It may help to consider impacts in categories, organized according to the types of costs and benefits that they cause. We can identify several categories that encompass most impact-related costs and benefits
  - **Reliability** (frequency and duration of customer interruptions)
  - **Utility Operations** (people and how they do their jobs: non-fuel O&M, non-production assets, public and employee safety)
  - **System Operations** (the power system and how efficiently it runs: losses, combustion, dispatch optimization, emissions)
  - **Utility Assets** (production assets required in GT&D)
  - **Power Quality** (harmonics, sags/swells, voltage violations)
  - **Customer** (customer-borne costs, changes in service amount or value)
- These categories are not all-inclusive, and users of the process may have others to include that are important in certain specific analyses. However, most impacts will affect the items in one of the groups.

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Reliability

- The Reliability benefit category refers specifically to the frequency and duration of customer service interruptions. It does not refer to device, plant, or component reliability, which will be dealt with in other categories.
- Nor does it refer to restoration cost, which will show up as a category of distribution cost in a different category.
- Table: Reliability Cost and/or Benefit Quantities

Reliability	Interruption Costs, Sustained	Δ Customer costs, from damage functions
	Interruption Costs, Momentary	Δ Customer costs, from damage functions
	Interruption Costs Major Event	Δ Economic loss estimate, apart from utility cost
	Interruption Costs, Other	Δ Other categories of customer cost, as appropriate

- Table provides a short list of the major interruption-cost quantities.

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Utility Operations

- This category of costs and benefits refers to how a utility does its job with people, tools, and buildings.
- Many Smart Grid applications put new tools in the hands of operators, planners, and workers in the field, changing the way they work, the time it takes to get their jobs done, and the cost of their time and materials.
- In some cases the main benefit of a project will be reduced operations cost, where investments are made in advanced applications for Distribution Management Systems (DMS), for instance.
- Other projects, such as Distribution Automation, may have profound impacts on reliability, but also reduce the cost of service restoration as well.
- In any case, for any given project, this category should capture any changes in staffing, office space, or office tools and equipment that may be related to the project, as well as any ongoing maintenance or support requirements.
- Utility Operations Cost Categories

Utility Operations	Non-Fuel O&M (Operating and Maintenance)	G	Δ O&M expenses by function
		T	Δ O&M expenses by function
		D	Δ O&M expenses by function
		Customer	Δ O&M, including meter reading expenses
		Admin & General	Δ Building-related O&M expenses
	Non-Prod Assets	Trucks, A&G, Tools	Δ revreqs Includes control rooms, software, computers, etc.

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System Operations

- The System Operations category deals with changes in the operation of the power system itself, i.e., the generators, wires and transformers that produce electric energy and deliver it to consumers.
- Technologies that reduce energy losses of various types on the power system will have an impact on system operations.
- The benefits of loss reduction or energy conservation appear as reduction of fuel use and emissions, but reduction of peak losses provide some capacity benefits as well, benefits that actually appear in the Utility Assets category.
- The System Operations category, however, includes only expense items associated with energy production and delivery. A list of operation expenses might include any of the following:

- Table: System Operations Costs

System Operations	Fuel	Δ Fuel expense (for generating companies)
	Purchased Power	Δ Purchased Power (esp for non-gen retailer)
	Ancillary Services	Δ A/S (mainly in ISO/RTO markets)
	Emissions - SO_2, NOx, CO_2	Δ for allowances (for generating companies)
	Operator Costs	Δ ISO/RTO operator costs
	Revenue on Enabled Sales	Δ for enabled sales, under some conditions

Utility Asset Costs/Capital Revenue Requirements

- The Utility Asset category accounts for the assets required to do the utility's main job of generating, transmitting, and/or delivering power.
- Utilities are always investing in and consuming assets.
- If utilities are able to provide the same reliable service with fewer or less expensive assets, then utilities are able to provide service at lower cost to consumers.
- A variety of impacts may contribute to a deferral or elimination of capital requirements.
- Reduction of peak losses or peak demand, for instance, vacate capacity in generators, lines, and transformers, such that upgrades or capacity additions may be deferred or eliminated.
- Similarly, reliability improvements brought about by distribution automation may allow deferral of upgrades or substation additions that would otherwise have been needed to support reliability.

- Table: Categories of Capital Revenue Requirements

Capital Revenue Requirements	Capital Deferral/ Advancement	G	Δ revenue requirements, including taxes and net income
		T	Δ revenue requirements, including taxes and net income
		D	Δ revenue requirements, including taxes and net income

Customer Costs/Benefits

- This category deals explicitly with non-reliability costs or benefits outside of the utility cost function.
- This is not intended to be a component of a participant or non-participant test; the CBA described here is concerned with total costs and total benefits.
- That is, it reflects a total resource cost view or a societal view.
- Consequently changes in a customer's bill are not a component of the analysis; such changes are reflected in the changes in the utility cost function.
- Rather, this category recognizes costs such as equipment purchases (e.g., in-home displays and/or programmable thermostats) or changes in service value.
- Table Account of Other Customer Costs

Customer	Value of Service (Comfort, Light, etc)	Δ Value at least as great as otherwise would have paid for it
	Cost of equipment (Devices)	Δ Cost of program-related devices

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Other: Theft Reduction

- Better detection of theft is often cited as a benefit of smart meters.
- Theft is a non-technical loss of energy that paying customers are paying for.
- Interestingly, looking at theft reduction only in terms of total revenue requirements can lead to a conclusion that theft doesn't matter.
- That is, aside from the fairness issues, theft doesn't change total revenue requirements, and correcting theft only redistributes cost responsibility among the group of customers.
- However, paying customers can be considered to be paying for the theft, losing value.
- There are at least two outcomes from resolving theft:
  - The consumer remains and pays for power, perhaps at a reduced rate of consumption, or the consumer leaves the service territory and doesn't consume at all.
  - If, however, the consumer reduces consumption, other customers are relieved of the cost of that energy, incurred at marginal cost.

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Summary of Economic (Monetized) and Informational Cost Changes (1)

- The table in summarizes the various cost categories discussed above, casting them in the form of a cost/benefit analysis summary, including both quantitative and qualitative categories of information.
- This table is a tally of *cost differences* between two alternatives. Some differences will be positive, impact-related *costs* or implementation costs and some will be negative.
- This table, then, takes the form of a cost/benefit analysis.
- The economic costs and benefits section of the table could be filled in entirely with monetary values, but only the top three subsections are changes that occur within the utility cost function: **System Operations, Utility Operations, and Capital Revenue Requirements**.

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Summary of Economic (Monetized) and Informational Cost Changes (2)

- System and Utility Operations are almost completely composed of expenses, that is, costs that are assumed to be recovered in the year they occur.
- That is, an expense is part of the annual revenue requirement.
- Capital Revenue Requirements, on the other hand, are annual amounts associated with return of and on invested capital, including taxes and any time-shifting effects of various tax policies, such as accelerated depreciation for income tax purposes.
- The Utility Operations category includes a non-production assets category (composed of relatively short-lived assets such as trucks, computers, tools, etc.), present because it is an integral part of operations, but that may be subject to revenue requirement treatment.

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Cost/Benefit Analysis Summary Table

				Δ Present Value	Year 1	Year 2	...	Year n
Economic Costs and Benefits	System Operations		Fuel					
			Purchased Power					
			Ancillary Services					
			Emissions - SO_2, NOx, CO_2					
			Operator Costs					
			Revenue on Enabled Sales					
	Utility Operations	Non-Fuel O&M (Operating and Maintenance)	G					
			T					
			D					
			Customer					
			Admin & General					
		Non-Prod Assets	Trucks, A&G, Tools					
	Capital Revenue Requirements	Capital Deferral/ Advancement	G					
			T					
			D					
	Reliability		Interruption Costs, Sustained					
			Interruption Costs, Momentary					
			Interruption Costs Major Event					
			Interruption Costs, Other					
	Customer		Value of Service (Comfort, Light, etc)					
			Cost of equipment (Devices)					
	Other		Savings from Theft Reduction					
	Environment		ΔTons SO_2					
			ΔTons NOx					
			ΔTons CO_2					
			ΔPounds Hg					
			ΔParticulates					
Security Impacts			Oil Saved					
			Major Blackouts Avoided					
Power Quality Impacts			Change in Momentary Outages					
			Change in Sags, Swells, Voltage violations	n/a				
Efficiency Impacts			ΔkWh System Losses	n/a				
			ΔkW System Losses	n/a				
			ΔkWh Consumed	n/a				
			ΔkW Consumed	n/a				
Metering Impact			Metering Accuracy					
Safety Impact			Public Safety					
			Employee Safety					

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Benefits Table from Methodological Approach Related to Cost/Benefit Categories

- The items below Economic Costs and Benefits are items that would not be included in the monetary analysis, but may be used for scoring of qualitative characteristics of a project. Any items that can be monetized should be moved into the Economic category and included there.
- For example, a project intended to solve a power-quality problem may focus on reduced damage of customer equipment, which would allow putting a monetary value on power-quality improvement.
- **Benefits Table from Methodological Approach Related to Cost/Benefit Categories** provides a list of the original Smart Grid benefits from the Methodological Approach, along with the Benefit Categories that best correspond to them.
- The list of benefits in the Methodological Approach is excellent for discussing or showing how a smart grid technology provides benefits because it categorizes benefits in commonly used high-level terms that people such as regulators and policy makers hear about.
- It concentrates on benefits, characterizing most rows in words that suggest a positive benefit, e.g., *reduced* losses or *deferred* investment.

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Benefits table from methodological approach related to Cost/Benefit categories

Benefits - "Methodological Approach"			Primary Benefit Category
Economic	Improved Asset Utilization	Optimized Generator Operation	System Operational Efficiency
		Deferred Generation Capacity Investments	Utility Asset Efficiency
		Reduced Ancillary Service Cost	System Operational Efficiency
		Reduced Congestion Cost	System Operational Efficiency
	T&D Capital Savings	Deferred Transmission Capacity Investments	Utility Asset Efficiency
		Deferred Distribution Capacity Investments	Utility Asset Efficiency
		Reduced Equipment Failures	Utility Asset Efficiency
	T&D O&M Savings	Reduced Distribution Equipment Maintenance Cost	Utility Operational Efficiency
		Reduced Distribution Operations Cost	Utility Operational Efficiency
		Reduced Meter Reading Cost	Utility Operational Efficiency
	Theft Reduction	Reduced Electricity Theft	Utility Operational Efficiency
	Energy Efficiency	Reduced Electricity Losses	System Operational Efficiency
	Electricity Cost Savings	Reduced Electricity Cost	Customer Efficiency
Reliability	Power Interruptions	Reduced Sustained Outages	Reliability
		Reduced Major Outages	Reliability
		Reduced Restoration Cost	Utility Operational Efficiency
	Power Quality	Reduced Momentary Outages	Power Quality
		Reduced Sags and Swells	Power Quality
Environmental	Air Emissions	Reduced CO_2 Emissions	System Operational Efficiency
		Reduced SOx, NOx and PM-10 Emissions	System Operational Efficiency
Security	Energy Security	Reduced Oil Usage (not monetized)	System Operational Efficiency
		Reduced Wide scale Blackouts	Reliability

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JRC: Guidelines for conducting a cost-benefit analysis of Smart Grid projects, 2012

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Goal of the report (1)

- The goal of this report is to provide guidance and advice for conducting cost-benefit analyses of Smart Grid projects.
- It presents a step-by-step assessment framework based on the work performed by the EPRI (Electric Power Research Institute), and we provide guidelines and best practices.
- Several additions and modifications have been proposed to fit the European context.
- This work draws on the existing collaboration between the EC and the US Department of Energy (DoE) in the framework of the EU-US Energy Council.
- The assessment framework is structured into a set of guidelines to tailor assumptions to local conditions, to identify and monetise benefits and costs, and to perform a sensitivity analysis of the most critical variables.

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Goal of the report (2)

- It also provides guidance in the identification of externalities and social impacts that can result from the implementation of Smart Grid projects but that cannot be easily monetised and factored into the cost-benefit computation.
- The content of guidelines should be seen as a structured set of suggestions, as a checklist of important elements to consider in the analysis.
- A comprehensive analysis of Smart Grid projects requires adaptation to local circumstances and will ultimately rely on the professional skills and judgement of project developers and relevant decision-makers.
- It is not goal to provide an exhaustive and detailed set of indications to fit all possible projects, scenarios and local specificities.

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Goal of the report (3)

- In setting up the guidelines for the CBA, our more general target is an economic-oriented CBA of Smart Grid projects, which goes beyond the costs and benefits incurred by the actor(s) carrying out the Smart Grid project.
- Guidelines ultimately aim to take a societal perspective in the CBA, considering the project’s impact on the entire value chain and on society at large.
- The proposed approach also recognises that the impact of Smart Grid projects goes beyond what can be captured in monetary terms.
- Therefore, general approach aims to integrate an economic analysis (monetary appraisal of costs and benefits on behalf of society) with a qualitative impact analysis (non-monetary appraisal of non-quantifiable impacts and externalities).

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Goal of the report (4)

- The economic analysis takes into account all costs and benefits that can be expressed in monetary terms, considering a societal perspective.
- In other words, the analysis tries to include all costs and benefits that spill over from the Smart Grid project into the electricity system at large (e.g. enabling the future integration of distributed energy resources, impact on electricity prices and tariffs, etc.) and into society at large (e.g. environmental costs).
- To what extent these additional benefits and costs might ultimately be internalised and included in the CBA depends on how defensible the calculation of their euro equivalent is.

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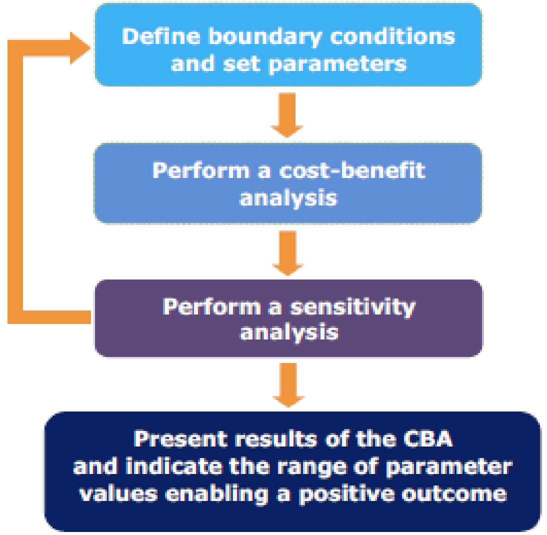
Proposed approach to CBA

- The proposed approach to CBA comprises three main parts:
  - definition of boundary conditions (e.g. demand growth forecast, discount rate, local grid characteristics) and of implementation choices (e.g. roll-out time, chosen functionalities)
  - identification of costs and benefits
  - sensitivity analysis of the CBA outcome to variations in key variables.
- To this end, the report aims to provide:
  - insights to choose key parameters
  - a systematic approach to link deployed assets with benefits
  - formulae to monetise benefits
  - an indication of most relevant cost categories
  - illustration of a sensitivity analysis to identify critical variables affecting the CBA.



Adaptation of the EPRI methodology to the European context

- On the basis of the literature review, the CBA framework described in this study builds upon the **EPRI CBA** methodology.
- Modifications and additions (qualitative impact analysis, formulae for the quantification of benefits, sensitivity analysis, etc.) tailored to the European context have been proposed wherever necessary.
- This work draws on the existing collaboration between the Commission and the US DoE in the framework of the EU-US Energy Council.
- Modifications to fit the European context have been proposed:
  - Step 3 (*Assess the principal characteristics of the Smart Grid to which the project contributes*) of the EPRI methodology has been skipped.
  - In steps 2 (Identify the functions) and 4 (Map each function onto a standardised set of benefit types), functions have been replaced by (European) functionalities
  - Steps 6, 7, 8 (Identification of benefits, quantification of benefits and monetisation of benefits) have been grouped together. They are considered as sub-steps of the single step ‘Quantification of benefits

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The ten guidelines

- The ten guidelines cover four main macro-steps, illustrated in detail:
  - definition of assumptions, critical variables and boundary conditions tailored to the specific geographical/regulatory context
  - implementation of the CBA
  - implementation of a sensitivity analysis to analyse the influences of key variables on the CBA
  - integration of the CBA with qualitative assessment of the merit of the deployment, externalities and social impact)
- The process is iterative in the sense that during calculations it could prove necessary to retune the assumptions or to collect more data and repeat the analysis.

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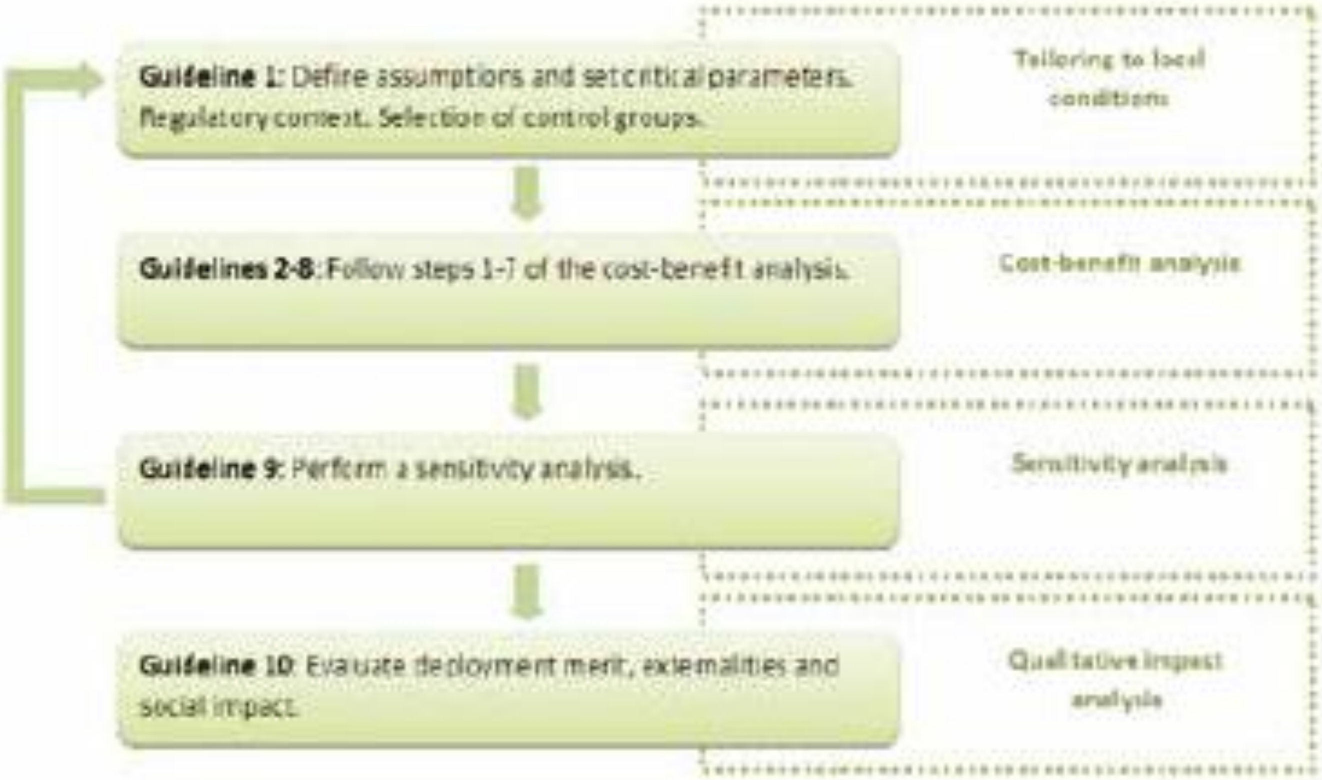
Guidelines flow chart



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I. Tailoring to local conditions

- Guideline 1 – Define assumptions and set critical parameters
- Critical parameters in Smart Grid projects that need to be chosen include (non-exhaustive list):
- Table: Non-exhaustive list of variables/ parameters to define.

Variables/data to be set/collected	Unit
Projected variation of energy consumption	%
Projected variation of energy prices	%
Peak load transfer	%
Electricity losses at transmission and distribution level	%
Estimated non-supplied minutes	Number of minutes
Value of lost load; value of supply	€/kWh
Discount rate	%
Hardware costs	€
Life expectancy of installed systems	Number of years
Installation costs	€
Carbon costs	€/ton
Inflation rate	%
Cost reduction associated with technology maturity	%
Implementation schedule	% asset deployment/year
Percentage of asset deployment in rural v urban areas	%

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II. Cost-benefit analysis (1)

Guideline 2 – Review and describe the technologies, elements and goals of the project

- The first step is to provide a main summary and to describe the elements and goals of the project.
- This may involve answering (some of) the following questions:
  - What are the project's overall purposes and solutions?
  - What are the main components/technologies deployed?
  - What are the functionalities of the main components?
- In the definition of the boundaries of the CBA, Smart Grid investments and applications should be considered together only if they need to function together.

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II. Cost-benefit analysis (2)

Guideline 3 – Map assets into functionalities

- Determine what Smart Grid functionalities are activated by the assets proposed by the project. Consider each asset individually and contemplate how it could contribute to any of the functionalities.
- Smart Grid assets provide different types of functionalities that enable Smart Grid benefits.
- If the assets deployed and/or functionalities enabled by the project are unclear, the analysis is likely to be incomplete.
- To complete this step, consider the assets of the project.
- Assess each asset in turn and select from among the 33 functionalities those that are (potentially) activated by the assets.

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II. Cost-benefit analysis (3)

Guideline 4 – Map functionalities on to benefits

- Link the functionalities identified in Step 2 to the (potential) benefits they provide.
- Consider each functionality individually and contemplate how it could contribute to any of the benefits.
- This analysis should continue until all applicable functionalities are considered.

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II. Cost-benefit analysis (4)

Guideline 5 – Establish the baseline

- The objective of the establishment of the project baseline is to formally define the ‘control state’ reflects the system condition which would have occurred had the project not taken place.
- This is the baseline situation against which all other scenarios of the analysis are compared.
- The CBA of any action/investment is based on the difference between the costs and benefits associated with the **BaU** scenario on the one hand and those associated with the implementation of the project on the other. In a situation where costs and benefits are related to projected behavioural impacts of electricity consumers, baselines should preferably be a ‘control group’ of comparable customers, randomly selected from the target population.
- The CBA should refer to the useful life of the Smart Grid investments, which indicates the period of time when the installed Smart Grid system is intended to reliably perform its designed functions.

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II. Cost-benefit analysis (5)

Guideline 6 – Monetise the benefits and identify the beneficiaries

- Identify, collect and report the data required for the quantification and monetisation of the benefits. Key assumptions and the level of estimation uncertainty should be clearly documented.
- Some recommendations:
    - benefits should represent those actually resulting from the project;
    - benefits should be significant (meaning - full impact), relevant to the analysis and transparent in their quantification and monetisation;
    - the individual benefit and cost variables should be mutually exclusive. In other words, avoid including one type of benefit as part of another type of benefit;
    - the level of uncertainty associated with the benefit estimation should be clearly stated and documented;
    - take into consideration the data requirements of the CBA in the design phase of the project in order to make sure that all data necessary for the CBA can be collected;
    - the beneficiaries (consumers, system opera- tors, society, retailers, etc.) associated with each benefit should be identified, as far as possible, with a quantitative estimation of the corresponding share.
    - In particular, it is recommended performing this kind of analysis at least for the actor(s) implementing the project (in order to evaluate the financial viability of the investment) and for the consumers.

Project co-funded by the Europen Union (ERDF, IPA).

II. Cost-benefit analysis (6)

Guideline 7 – Identify and quantify the costs

- Estimate the relevant costs. Some costs can be measured directly by the company, while others are typically easy to estimate since their prices, or very good proxies, can be easily obtained in the market place.
- The costs of a project are those costs incurred to implement the project, relative to the baseline.
- The costs should include capital, ongoing/operational and transitional costs.
- Collecting information on the project's costs allows calculating a project's return on investment, which shows whether it is positive and, if so, when the project will break even.
- Even though identifying these costs is not usually a difficult exercise, it does require meticulous internalisation of all necessary expenses.

Project co-funded by the Europen Union (ERDF, IPA).

II. Cost-benefit analysis (7)

Guideline 7 – Identify and quantify the costs

- Some recommendations:
  - costs should only be those necessary and sufficient for the purpose of implementing the Smart Grid measure(s);
  - stranded costs (e.g. replacement of traditional meters before their expected lifetime) should be highlighted and reported as a separate line item;
  - the level of uncertainty associated with the cost estimation should be clearly stated and documented;
  - the stakeholders (consumers, system opera- tors, society, retailers, etc.) bearing the different costs should be identified, as far as possible, with a quantitative estimation of the corresponding share;
  - costs could also include investments in pilot projects that prove necessary to substantiate the cost-benefit estimates before the actual roll-out;
  - good practices to estimate costs include a market consultation;
  - use approved accounting procedures for handling capital costs, debit, depreciation and taxes;
  - the choice of the amortisation rate depends on the technology ageing speed and on the assumptions about the market conditions. If the market imposes high innovation turnover for some assets (e.g. IT) or if uncertainty exists, the amortisation rate has to be set conservatively high.

Project co-funded by the Europen Union (ERDF, IPA).

II. Cost-benefit analysis (8)

Guideline 8 – Compare costs and benefits

- Once costs and benefits have been estimated, there are several ways to compare them in order to evaluate the cost-effectiveness of the project.
- The most common methods are annual comparison, cumulative comparison, NPV and benefit-cost ratio.

Project co-funded by the Europen Union (ERDF, IPA).

III. Sensitivity analysis

Guideline 9 – Sensitivity analysis

- Perform a sensitivity analysis. Sensitivity analysis is a method used for investigating the impact of changes in project variables on the baseline scenario.
- Typically, mainly adverse changes are taken into consideration.
- The sensitivity analysis assists in identifying key variables that influence the project’s costs and benefits, and demonstrates the consequences of likely adverse changes in these key variables.
- For example, it could demonstrate how the NPV would change with the increase/decrease of a particular variable.
- A sensitivity analysis can aim at varying major benefits and costs one at a time or in combi- nation.
- This technique will help project promoters assess whether and how project decisions could be affected by such changes and will help them identify actions that could mitigate possible adverse effects on the project.
- Good candidates for inclusion are variables with a wide range of potential values and/or which are more subjective in nature (e.g. discount rate, estimation of peak transfer).

Project co-funded by the Europen Union (ERDF, IPA).

IV. Performance assessment, externalities and social impact (1)

Guideline 10 – Qualitative impact analysis: non-monetary appraisal

- The CBA should be complemented by a qualitative impact analysis, i.e. a qualitative estimation of additional costs and benefits that cannot be monetised and included in a CBA.
- The qualitative impact analysis should include (1) deployment merit of the project (performance assessment); (2) externalities, with particular reference to social impacts.

Project co-funded by the Europen Union (ERDF, IPA).

IV. Performance assessment, externalities and social impact (2)

Guideline 10 – Qualitative impact analysis: non-monetary appraisal

- Performance assessment – KPI-based project merit deployment
- Fill in the benefit-functionality matrix ([EC Task Force for Smart Grids 2010c], Annex VII) and draw the corresponding spider diagrams.
- We recommend that at the national level, a single institutional body (e.g. national regulator) should be in charge of monitoring this exercise, and they should clearly document choices and assumptions made in filling in the matrix.
- The outcome of this performance assessment is a vector of KPI-based scores representing the merit of the project for different objectives.

Project co-funded by the Europen Union (ERDF, IPA).

IV. Performance assessment, externalities and social impact (1)

Externalities and social impacts

- Identify externalities and express them in physical terms (e.g. use decibels to quantify noise reduction benefit).
- The choice and the calculation of each indicator should be transparently illustrated and motivated.
- Where the calculation of an indicator is not feasible, a detailed description of the estimated impacts of the project should be provided to give decision-makers the whole range of elements for the appraisal.

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IV. Performance assessment, externalities and social impact (2)

Externalities and social impacts

- Social impacts typically represent a significant portion of the project externalities. Some areas of focus include:
  - job impact
  - safety
  - environmental impact
  - social acceptance
  - time lost/saved by consumers
  - enabling new services and applications and market entry to third parties
  - reduction of the gap in skills and personnel
  - privacy and security.
- The outcome of the externality assessment (including social impacts) should then be integrated into the KPI-based scores of the performance assessment. It is then necessary to specify weights to combine the different elements of the analysis.
- The weights should reflect the relative importance of each objective in the decision-maker's view.

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IV. Performance assessment, externalities and social impact (3)

Guideline 10 – Qualitative impact analysis: non-monetary appraisal

- Combining economic and qualitative analysis
- Once the outcomes of the economic analysis and of the qualitative impact analysis have been assessed, suitable weighting factors to combine the quantitative and qualitative analysis should be advised.
- The choice of weighting factors needs to be explained clearly and convincingly
- The economic appraisal needs to be integrated with a qualitative impact analysis to assess externalities that are not quantifiable in monetary terms.
- This includes the costs and the benefits derived from broader social impacts like security of supply, consumer participation and improvements to market functioning.
- Guidelines provide to identify and assess (in physical terms or through a qualitative description) project impacts and externalities, in order to give decision-makers the whole range of elements for the non-monetary appraisal.

Project co-funded by the Europen Union (ERDF, IPA).

Interreg
Danube Transnational Programme
STRIDE

Smart grid financing

General information

Project co-funded by the Europen Union (ERDF, IPA).

Financing the Smart grid

- Smart Grid Financing: Using the Regulatory Tools
- Smart Grid Financing: Conventional Tools
- Smart Grid Financing: EU Contribution toward deployment

Project co-funded by the Europen Union (ERDF, IPA).

Using the Regulatory Tools

Using the Regulatory Tools:

- Distribution and Transmission Improvements
  - Recovered on Cost + Basis
  - Standard for rate base inclusion: “Used and Useful”
  - No “single issue” ratemaking
  - Incentive Rates
  - Matching Funds

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Conventional Financing

- Traditional utility access to capital
- Backed by customer revenues over time
- Attractiveness of incentive rate treatment
- Utility access to capital not significant challenge - larger challenge is regulatory uncertainty

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Stimulus Monies

- EU and government matching funds
- Mix between R&D and deployment euros
- Mix of projects in size, geography and degree of customer benefit
- **TEN-E Guidelines**
- The guidelines for a trans-European energy infrastructure Regulation (2013/347/EC) list and rank, according to the objectives and priorities laid down, projects eligible for EU assistance, including smart grids. The text introduces the concept of ‘projects of common interest’ (PCIs) for Europe, which are directly linked to the spending of funds available through the EU’s Connecting Europe Facility (CEF).
- **EU to invest nearly €1bn in new energy infrastructure projects**
  - Grants will be provided for 10 projects – two for electricity transmission, **one for smart electricity grids**, six for transport of CO_2 and one for gas

Project co-funded by the Europen Union (ERDF, IPA).

Future Challenges

- Does Stimulus Money spur private investment or deter that investment?
- Will regulators allow late entrants who cannot access federal funding?
- Challenge of future funding

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EU Supporting smart grids and storage projects

- Electricity is at the centre of the EU energy system.
- Smarter and better connected distribution and transmission grids, as well as increased storage support the movement towards an integrated energy system.

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Smart grid projects risk losing out on EU funding due to national focus

- Smart grid projects risk losing out on millions of EU funding because they do not cross borders or meet pan-European requirements.
- Barriers to complying with EU cross-border requirements for funding are pretty high for Smart grids due to the difficulty of getting sufficient distribution system operators and transmission system operators from different member states to work together.
- National regulators should be encouraged to give a more pan-European element to projects to benefit from some EU funds.

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