Methodologies to aid decision making in solar feasibility studies

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Outline

- Introduction to feasibility studies
- Main aspects of feasibility in solar energy projects
- The special case of public buildings
- Methodologies to aid decision making in solar feasibility studies
- Further remarks

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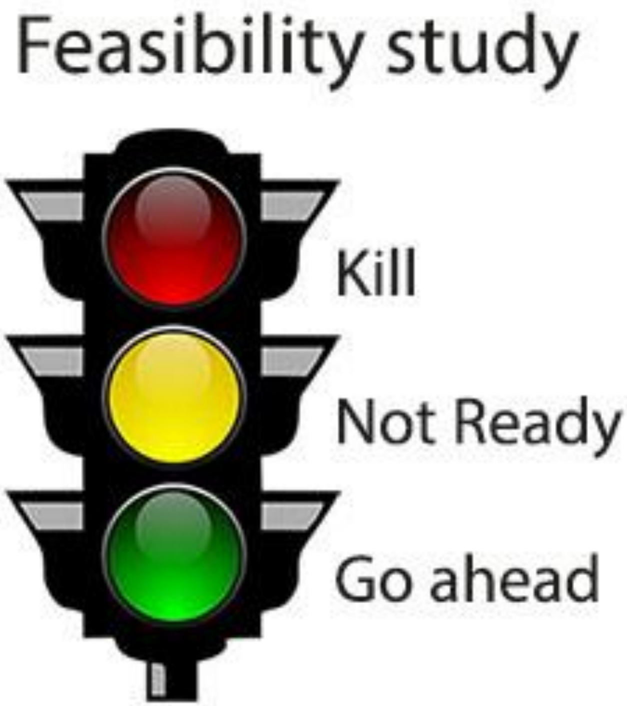
Feasibility studies

- A **feasibility study** is a set of investigations that establishes whether a particular project meets the conditions to be implemented
- It makes **recommendations** on whether or not the project should go ahead, and under what circumstances it should go ahead.



Feasibility studies

The objectives of the feasibility studies include typically:

- ✓give focus to the project;
- ✓provide valuable information for a "go" / "no go" decision
- ✓narrow the alternatives;
- ✓increase the probabilities of contributing to the success by identifying weaknesses at an early stage;
- ✓Enhance the success rate by evaluating multiple alternatives
- ✓consider the life cycle and impact of the project

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Importance of feasibility studies

- Feasibility studies offers the opportunity to "get it right" before committing time, money and resources to an idea that may not work in the way that was originally intended
- They help avoid additional costs to correct flaws and remove limitations that could have been identified earlier
- They may also help identify new possibilities, opportunities and solutions you might never have otherwise considered

https://solarpanelpower.ca/how-solar-power-works-canada/attachment/roof-collapse-solar-power/

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Main aspects of feasibility in solar energy projects

Typically, a solar feasibility study includes the following major aspects:

- Technical
- Financial
- Environmental
- Social / Legal

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Technical aspects

- Prediction of the electricity production capacity of the solar plant
- The optimum location and orientation of a solar array
- Surveys for open terrain, roof based and building/roof integrated systems
- Solar panel mounting options

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Technical aspects

- Local shading considerations in relation to nearby structures
- Assess the need for any electrical, roof, ground or any other works
- Assess any potential on-site hazards and risks
- Identify any site access restrictions
- Identify any potential grid connection restrictions

https://blog.aurorasolar.com/shading-losses-for-pv-systems-and-techniques-to-mitigate-them/

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Technical aspects

- Includes key indicators, such as efficiency, warranty terms, degradation, life cycle, maintenance requirements, for key items of equipment including
  - Solar panels
  - Batteries
  - Inverters
  - Solar collectors

https://thepowerstore.co.za/products/axpert-ii-5000va-5000w-solar-inverter-4000w-mppt-220v-48vdc-pf1-120v-450v-mppt

Financial aspects

- Financing of a commercial solar project is possible when the plant is **highly likely** to generate enough **revenue** to pay for **debt**, **costs** and produce an acceptable **return** for the equity invested
- Decision to proceed with the development of a commercial solar energy project **depends heavily on the financial viability** of the project

https://www.philips.ac.cy/department/accounting-finance/

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Financial aspects

- The requirements for return on investment may be lower or non-existent for **public** or **non-profit** organisations, such as local councils and universities
- Moreover, in some cases, a negative return on investment can be acceptable if the principal aim of the project is different from generating profits (e.g. in the case of **demonstrators**)

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Financial aspects - revenues

- Annual **energy yield** directly drives the **revenue** line in the cash flow model.
- **Accurate energy yield predictions** are extremely important in large scale projects.
- The **uncertainty** of the estimated energy yield is also very important, as the annual energy yield directly affects the annual revenue and therefore project viability.

https://www.information-age.com/smart-metres-vulnerable-cyber-attacks-123470837/

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Financial aspects - revenues

- The key revenue stream for most solar power plants is the **tariff** paid for each kWh of electricity generated.
- **Power Purchase Agreements** (PPAs) can be signed with a commercial buyer
- Sometimes there are other sources of revenue, such as renewable energy credits, tax credits, etc.
- The permanency of such incentives should be assessed carefully, as they are often modified or eliminated
- Tariffs and incentives vary from country to country.

https://www.caplor.co.uk/solar-pv/feed-in-tariff/

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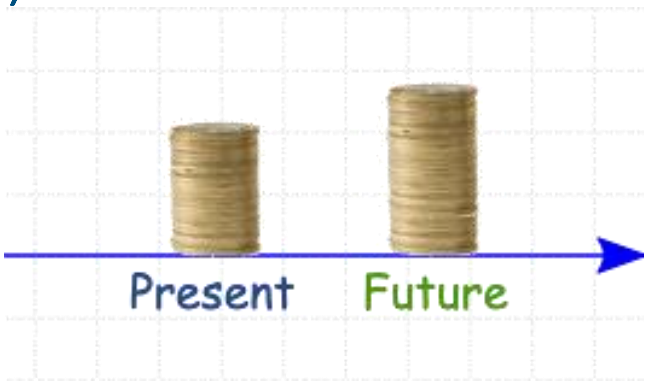
Financial aspects – key indicators

Key indicators often used to assess the financial viability of a solar project include:

- Net present value (NPV)
- Internal rate of return (IRR)
- Payback period (PP)
- Cash Flow Available for Debt Service (CFADS)
- Debt Service Coverage Ratio (DSCR)
- Loan Life Coverage Ratio (LLCR)
- Levelised Cost of Electricity (LCOE)



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Environmental aspects

- The potential environmental impacts associated with solar power typically include
  - Land use and habitat loss,
  - Water use,
  - Manufacturing (use of chemicals, carbon use),
  - Landscape and visual impacts, and
  - Global warming emissions
- These can vary widely depending on the technology used, the location, the scale and other aspects of the project.

https://parkinsurance.co.uk/solar-farm-cost-setting-up/environmental-impact-solar-panels/

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Environmental aspects – habitat loss

- When a **habitat** is destroyed, the local organisms decline or disappear.
- Larger utility-scale solar facilities can bring about worries about **land degradation** and **habitat loss**
- Total land area requirement depends on the technology, the topography, and the intensity of the solar resource at the location.
- Habitat loss impacts from utility-scale solar systems can be minimised by locating them at **lower-quality locations**, such as **former landfills**.

https://www.ledwatcher.com/environmental-effects-solar-farms/

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Life cycle environmental impact of solar energy systems

- Solar energy systems provide significant environmental benefits in comparison to the conventional energy sources
- Sometimes however, their wide scale deployment has potential negative environmental implications
- Perhaps the simplest measure is to consider the global warming emissions associated to the solar installation.

http://www.bbc.co.uk/learningenglish/features/6-minute-english/ep-160915

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Environmental aspects – landscape and visual impacts

- These can include the visibility of the solar panels within the wider landscape and surrounding communities.
- Mitigation measures to reduce impacts can include
  - consideration of layout, size and scale during the design process
  - landscaping and planting to screen the modules.
- Glint and glare should also be considered in the environmental assessment process.

https://www.solarpowerworldonline.com/2016/10/software-lets-installers-assess-solar-glare-sensitive-areas/

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Reduction in carbon emissions

- The **reduction in carbon emissions** because of the substitution of fossil fuel generation that a solar installation enables **has a positive impact** in the environment.
- A simple initial calculation assumes that all solar electricity directly replaces electricity produced by large power stations.
- A common way uses the '*average grid carbon intensity*', which is the average amount of CO_2 emitted for each kWh of electricity produced for the power grid.
- Estimated at 445g CO_2 in 2013 for the UK

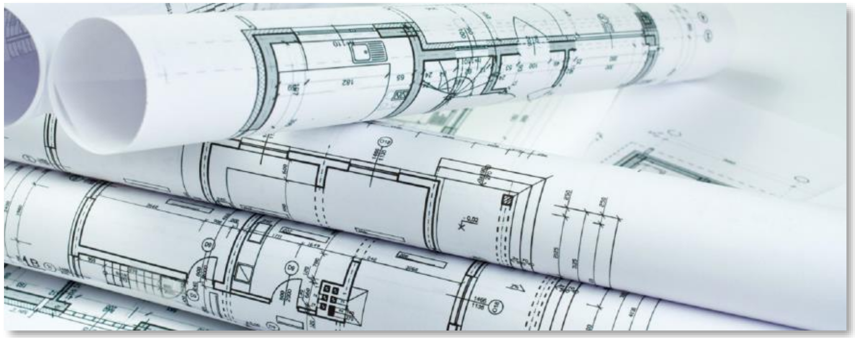
http://www.ox.ac.uk/news/2015-03-18-world%E2%80%99s-most-polluting-coal-plants-are-identified

Legal and social aspects

Legal aspects

Permits and licensing can be a lengthy process involving multiple agencies in the central and local governments. Depending on the characteristics of the project, some the following may be needed:

- Land lease agreement
- Site access permit
- Planning permission
- Environmental permit
- Grid connection agreement
- Operator/generation license



https://www.allcottassociates.co.uk/blog/i-need-planning-permission/

Legal and social aspects

Impacts on cultural heritage

- These can include **effects** on the setting of designated heritage sites or direct **impacts** on **underground archaeological deposits**
- **Field surveys** may need to be carried out prior to construction
- **Mitigation** measures can include **careful site layout** and design to avoid areas of cultural heritage or archaeological value

http://www.buildingconservation.com/articles/church-solar/church-solar.htm

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Solar feasibility studies in public buildings

- Installation of solar energy systems in public buildings helps reduce energy costs and carbon footprint and to promote use of solar energy to the general public
- There is a need to conduct feasibility studies to target the best opportunities for solar installations in public buildings as resources are limited
- In the case of public buildings, feasibility studies analyse energy potential, risks, and investment requirements, legal and regulatory aspects, cost/benefit analysis, required work, equipment, and potential CO_2 reduction

Solar installation at Portsmouth City Council

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Key benefits of solar technologies in public buildings

- Government branches and other public institutions have long time horizons and very low costs of capital.
- Moreover, they may be subject to more stringent energy performance standards than the private sector, propelling the need for solar energy.
- Adequate battery storage makes a PV system self-sustainable and resilient to time of use.
- However, some public buildings are meant for more daytime energy usage and this encourages self-consumption of solar energy

Solar installation at the University of Portsmouth

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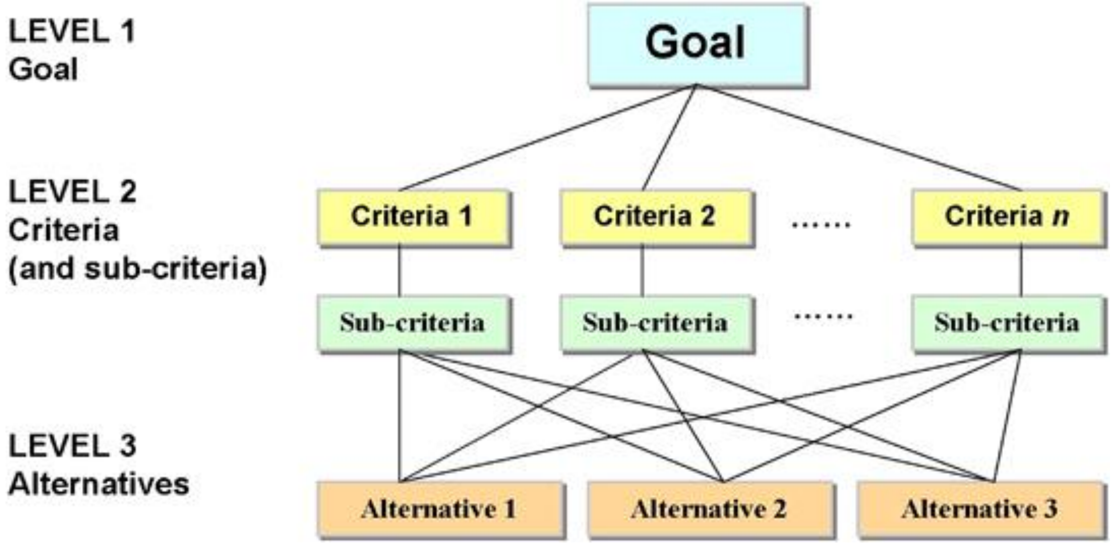
Challenges – hybrid systems in public buildings

- Public buildings without heritage value have less restrictions and advanced solar technologies like PVT or hybrid energy systems can be considered during the construction phase or refurbishment phase.
- This will increase the complexity of the feasibility study due to distinct energy sources (heat pumps + solar PV) or types (e.g. electricity and heat).
- One way of dealing with this complexity is the use of Multi Criteria Decision Analysis (MCDA) which is a family of tools to aid decision making in complex problems where a variety of objectives are involved.
- MCDA allows breaking the problem into more manageable pieces to allow data and judgements to focus on the pieces, and then of reassembling the pieces to present a coherent overall picture to decision-makers.

Methodology to assess feasibility



- Solar feasibility studies consider a range of criteria, including for example, technical, financial, environmental as well as legal and social aspects.
- Methods for decision making may vary, but in general the decision making process can be seen as a **multi-criteria decision analysis problem**.

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Methodology to assess feasibility

- To effectively assess the feasibility of the solar installation project, a possible approach is to use a **decision matrix**.
- This type of evaluation helps to inform the feasibility study by **weighting and scoring** the various elements which are relevant to the project and organisation.
- As part of one of the work packages in SOLARISE, we developed a methodology to aid decision making in solar feasibility studies.

Criteria	Weight (0– 5)	Score (1 – 10)	Weighted Score
Technical aspects	A	T	A×T
Financial aspects	B	E	B×E
Environmental aspects	C	E	C×E
Social and legal aspects	D	S	D×S
Total score (percentage)	-	-	10(A×T+ B×E +C×E +D×S)/(A+B+C+D)

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Methodology to assess feasibility

- The methodology allows the evaluation of different sub-criteria for each major criterion, resulting in a numerical score for each major criterion.
- Particular sub-criteria are classified as essential/non-essential
- Infeasibility of essential sub-criteria results in infeasibility of the alternative being considered.

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Methodology to assess feasibility

Example of data entry for environmental sub-criteria

Sub-criteria	Value (if applicable)	Units (if applicable)	Essential?	Score (0 to 10), 0='not applicable'
Habitat loss		-	N	0
Ground concurrency			N	0
Water use		gal/MWh	N	0
Life cycle environmental impact of solar energy systems	4802.5	kg CO2 eq	Y	7
Lanscape and visual impacts	-	-	N	0
Life-cycle carbon emission reduction	41650	kg CO_2	Y	9

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Methodology to assess feasibility

- The user selects the **weights** for each criterion and the **pass score** for sub-criteria and for overall feasibility
- An **overall score** for each alternative is calculated as a weighted sum of the scores for each criterion
- This allows to **rank** different feasible alternatives for the same project
- This ranking can be used by the analyst to **aid decision making**
- The definition of sub-criteria can be **adapted** and particular sub-criteria can be added or removed according to the user's preferences

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Methodology to assess feasibility

Case description:	20 kW rooftop solar installation	
PASS SCORE FOR ESSENTIAL SUB-CRITERIA (1-10)		**5**
PASS WEIGHTED SCORE FOR FEASIBILITY (%)		**50**

Criteria	**Weight (1 to 5)**	**Score (1 to 10)**	**Total Average Weighted Score**
Technical aspects	4	7.13	**28.50**
Financial aspects	5	7.25	**36.25**
Environmental aspects	4	7.33	**29.33**
Social and legal aspects	4	6.00	**24.00**
			69.46

Key for criteria weighs		**Key for scoring**	
0	Not important/not relevant	0	Not relevant
1	Very low importance	1	Not satisfied at all
2	Low importance	2	Very poor
3	Medium importance	3	Poor
4	High importance	4	Below satisfactory
5	Very high importance	5	Satisfactory
		6	Above satisfactory
		7	Good
		8	Very good
		9	Excellent
		10	Outstanding

FINAL RESULT	THE PROJECT OPTION IS FEASIBLE

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Final remarks

- We have had a look at solar feasibility studies, their objectives and importance.
- We considered key aspects of solar feasibility studies, including technical, financial, environmental, social and legal aspects.
- We also had a brief look at the special case of public buildings
- We discussed a methodology that has been developed under SOLARISE as an aid in the assessment feasibility of solar projects, to compare alternatives, and to make decisions.

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Thank you

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