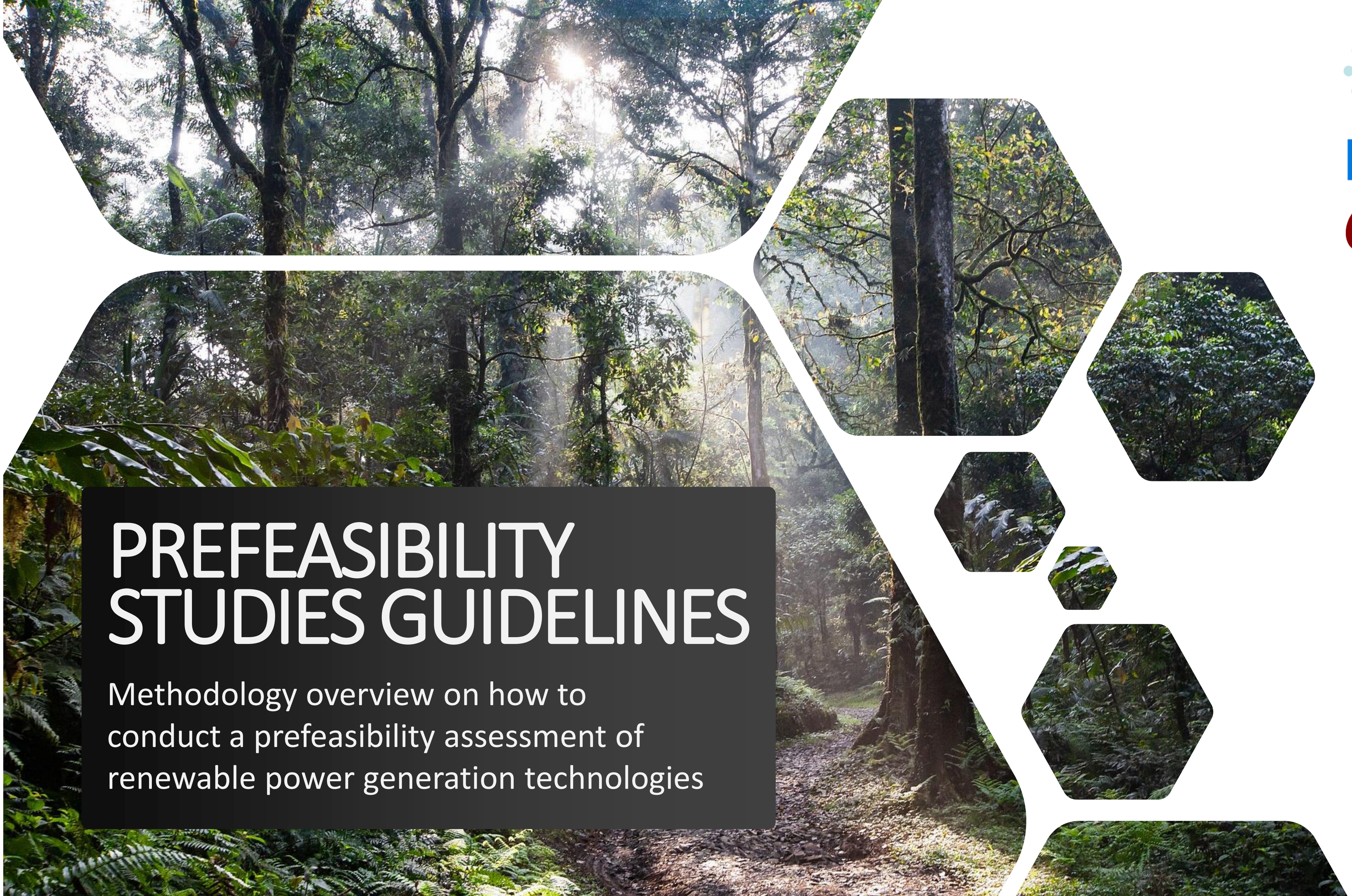


PREFEASIBILITY STUDIES GUIDELINES

Methodology overview on how to conduct a prefeasibility assessment of renewable power generation technologies

Danish Energy Agency

Viegand Maagøe

Ea Energy Analyses

PROJECTS MATURES OVER FOUR PHASES; FROM IDEA, CONCEPT AND BUSINESS DEVELOPMENT TO EXECUTION

Idea development

The idea development phase consists of brainstorming and idea generation activities to give the project a more rounded shape.

The main purpose of this phase is to flesh out selected business ideas and structure the rest of the project.

Concept development

The concept development phase usually consists of two stages and related studies:

i. a prefeasibility study (PFS)
ii. a feasibility study (FS).

The PSF is a rougher version of a FS. The purpose of a PFS is to discard unattractive ideas and choose the best among many.

Business development

The business development phase usually consists of two stages

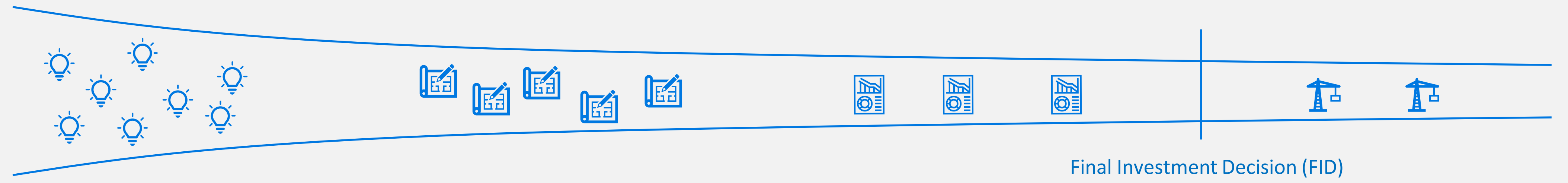
i. a validation stage
ii. a preparation stage

The best feasible idea is validated with detailed analyses of design and operations. Sourcing of permits and licenses follows.

Project execution

The project execution phase entails construction and installation of the plant, plus any other civil work needed for the project operations.

The number of possible projects shrinks during the project development phase, as different options are assessed. One (or a subset) of initial ideas will go to execution.



Source: AACE International recommended practices; Ea Energy Analyses and Viegand Maagoe analysis.

THE CONCEPT DEVELOPMENT PHASE USUALLY CONSISTS OF A PREFEASIBILITY STUDY AND A FEASIBILITY STUDY

Idea development → **Concept development** → Business development → Project execution

The concept development phase usually consists of two stages and related studies; a prefeasibility stage and study (PFS) and a feasibility stage and study (FS).

	Prefeasibility study vs **Feasibility study**
Scope	A prefeasibility study scans a series of options and determines the best one in the set. The feasibility study analyzes in depth the best solution from the prefeasibility phase.
Uncertainty	Uncertainty in the prefeasibility study is often much higher than for the feasibility study, e.g., -35% to +65% for PFS, and -22% to +35% for FS for Capital Cost.
Financing	Financial security is usually not mandatory for a PFS (though a preliminary assessment is generally made), whereas financial bankability must be ensured at the end of the FS.

Source: AACE International recommended practices; Ea Energy Analyses and Viegand Maagoe analysis.

PREFEASIBILITY STUDIES ARE SCREENINGS THAT IDENTIFY THE BEST FEASIBLE OPTION(S) OUT OF A SET

Prefeasibility study

A prefeasibility study is rough screening aiming at **identifying the most promising idea(s) and discard the unattractive options**. This reduces the number of options that are chosen to proceed with a more detailed feasibility study and eventually with business development, ultimately saving time and money. Often, the pre-feasibility study returns only one most promising option.

The assessment of the business idea has different focuses: technical, regulatory, environmental, economic and financial aspects are analysed. A pre-feasibility study is a **preliminary systematic assessment of all critical elements of the project** – from technologies and costs to environmental and social impacts.

Questions to be answered in a pre-feasibility study include:

- Is the expected revenue enough to proceed with evaluating the project more in depth?
- Are there any regulatory issues of decisive importance for the project?
- Is it economically (and financially) worthwhile to go further with this idea?
- What is the project's expected environmental and social impact?
- What are the risks and uncertainties connected to the idea?

Usually, a feasibility study concerns the analysis of an **individual project** only, normally with well-defined boundaries. The whole energy system is usually assumed as given and thus related data can be used as input to the analysis.

Source: Ea Energy Analyses and Viegand Maagoe analysis.

THE 8 STEPS OF A PREFEASIBILITY STUDY

The content and topics of a prefeasibility study can be broken down in 8 steps. The last 3 steps build on the project details analysed in the first 5 steps.

Step		
1	**Background & scope**	Scope of the study, investment context, case descriptions, power system and stakeholder overview.
2	**Revenue streams**	Revenue sources, markets, support schemes or tariffs, other important regulatory aspects
3	**Resource evaluation**	Sourcing of fuel and fuel price (e.g. biomass), assessment of natural resources and expected energy yield
4	**Financial & technical key figures**	Estimation of CAPEX, OPEX, technical parameters (efficiency, lifetime)
5	**Project size & restrictions**	Grid and system perspective, physical planning issues, space requirements, other relevant barriers

6 **Business case**

Economic attractiveness for the investor (NPV, IRR..), robustness of the case (sensitivity analyses). Rough financial analysis.

7 **Environmental & social aspects**

Evaluation of the potential impacts on the area’s environment and other social implications.

8 **Risk assessment**

Assessment of project risks and potential mitigation factors.

Source: Ea Energy Analyses and Viegand Maagoe analysis.

DETAILED STEPS

Description of each step of a prefeasibility study

1 BACKGROUND & SCOPE

The outset of a prefeasibility study should introduce the case study and shed light on the project context, touching on:

Location
Geography, weather, demographics

Power system context
System description, annual demand and generation, installed capacity, future projections

Infrastructure and logistics
Ports, roads, availability of services, grid infrastructure (strength of the grid at connection point)

Political context
RE and other policy targets, investment landscape, political stability

Regulation
Key regulation in place and how it affects the project

Stakeholders
System operators, off-takers, governmental bodies, local population, environmental groups

Evaluation of project boundaries and energy system considerations
Project boundaries need to be defined at the project's outset. This approach clearly states to which extent technical, economic and environmental aspects are considered. Project boundaries can differ across themes. For example, cost figures might concern only the facility under study (up to the grid connection point) but environmental studies can extend to larger areas impacted by the project.

To the Business Case

- → Parameters affecting business robustness (system development, regulation, investment landscape etc.).
- → Cost of capital, financial environment.

Source: Ea Energy Analyses and Viegand Maagoe analysis.

2 REVENUE STREAM

One of the most important aspects of a prefeasibility study is understanding the **source of revenue for the project.** The main ones are:

Merchant project – power markets

Need to collect information on historical power prices and make a projection of future power prices, or negotiate a PPA with off-takers

Vertically integrated system

Need to collect information on average generation cost in the system and current procurement regulation, assess potential off-taker of PPA

Existing Subsidy Schemes

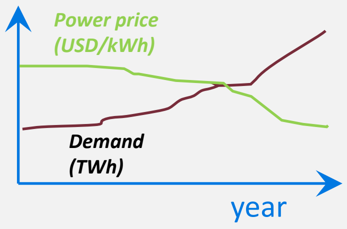
Analyse subsidy scheme, including duration, remuneration, contractual conditions, taxation and risks

Revenues can also be stacked, i.e., they can be sourced from different support schemes, agreements and/or markets.

Other factors to consider include:
Currency denomination (local vs international), taxation level, inflation index, possible local content requirements, other potential revenue stream (e.g. sale of process heat, residues, by-products)

Evaluation of future power demand and/or power prices
It is important to assess whether the revenue stream is stable over the years. This would involve an estimation of, for instance, the development in future power prices (if in a power market context) or the risk of a stagnation of power demand and related risk of overcapacity in the system, which could reduce the utilization of the power plant under investigation.

Both yearly demand projections and load profiles are key aspects to be considered in relation to power demand, especially in non-hedged contexts. For merchant projects, the average power price, as well as its hourly distribution, should be considered. Official projections by system operators can be used and uncertainities assessed in relation to the project size.



Background & scope
Revenue streams
Resource evaluation
Financial & technical key figures
Project size & restrictions
Business case
Environmental & social aspects
Risk assessment

To the Business Case

→ Quantified revenue sources for the entire project lifetime

→ Stability of revenue sources over time to assess robustness of the business case (including outages, maintenance needs, demand projections etc.)

Source: Ea Energy Analyses and Viegand Maagoe analysis.

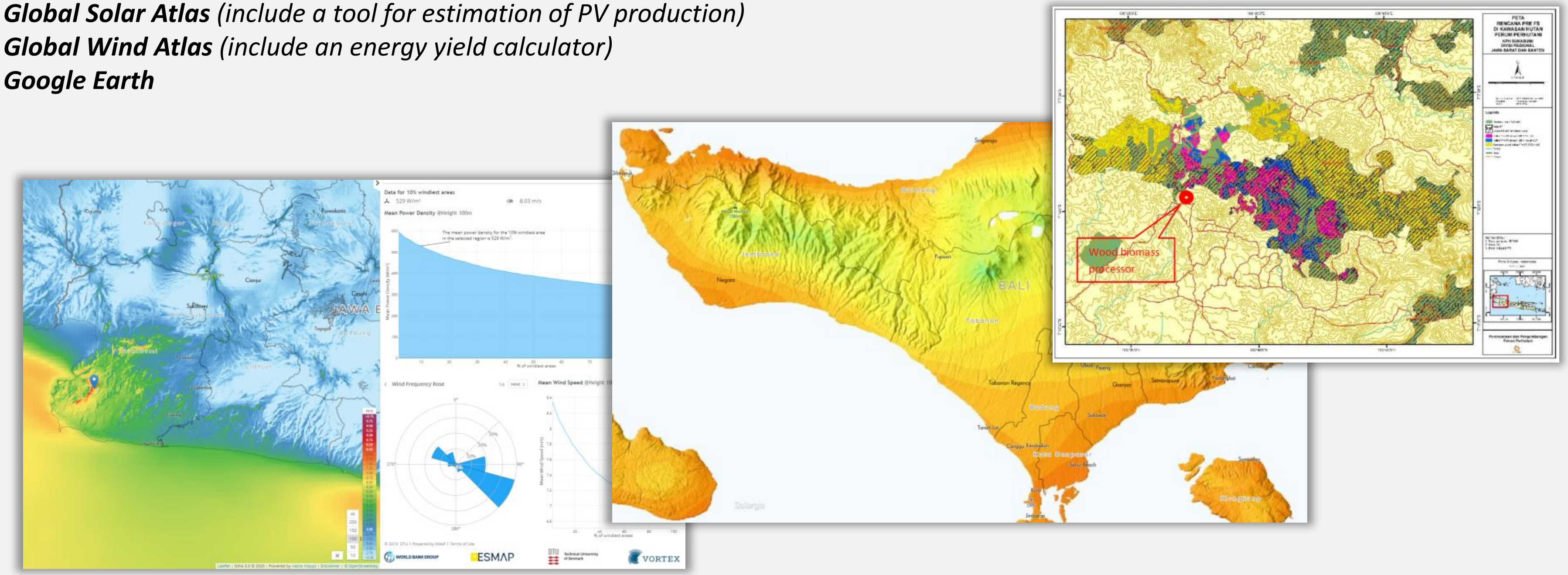
3 RESOURCE EVALUATION

RE mapping

Tools like GIS are good for detailed mapping of wind/solar resource, hydro catchments, as well as forestry/biomass resource.

At a prefeasibility stage, simpler tools like available resource maps or online databases are usually sufficient.
For biomass, it is important to not only map the potential resource, but also interview potential fuel suppliers

Example of mapping tools:
Global Solar Atlas *(include a tool for estimation of PV production)*
Global Wind Atlas *(include an energy yield calculator)*
Google Earth



To the Business Case

→ Potential annual power generation, expressed as full load hours or capacity factor (incl. uncertainty)

→ Total avaiability and price of feedstock for biomass and biogas

Source: Ea Energy Analyses; Global Solar Atlas; Global Wind Atlas; Ea Energy Analyses and Viegand Maagoe analysis.

3 RESOURCE EVALUATION

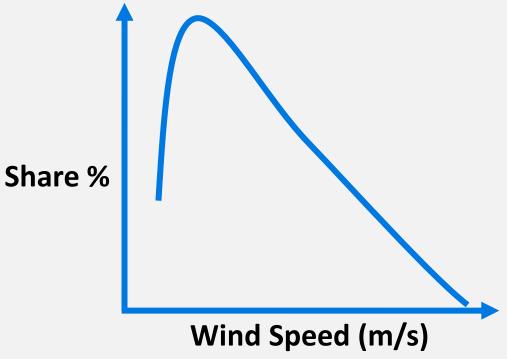
Evaluation parameter / *Technology*	Wind power	Solar PV plant	Bioenergy power	Hydro power	Geothermal power
Power generation source/fuel	Wind	Sun	Organic waste from plants and animals	Water	Thermal energy within Earth's crust
Potential for power generation dependency	Distribution of wind speeds at site, preferably over multiple years	Global Horizontal Irradiation at site (GHI), preferably over multiple years	Feedstock (fuel) availability, including quality of feedstock	Falling water having certain head and flow rate, preferably over multiple years	Well conditions (temperature and material makeup of crust)
Annual power generation	Wind speed distribution combined with power curve	Projections for solar irradiation combined with technical conditions	Plant efficiency and availability (outages, maintenance, feedstock etc.)	Turbine efficiency, water inflow and availability (outages, maintenance, wet/dry years), environmental restrictions	Plant efficiency and availability (outages, maintenance etc.)
Fuel price	None	None	Price of feedstock and transportation cost	None	None
Available software	*WindPro, WaSP Global Wind Atlas*	*PVsim, Pvgis, Global Solar Atlas*			

Source: NEC, BPPT Engineering, Ea Energy Analyses and Danish Energy Agency; Ea Energy Analyses and Viegand Maagoe analysis.

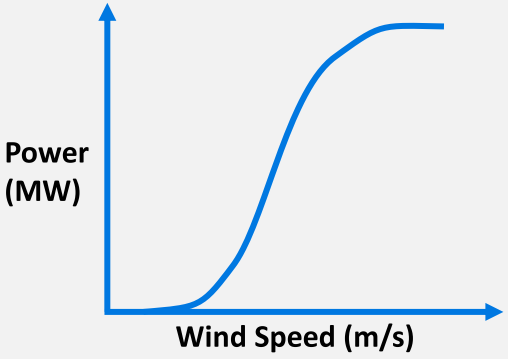
3 RESOURCE EVALUATION

Wind power

Distribution (%) of wind speeds (m/s) at location



Wind speed (m/s) turbine power (MW) curve



Annual power generation (MWh)

Total annual power generation (MWh) of turbine

Bioenergy power

Determine feedstock availability

- Determine the type of biomass
- Determine potential of the available feedstock
- Mapping of the available feedstock
- Determine the optimal location and size (capital cost vs. transport)
- Determine a reasonable price for biomass

Given location, prices and capacity

Total potential capacity (MW)

Optimal location

Feedstock price

Total amount of biomass

Heating value of biomass

Source: Ea Energy Analyses and Viegand Maagoe analysis.

4 KEY TECHNOLOGY AND FINANCIAL FIGURES

Technology figures

- Typical capacity of power plants *(MW)*
- Technical lifetime *(years)*
- Plant availability, outages *(%, days)*
- Efficiency (Condensing and CHP, where appropriate) *(%)*
- Space requirement *(m^2/MW)*
- Capacity factor ranges *(%)*
- Other technical info (e.g., power curve for wind, performance ratio for PV) relevant for the project purpose and expected operations

Financial figures

- Capital cost (CAPEX and DEVEX) *(USD/MW)*
- Operation and maintenance cost (OPEX) *(USD/MW, USD/MWh)*
- Weighted average cost of capital (WACC) *(%)*
- Corporate tax rate *(%)*
- Depreciation rate and amortization approach, if relevant
- Inflation rate *(%)*
- Economic lifetime of project *(years)*

Uncertainty

At the PFS stage of the project development, a large amount of parameters are characterized by a substnatial level of uncertainty. In the business case analysis, it is important to understand the impact of the change in key parameters (e.g. CAPEX, WACC, lifetime) on the economical feasibility of the project. It is therefore very important to include uncertainty ranges on as many figures as possible, to allow for detailed sensitivity analyses.

Sources for technological and financial figures

In PFS, the main sources can include existing studies in the literature and audits with industry experts and relevant stakeholders

Literature

Manufacturers catalogues

Technology catalogues

Interviews with manufacturers

To the Business Case

→ Technology estimates for the project lifetime

→ Financial figures for the project lifetime

→ Uncertainty ranges for as many figures as possible

Source: Ea Energy Analyses and Viegand Maagoe analysis.

4 KEY TECHNOLOGY AND FINANCIAL FIGURES

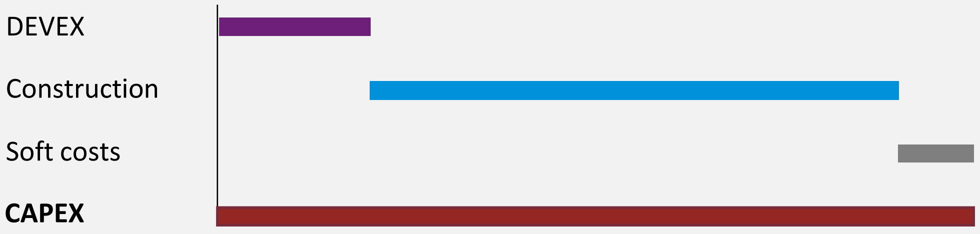
Capital Expenditures (CAPEX)

In most energy projects, especially capital-intensive ones such as PV and wind, **CAPEX are the most important cost figure** and thus are key to determining the feasibility of the project. CAPEX includes also development expenditures (DEVEX) in this guide.

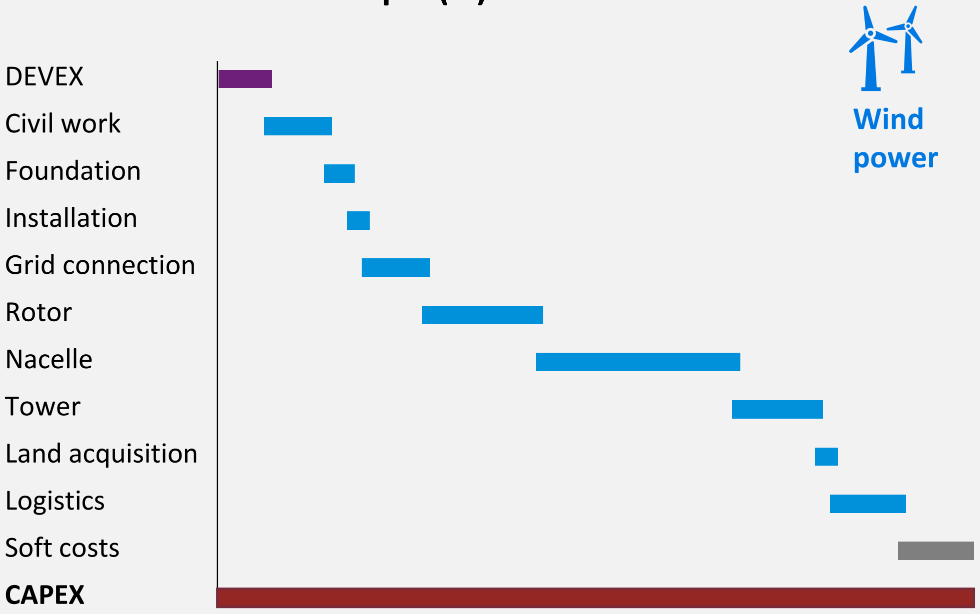
To be considered when defining CAPEX:

- Include **each CAPEX component**
    - Pre-construction costs (**DEVEX**), such as development and planning, land acquisition, permitting and logistics and so forth, which occur before the Final Investment Decision (FID)
    - **Construction** costs, which comprise equipment, grid connection costs, civil works etc. (occurring after the FID)
    - Other **soft expenditures** such as financing, overhead costs and eventual decommissioning costs
- Consider **cost changes overtime** and installation date, especially for technologies whose costs evolve quickly like PV
- Consider distance to the grid and **cost of connection**, including evaluation of regulation on the matter (e.g., does the developer pay shallow or deep connection costs?)
- **Estimate the uncertainty**, which can be used to test the case robustness

CAPEX breakdown (%)



CAPEX breakdown example (%)



Source: KPMG, Danish Embassy in Jakarta, Danish Energy Agency; Ea Energy Analyses and Viegand Maagoe analysis

5 PROJECT SIZE & SITING: SYSTEM AND GRID

Each technology has a list of considerations for determining a first estimation of the optimal site and size of a project, which will be finally determined in the FS.

	Wind power	Solar PV plant	Bioenergy power	Hydro power	Geothermal power
Power plant sizing	Turbine rating and number of turbines	Surface area of panels	Total availability of feedstock	Size of reservoir or river flow rate	Size of well
Location considerations	Wind resource distribution, space limitations, obstacles that can disrupt airflow and visual impact on landscape	Space limitations, shading between rows and surface slope of the site	Trade off for distance: capital cost (lower for larger project) vs transport cost (lower for small projects), alternative uses of feedstock	Water reservoirs or rivers, local water life, environmental restrictions on use of water	Temperature of crust, risk of mudslides during drilling
Grid integration	Non-dispatchable – weather dependent, considerations on security of supply and limits of grid integration	Non-dispatchable – weather dependent, considerations on security of supply and limits of grid integration	Dispatchable – plants can be ramped up and down, considerations on security of supply	Dispatchable – rapid ramp rates and large ramp ranges, considerations on security of supply	Dispatchable – best economical case as base load (flexibility increases costs), considerations on security of supply

Background & scope

Revenue streams

Resource evaluation

Financial & technical key figures

Project size & restrictions

Business case

Environmental aspects

Risk assessment

To the Business Case

- → Expected central estimate for project size
- → Range of potential project sizes for eventual sensitivity analysis

Source: NEC, BPPT Engineering, Ea Energy Analyses and Danish Energy Agency; Ea Energy Analyses and Viegand Maagoe analysis.

6 BUSINESS CASE: INPUTS FOR BUSINESS CASE

1 Background & scope

From study
Parameters affecting business robustness (system development, regulation, investment landscape etc.).

Cost of capital, financial environment.

Input to Business case
WACC
CAPEX

2 Revenue streams

From study
Quantified revenue sources for the entire project lifetime

Stability of revenue sources over time to assess robustness of the business case (including outages, maintenance needs, demand projections etc.)

Input to Business case
Revenue over time
Demand
Outage

3 Resource evaluation

From study
Potential annual power generation, expressed as full load hours or capacity factor (incl. uncertainty)

Total availability and price of feedstock for biomass and biogas

Input to Business case
Generation
Feed stock price
Potential capacity

4 Financial & technical key figures

From study
Technology estimates for the project lifetime

Financial figures for the project lifetime

Uncertainty ranges for as many figures as possible

Input to Business case
CAPEX and OPEX
WACC
Efficiency
Lifetime
Outage
Land requirement

5 Project size & restrictions

From study
Expected central estimate for project size

Range of potential project sizes for eventual sensitivity analysis

Input to Business case
Potential capacity
Land requirement

Source: Ea Energy Analyses and Viegand Maagoe analysis.

6 BUSINESS CASE: METHOD

Discounted Cash Flow (DCF) method

- Cash flows in the earlier periods are weighted higher than cash flows in the later periods
- Achieved with the discount factor: $\frac{1}{(1+r)^t}$

  Where r is the chosen discount rate and t is the number of years
- The discount rate has a large impact on the evaluation and is also referred to as the **Cost of Capital**

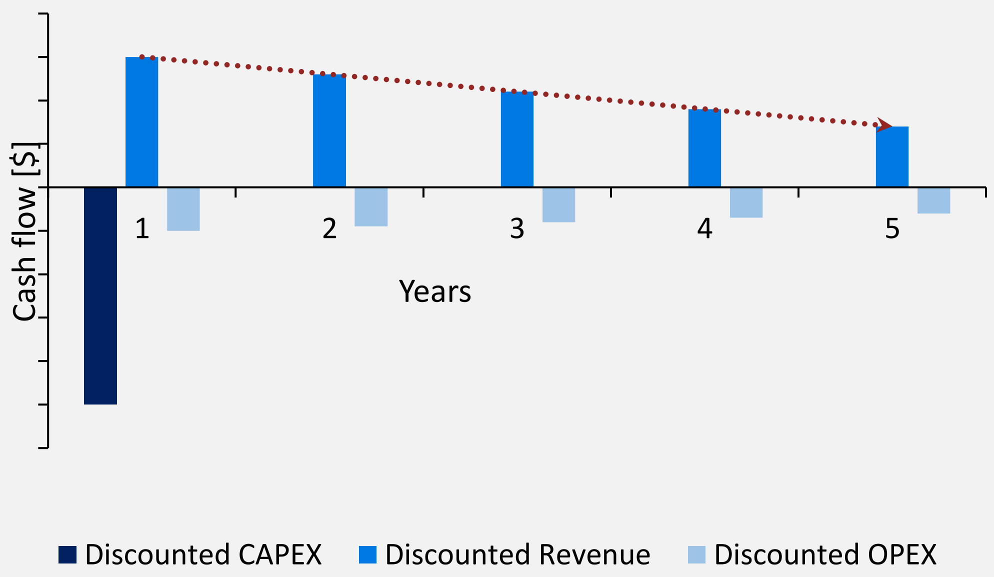
The importance of the Cost of Capital

- The weighted average cost of capital (WACC) is an essential element for calculating the value of a project
- The WACC is the rate that a company is expected to pay on average to all its security holders to finance its assets
- For a project to be financially feasible its returns (on a project basis) must exceed the WACC

WACC = **Cost of Equity** + **Cost of Debt** (after tax)

- The WACC is especially important at capital intensive project, such as RE projects.

Discounted Cash Flow (DCF) method



Nominal vs Real prices

- In economic language, real and nominal values represents two different ways of expressing monetary terms (i.e., units of currency).

Nominal Prices

What you pay for a product at any given point in time:

The price tag on a product

Real Prices

Takes inflation into account:

Measure of purchasing power

Source: Technical University of Denmark; Ea Energy Analyses and Viegand Maagoe analysis.

6 BUSINESS CASE: EVALUATION

A business case can be evaluated based on various financial metrics

Key metrics for evaluation

When evaluating the economic feasibility of a project, the following indicators are relevant:

- **Net Present Value (NPV) –** shows what a project is worth to us today based on discounted cash flows. Enables comparisons of projects with different timings and cash flow distributions over the project lifetime.

$$NPV = -CF_0 + \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t}$$

- **Internal Rate of Return (IRR) –** shows the annual effective compounded return rate of a project i.e. the annual return a project is expected to yield. The discount rate yielding an NPV of 0.

$$0 = -CF_0 + \sum_{t=1}^{T} \frac{CF_t}{(1+IRR)^t}$$

- **Payback Time (PBT) –** shows the number of years required to recover an initial investment based on cumulative cash flows.

- **Levelised Cost Of Energy (LCOE) –** shows the average cost of a project over its lifetime, taking into account the cost of capital. Often used for comparing technologies and for tracking economic developments of technologies over time.

Sensitivity Analyses

- Often used to assess the robustness of the business case. Usually done on key parameters: CAPEX, fuel price, WACC.
  - Also, important to consider technical assumptions (e.g., wind production estimates)

- Not to be confused with scenario analyses!
  - In **scenario analyses** we create a certain picture of the future (e.g., “Business as Usual”, “Green Scenario”)
  - In **sensitivity analyses** we test the robustness of a business case against one parameter while keeping all other assumptions the same.

Different approaches in business case evaluation

- Comparison of LCOE with potential tariff or PPA
- Comparison of IRR with expected WACC or investor benchmark
- Evaluation of absolute value of NPV
- Comparison of payback time to economic lifetime and investor preference or duration of PPA

Source: Technical University of Denmark; Ea Energy Analyses and Viegand Maagoe analysis.

7 ENVIRONMENTAL & SOCIAL ASPECTS

Environmental and social impacts are an important part of feasibility study and prefeasibility study that are often overlooked due to a focus on the economics. This allows to hedge against serious problem, which might arise during the project implementation and operations. In a prefeasibility study, these issues should be mapped as a minimum. The assessment can be based on current regulation, past experience (when relevant), and acceptance levels. Environmental and social considerations can also feed into the Risk Assessment.

Key aspects to consider:

- Pollution of air, water and soil
- Land use
- Visual impact, noise, odor
- Wildlife endangerment
- Emissions of pollutants (PM, NOx, SOx) and carbon dioxide (CO_2)
- Conflict with other local activities (e.g., agriculture/fishing)
- Project acceptance from local stakeholders

Considerations should be made also with respect to current or alternative technologies deployed.

RE projects: avoided emissions

CO_2 NOx PM

Often, when investing in RE projects, there are positive environmental externalities for example in terms of avoided PM, NOx, SOx, and CO_2 emissions. It is relevant to quantify this benefit of the projects.

To assess the avoided emission of CO_2 and other pollutants, existing or alternative energy projects need to be considered. This is often complicated since the power sector is complex and interconnected (import/export), generation patterns change hour-by-hour and the fleet evolves overtime.

Two main approaches exist:

- **Average approach**: today's average emissions for the power sector are calculated based on annual production and it is assumed that the project replaces the average annual generation.
- **Marginal approach**: this entails the identification of the marginal production technology that is replaced by the project, hour-by-hour and over time. Energy systems models can support this activity.

Source: Technical University of Denmark; Ea Energy Analyses and Viegand Maagoe analysis.

8 RISK ASSESSMENT

Risk is an event or a set of events that, should they occur, will have an effect on the project. Risks are classified within the following categories:

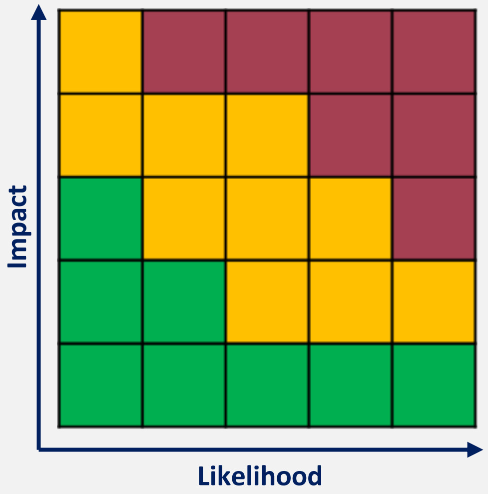
- **Political risks** – changes in support schemes, taxation rates, international sanctions etc.
- **Technical risks** – efficiency, maintainability, new technologies etc.
- **Economic risks** – Interest rates, credit risk, option price etc.
- **Social risks** – safety, labor, environmental etc.

These potential risks should be screened, and main project risks identified – Useful tool is the **Risk Matrix**

For each risk identified, a dedicated **risk mitigation measure** (or strategy) should be identified – Useful tool is a **Risk Register**

Risk Matrix

- Plots **Likelihood vs Impact** for the identified risks
- Likelihood is estimated as a level of **probability**
- Impact is normally estimated in terms of **potential capital loss**



Risk Register

Set up as a table that should at least contain the following themes:

Risk name	Description	Impact	Action
Short name of the identified risks	Brief description of the risks – should enable a discussion	Describe the impact that the risk can have on the project	Identify which actions to take for mitigating the risk

Source: KPMG, Danish Embassy in Jakarta, Danish Energy Agency; Ea Energy Analyses and Viegand Maagoe analysis

8 RISK ASSESSMENT: SPECIFIC RISK

Each power generating technology has its own list of potential risks factors to be considered

Wind power	Solar PV plant	Bioenergy power	Hydro power	Geothermal power
Pre-construction • Change in PPA/tariff structure • Local opposition stop/delay construction • Land acquisition issues • Limits in the infrastructure to deliver materials or construct • Shortage skilled personnel	**Pre-construction** • Change in PPA/tariff structure • Local opposition stop/delay construction • Land acquisition issues • Limits in the infrastructure to deliver materials or construct • Shortage skilled personnel	**Pre-construction** • Change in PPA/tariff structure • Fail to secure feedstock supply ahead of construction • Land use competition for agriculture land • Evaluation of sustainability of supply of feedstock	**Pre-construction** • Change in PPA/tariff structure • Complex licensing and consent processes • Errors in geotechnical surveys • Limitations due to environmental constraints • Local opposition stop/delay construction	**Pre-construction** • Change in PPA/tariff structure • Resource characteristics different than anticipated • Complex licensing and consent processes • Errors in geotechnical surveys • Local opposition stop/delay construction
Post-construction • Wind resource less consistent than anticipated • Curtailment • Damage from extreme event • Increased requirements for forecasting or regulation • Technology risk (breakdown, lower performance)	**Post-construction** • Higher degradation of panels • Curtailment • Damage from extreme event • Increased requirements for forecasting or regulation • Technology risk (breakdown, lower performance)	**Post-construction** • Overlapping activities with the agriculture sector reducing availability of feedstock • Increase in feedstock price • Fuel supply agreements • Reduction running hours (e.g., lower power demand) • Technology risk (breakdown, lower performance)	**Post-construction** • Risk of persistence of consecutive dry years • Post-commissioning limitations of operations for environmental constraints • Technology risk (breakdown, lower performance)	**Post-construction** • Risk of reduction of steam pressure/temperature • Depletion of the well ahead of time • Technology risk (breakdown, lower performance)

Source: Ea Energy Analyses and Viegand Maagoe analysis.

8 RISK ASSESSMENT: GENERAL RISK

Financial risks

Currency – unfavorable moves in exchange rates

Inflation – inflation rate higher than expected

Interest rate – interest rate higher than expected

Off-taker default – sudden and persistent loss of demand

Regulatory risks

Change in law – unfavorable laws changes

Amendment of terms – unfavorable changes in terms

Revision of support – unfavorable changes in subsidies and support

General risks

Cybersecurity – risk of hacking and lock-down from cyber-attack

Terrorism – risk of terror attack and damage to the project

Natural catastrophe – risk of natural event that will damage the project

Source: Ea Energy Analyses and Viegand Maagoe analysis.

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GLOSSARY AND DEFINITIONS

Net Present Value (NPV)

Net present value (NPV) is the difference between the present value of cash inflows and the present value of cash outflows over a period of time.

Formula notation: CF_0 is the cash flow at year 0 and CF_t is the cash flow at year t, r is the discount rate considered and T the total lifetime of the plant.

$$\boldsymbol{NPV} = -CF_0 + \sum_{t=1}^{T} \frac{CF_t}{(1+r)^t}$$

Internal Rate of Return (IRR)

The internal rate of return is a discount rate that makes the net present value (NPV) of all cash flows equal to zero in a discounted cash flow analysis.

$$0 = -CF_0 + \sum_{t=1}^{T} \frac{CF_t}{(1+\boldsymbol{IRR})^t}$$

Weighted Average Cost of Capital (WACC)

The weighted average cost of capital (WACC) is a calculation of a firm's cost of capital in which each category of capital is proportionately weighted.

Formula notation: E and D are the total Equity and Debt, R_e and R_d the return on equity and debt respectively and T the tax rate in the country.

$$\boldsymbol{WACC} = \frac{E}{E+D} * R_e + \frac{D}{E+D} * R_d * (1-T)$$

Levelized Cost of Electricity (LCoE)

The LCOE can also be regarded as the minimum constant price at which electricity must be sold in order to break even over the lifetime of the project.

Formula notation: I_t , M_t and F_t are respectively the investment, maintenance and fuel cost at the year t, E_t is the output of the plant at the year t, r is the discount rate considered and T the total lifetime of the plant

$$\boldsymbol{LCOE} = \frac{total\ discounted\ cost\ over\ lifetime}{total\ lifetime\ discounted\ output} = \frac{\sum_{t=1}^{T} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{E_t}{(1+r)^t}}$$

Full load hours and Capacity factor

Full load hours (FLH) is a convenient notion expressing the equivalent number of hours of production at rated capacity that would give the same annual generation. Multiplying the FLH value by the installed capacity gives the production throughout one year.
The concept is equivalent to that of capacity factor (%); to convert capacity factor to FLH simply multiply the capacity factor by the total number of hours in a year (8760).

$$\boldsymbol{FLH}\,[h] = \frac{Annual\ generation\ [MWh]}{Rated\ power\ [MW]}$$

$$\boldsymbol{CF}[\%] = \frac{FLH}{8760}$$

LIST OF ACRONYMS

CAPEX	*Capital Expenditures*
CHP	*Combined Heat and Power*
DCF	*Discounted Cash Flow*
FID	*Final Investment Decision*
FS	*Feasibility study*
GHI	*Global Horizontal Irradiation*
GIS	*Geographical Information System*
LCOE	Levelized Cost Of Electricity
OEM	Original Equipment Manufacturer
OPEX	*Operational Expenditures*
PBT	*Pay-Back Time*
PFS	*Prefeasibility Study*
PPA	*Power Purchase Agreement*
PV	*Photovoltaics*
USD	*United Stated Dollars*
WACC	*Weighted Average Cost of Capital*