

Project Finance & Sustainable Investment Model (SIM)

A sustainable approach in financing off-shore wind farms

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Abstract

Usability of traditional financial investment models in sustainable (innovative) business decisions: Sustainable Investment Model (SIM) for off-shore wind farms.

Traditional financial models (e.g. capital budgeting theory) applied in sustainable business decisions for off-shore wind farm projects.

The success of innovation rests on technology, market development and on developing and creating access to financial resources. The latter should be detailed in a thorough business case including an investment model.

There are specialised publications in the field of Finance (Ross et al and Eiteman et al), Management Accounting (Horngren et al), Project Finance (Yescombe) and Engineering of Wind Turbines / Wind Farms (Krohn and Twidell et al), but not an integrated approach: To bridge the gaps between Engineering, Marketing, Financing and Managing investment in sustainable business innovations for the off-shore wind farms.

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Abstract

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1. Introduction

1.1 Introduction

Project finance is a useful tool for professionals to finance large, medium sized and small infrastructural projects in different sorts of industries (e.g. wind farms, solar energy, waste processing etc.) that want to contribute to sustainable development in a business environment.

Most of the projects are a cooperation between public and private initiatives (PPP = Public Private Projects), where the bottom line is that the project should generate enough cash flows to cover the initial investment. The role of the government is that initial subsidies and/or tax facilities are given to make the project possible and/or profitable.

Most of the infrastructural projects have in common that the life cycle is 20 – 30 years; so certain economic data are difficult and/or quite impossible to forecast, such as:

- Interest rate
- Inflation
- Labour costs
- Maintenance costs
- Energy prices
- Prices of raw materials
- Exchange rates
- Residual costs (Scrap value)
- Etc.

Projects with such a long term duration and being a public / private initiative; are often due to political risks and changes in the composition of the government (electoral cycle).

Infrastructural projects in the field of sustainable development of for instance the energy sector, decisions are very much influenced by the development in the energy markets and the political ideas of governments concerning renewable energy.

In 2030 36% of the electricity production should come from wind energy (EWEA, Annual report 2010).

1.1 Project finance

In the well-known textbooks about corporate finance (Ross cs) we cannot find the typical knowledge about project finance, although a lot of attention is focused on topics like capital budgeting, weighted average costs of capital (WACC) and the capital asset pricing model (CAPM). Useful tools for project finance, but the traditional tools for finance focus heavily on the point of view of the shareholder and less from the point of view of the banks (providing loans to finance projects).

So we need to realize that project finance differs from the approach of finance textbooks in finance / financial management (Yescombe and Gatti), because the project is often a separate legal entity; and the project company is often financed by several providers of equity (sponsors) and several bank loans (syndicate of banks). The value and the legal right of property are not easy to use for collateral of a loan and can be used in a bankruptcy to repay the debtors.

The value of the future incoming cash flows (Off taker contracts and tax facilities / subsidies of the government) play a larger role than the value of the off shore wind energy turbines, because it is difficult to sell something off shore (legal complications).

The role of ring fencing (Yescombe) is so important to understand project finance; ring fencing is actually meant for establishing a separate project company or SPV (Special Purpose Vehicle)

(Gati). So in the case of a bankruptcy of one of the sponsoring companies, the project company can still continue and is not 'dragged' into the bankruptcy of one of the sponsors.

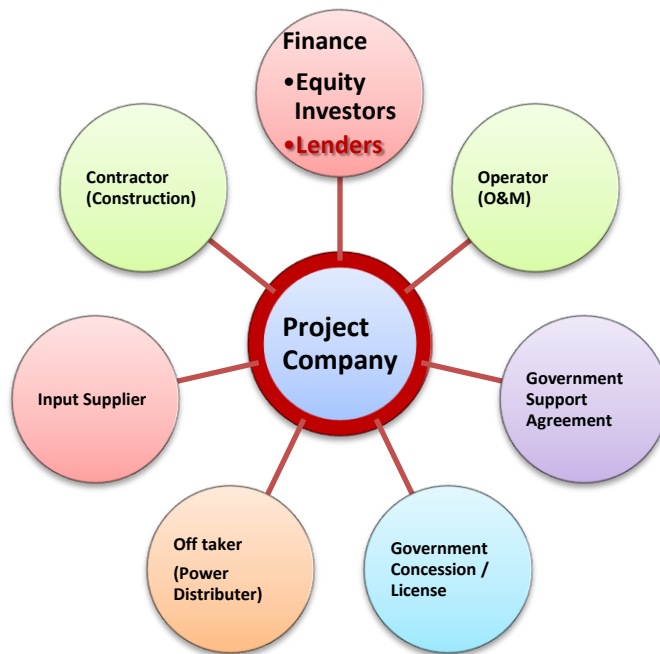


Figure 1: Project Finance & Ring Fencing (Yescombe)

1.2 Project risks

Projects like wind energy farms have many aspects of general risks of international business (Eiteman) and typical risks of project finance (Yescombe).

Off shore wind farms have from the point of view of the equity sponsors contain three main risks:

- Commercial Risks
- Macroeconomic risks
- Political risks

As explained in the next figure (Yescombe)

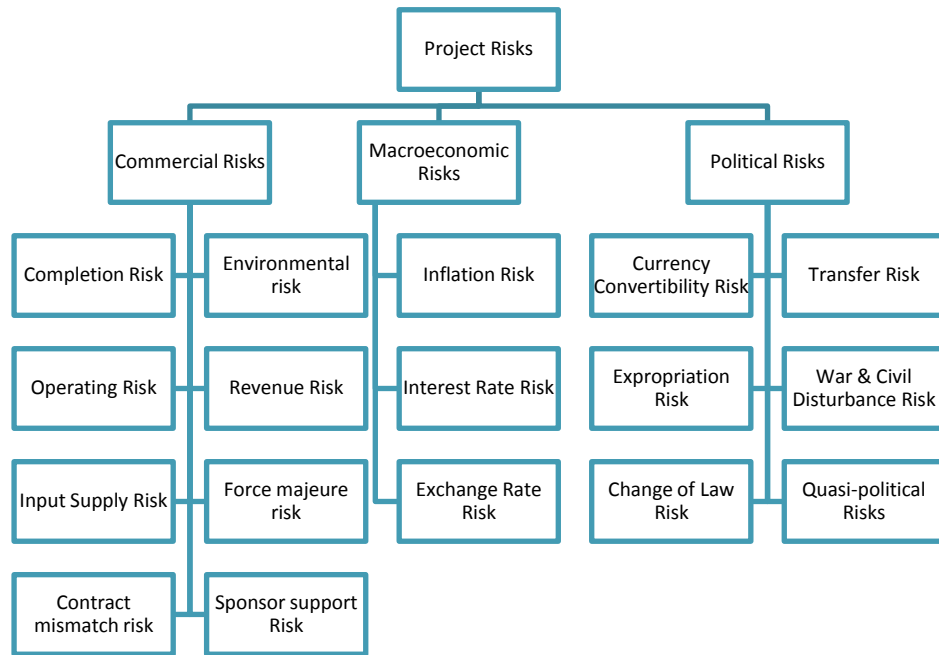


Figure 2: Project Risks (Yescombe)

Besides the above mentioned project risks we can distinguish them from the international business risks (Eiteman)

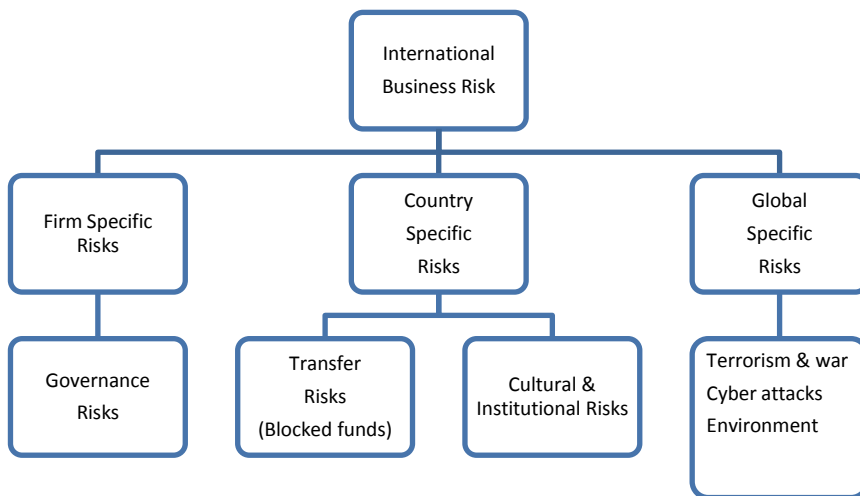


Figure 3: International business risks (Eiteman)

The exchange rate exposure (Eiteman) plays an important role in as well the cash outflows and the cash inflows, assume that the main providers of equity and loans are from the €uro-zone; and

for instance the hardware (CAPEX¹) is from an US \$ area and the maintenance (OPEX²) from the UK. The outgoing cash flows have a US\$ /€ risk (translation exposure) and UK £ / € risk (transaction & economic exposure).

Assume that the generated electricity from this wind farm is sold to Denmark, than the incoming cash flow has a DK Kr / € risk (transaction & economic exposure).

2 Markets for energy and renewable energy

The market for electricity is a complicated one from at least 3 perspectives.

When we produce electricity we can at least use 9 sources of input, normally we have 4 traditional ones that pollute the environment when used in producing electricity (Oil, Gas, Coal and Nuclear) and 5 renewable ones (that do not affect for instance CO2 emission).

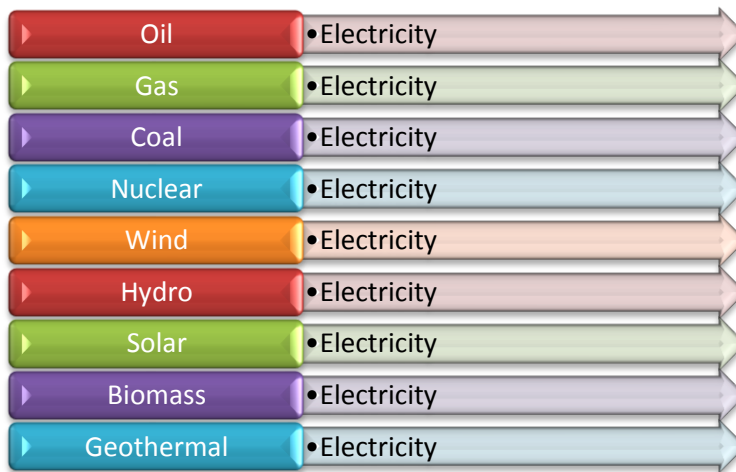


Figure 4: Sources of electricity production

A second perspective concerns direct storage of electricity, which is in general not possible in an efficient large scale way. So we use as reserve capacity the above mentioned factors of indirect storage.

Thirdly the electricity that is transported incurs some loss of electricity, so not the full 100% arrives at the final destination for the users (companies, private households etc.)

Because of the above mentioned complexity of the market for electricity, new ways of generating (renewable) energy heavily depends on the prices of traditional sources to produce electricity (e.g. oil prices); and the tax and subsidy policies of the government.

When oil prices increase enough, renewable ways of producing electricity get more attractive in a financial way; and or the government influences allocation in the electricity industry by regulations, subsidies and tax policies.

So allocation for the electricity industry is very much influenced by the development of prices in the factor markets (e.g. expected oil prices) and the energy policy of the government (regulations, subsidies and tax policies).

Production of electricity is not only complex because of the above mentioned 3 perspectives, but also because of the long term development of energy prices and the energy policy of the government. The role of the government is an important one, normally government are elected for a period of 4 or 5 years, while an investment decision to build an electric power plant is a project with an economic life cycle of more than 20 to 30 years.

¹ CAPEX: Capital Expenditures

² OPEX: Operational Expenditures

In the next sections we will discuss the environment on a macroeconomic level, industry level (meso level) and firm level (microeconomic level)

2.1 Macroeconomic level

The developments at the macroeconomic level are quite clear: the battle for fossil energy sources. In a fast developing world we have the traditional consumers of energy (USA and Europe), but the emerging economies (BRIC³ countries) that are rapidly changing this pattern of energy consumption. So in most scenarios for the coming 20 – 30 years we see that the prices of fossil energy will increase (IEA).

From the Annual Energy Outlook 2010 of the U.S. Energy Information Administration the average annual increase in real electricity prices till 2035 is calculated; the expected annual increase is 0.85% for real electricity prices per KWh
$$\left[\left\{ \left(\frac{10.2}{8.6} \right)^{(1/27)} - 1 \right\} * 100 \right].$$

In the Commodity Price Forecast 2012 from the Worldbank (IBRD) the annual US GDP deflator is expected to be 2% per annum.

So nominal prices of electricity per KWh are expected to increase for the coming 25 years around 2.85% per annum ($2.85\% \approx 2\% + 0.85\%$) in the USA.

This forecast, as an assumption, we will later use in our decision model.

2.1 Meso economic level

The industry (meso) level provides insight into the factors of how prices are established in the market for electricity power.

Some questions arise:

- Is it a factor market or a market for final goods/services?
- What is the level of government intervention?
 - Indirect taxes
 - Subsidies
 - Regulations
 - Anti trust
 - Pollution
- How is the competition?
 - Monopoly
 - Monopsony
 - Oligopoly
 - Oligopsony
 - Perfect Competition
 - Monopolistic Competition

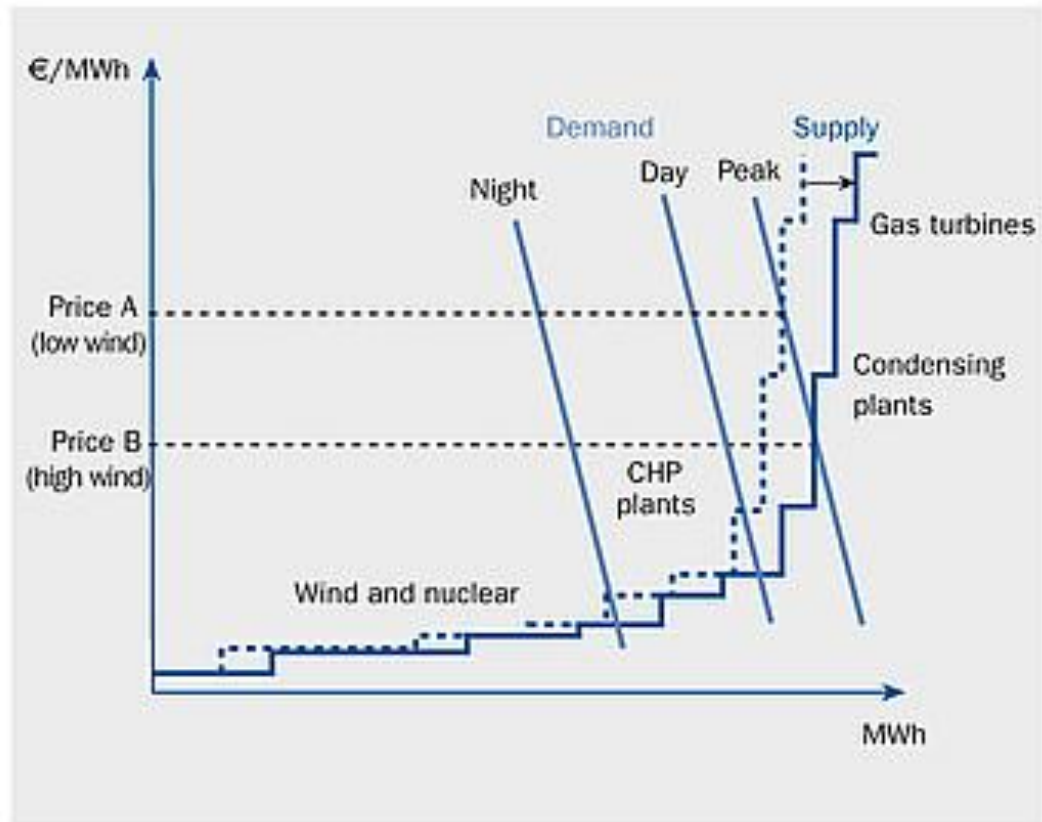
To make a convenient choice a market of perfect competition is chosen for final products with no governmental intervention in the market.

In table 1 we can derive a set of 6 prices for Low or High wind combined with Peak, Day or Night hours, where the (stair cased) supply curve meets the 3 demand curves. We can observe in the (stair cased) supply curve several sorts of combined electricity production modes (wind, nuclear, gas etc) and during 24 hours 3 demand patterns (night, day and peak).

³ BRIC stands for Brazil, Russia, India and China

	Low wind	High wind
Peak	Price A (figure 5)	Price B (figure 5)
Day		
Night		

Table 1: Demand & Supply



Source: Risø DTU

Figure 5: Electricity Market {EWEA (Economics of Wind)}

So when in the financial decision models energy prices are used, we have to realize that it are averages of the above mentioned market forces on as well the supply side as the demand side.

2.2 Microeconomic level

Finally the firm (micro) level is taking into account, for that it is important to know in which part of the supply chain the company is situated. The (off shore) wind farm is only generating electricity so inbound logistics are outsourced (like maintenance) and outbound logistics as well (transport and distribution of electricity); this is an alignment with the earlier introduced concept of ring fencing of the project company. To satisfy the (main) stake holders the company has to generate a 'good' profit, because shareholders want to have a continuous stream of stable dividend (with a

'fair 'mark up above the risk free interest rate), the same expectation the banks have for their loans: repayment of the debt plus interest remuneration. Normally companies in the renewable energy sector have besides the financial goals, also goals in the field of Corporate Social Responsibility (CSR); producing wind energy is normally seen as a quite clean mode of electricity production. And of course using wind causes no CO₂ emission, but a wind farm is of course produced , has to be maintained and after the economic life has to be removed. So in the investment itself those three aspects have to be taken into account.

3 ETO's & Engineering

3.1 Economic Trade Off's (ETO's)

Economic Trade Off's (ETO) is one of the basic assumptions in economics, and well known as opportunity costs or alternative costs in more recent developments in management or cost accounting (Horngren cs)

Opportunity cost is: *"the contribution to operating income that is forgone by not using a limited resource in its next best alternative use"* (Horngren cs cs)

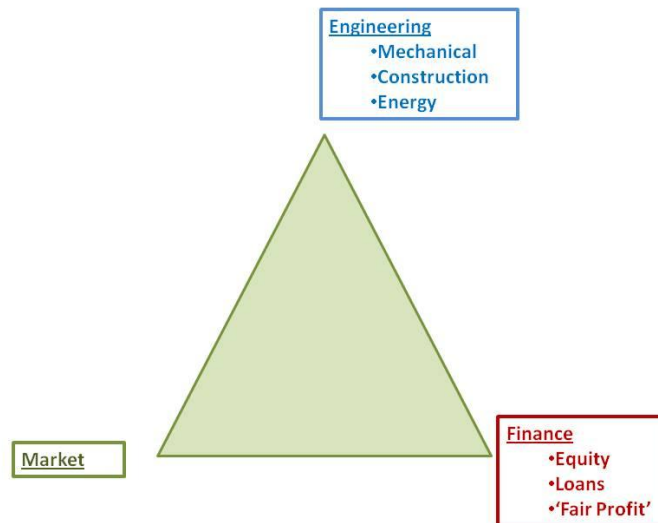


Figure 6 MEF Triangle (Berendsen cs, 2012)

ETO's play an important role in the trade-off's made in the MEF triangle (figure 6), for instance a more durable construction of a mechanical part of the wind farm, will cost more in terms of investments (CAPEX) but will be less in terms of maintenance costs (OPEX) and replacement expenditures.

In the sea environment it is quite complicated to repair and/or to replace spare part of the wind turbine, because of waves and wind.

3.2 QC, TCO & LCC

When investing in an off shore wind farm a few abbreviations play an important role:

- QC: Quality Costs

- TCO: Total Cost of Ownership
- LCC: Life Cycle Costing

All three concepts try to tackle similar aspects. While engineering the wind turbines trade off's should be made when to replace the gearing box and/or moving parts of the wind turbine; and what are the costs of doing so off-shore? Or to invest additional in a more durable gearing box and mechanical parts.

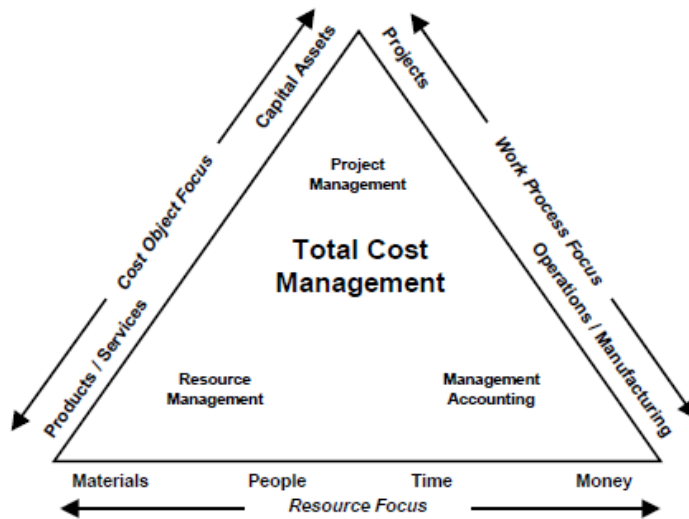


Figure 7 The Total Cost Management Triangle (Hollman)

In this article – see figure 7 - an attempt is made to connect technical and financial trade-off's using the Total Cost Management (TCM) framework of the American Association of Cost Engineers (Hollmann), so the capital investment (CAPEX) is brought into alignment with the operations of the project (OPEX). In the context of this article the TCM framework is applied for an off-shore wind farm.

The input for such decisions are prepared by the engineers and financial managers of such projects in tight cooperation; and making the ETO's as mentioned above.

Costs of quality (Horngren cs) are classified into four main categories:

- I. Prevention Costs
 - a. Engineering
 - b. Supplier evaluation
 - c. Preventive maintenance of equipment
 - d. Testing of new materials
 - e. Etc
- II. Appraisal Costs
 - a. Inspection (manufacturing process)
 - b. Product testing
- III. Internal Failure Costs
 - a. Rework
 - b. Scrap
 - c. Spoilage
 - d. Additional engineering
 - e. Etc
- IV. External Failure Costs

- i. Customer support
- ii. Additional repair and/or engineering
- iii. Warranty
- iv. Liability claims

It is obvious that in the engineering stage of a project (prevention costs) the voice of the client is important (to prevent cognitive dissonance afterwards); as well as future costs of maintenance respectively expenditures of replacement of parts.

We distinguish three main technical aspects of wind farms:

- Foundation
- Mechanical Engineering
- Energy

3.3 ETO's and Foundation

The foundation on the seafloor depends of course on the soil and structure (slope!) of the seabed, the water fluxes (e.g. currents) as well on the sort of jacket (monopole, tripod, three-legged jacket or four-legged jacket). (Twidell)

The choice of the jacket also depends on the depth of the water, and the size of the wind turbine (tower and rotor).

So the stability of the seabed should be checked very well, before making a choice for the location and the type of foundation (e.g. choice of the jacket). According to Twidell we can distinguish four sorts of soil instability:

- I. Instability of the natural slope of the seabed (especially relevant for clay and sandy soils)
- II. Hydraulic instability caused by water fluxes (turbulences of currents)
- III. Instability caused by scouring (scour protection)
- IV. Instability caused by liquefaction (e.g. earthquake)

Depending on this technical information of the (natural) foundation conditions, choices are made for the 'right' foundation; and thus for the investment expenses (CAPEX) versus additional maintenance expenses in the future (OPEX). Because of natural causes, it is not only difficult but also expensive to repair and/or change foundation of the wind farm during the economic life of this investment. So choices are made for 20 – 30 years ahead, in fact based on the duration of the project.

3.4 ETO's and Mechanical Engineering

Manwell cs distinguish the following component used in a wind turbine:

Component	Material
Blades	Composites (fibers, epoxies, etc)
Hub	Steel
Generator	Steel & Copper & Magnets
Gearbox	Steel & Lubricants
Mechanical equipment	Steel
Nacelle cover	Composite / Fiberglass
Tower	Steel
Foundation	Steel & Concrete
Electrical & Control system	Copper & Silicon

Table 2 Components and materials used in wind turbines

Because of special climatologically circumstances (salt water, wind, temperature and waves) and the long economic life of the wind turbine trade-offs have to be made in the fields of mechanical engineering, maintenance and CAPEX/OPEX.

As already mentioned, due to the fact that the wind farm is located in the sea, repairs and replacement should be minimized as possible because of high waves and strong winds it is quite difficult to do so.

The technical choices made from a mechanical engineering point of view are based on aspects as:

- Corrosion
- Fatigue
- Performance (long term)

So again (like in paragraph 3.3) we can conclude that the economic trade-off is made to minimize the Total Costs of Ownership (TCO) of the economic life of the investment in the wind farm.

3.5 ETO's and Energy

The wind turbine has electrical and control aspects in its system, as well as the transport of electrical from the turbines to the wind farm level (PCC = point of common coupling) and from the transport of the electricity from the wind farm to the mainland (POC = point of connection).

Manwell cs distinguish the following aspects of the electrical & control system:

- Power generators
- Power electronic converters
- Power cables
 - Between wind turbines on the wind farm
 - Between wind farm and mainland
- Grids
 - Switches
 - Transformers
 - Conductors
- Sensors
- Controllers
- Converters
- Computers
- Batteries
- Motors
- Lighting
- Climate control

A wind turbine control system (Manwell cs) has the following functions:

- Monitoring for safe operations
- Information gathering (& reporting)
- Monitoring for operation
 - Wind speed & direction
 - Grid connection
- Managing turbine operation
- Actuating safety & emergency systems

As already noticed in the paragraphs 3.3 and 3.4 the technical installations should be as durable as possible (nearly to the economic life of the wind farm), so again economic trade-offs are made to minimize the total costs of ownership for the electrical components of the wind farm.

Besides the typical electrical mechanical (cables, motors, generators etc.) we have to take into account that we have to control the wind farm and each wind turbine from a distance using sensors, computers and EDI cables; so on shore the management of the wind farm can monitor operations and decide on (preventive) maintenance.

3.6 Risk Management

According the Enterprise Risk Management - Integrated Framework (COSO) risk management is:

“... a process, effected by an entity's board of directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risks to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives.”

The Enterprise Risk Management - Integrated Framework (COSO) distinguish for main risk categories:

- Strategic
- Operational
- Compliance
- Financial

The three dimensional framework is summarised in figure 8.



Figure 8 COSO Cube (COSO)

The Enterprise Risk Management - Integrated Framework of COSO, fits very well into modern approach of the control function in the company (Bove ):

- I. Set strategic goals

- II. Set standards
- III. Measure performance
- IV. Compare performance with standards
- V. Feed-back actions (see I)`
 - a. Corrective actions: performance \neq standard
 - b. No change: performance = standard

Operational Risk can structured, according the Operational Risk Management Framework (Blunden cs), into internal and external risk, as mentioned below:

- Operational Failure Risk (Internal)
 - People
 - Process
 - Technology
- Operational Strategic Risk (External)
 - Political
 - Taxation
 - Regulation
 - Government
 - Societal
 - Competition

This is all a very general approach for how to deal with risk and the management of risk, the ABS group (www.eqecat.com) developed a risk modeling process, that is more specific for wind farms. In figure 9 we find the structure of this risk modelling process, as we can observe this from the figure there are four main risk processes: Asset Attributes, Hazards, Vulnerability and Risk of Loss . Each main category is dived into sub-categories.

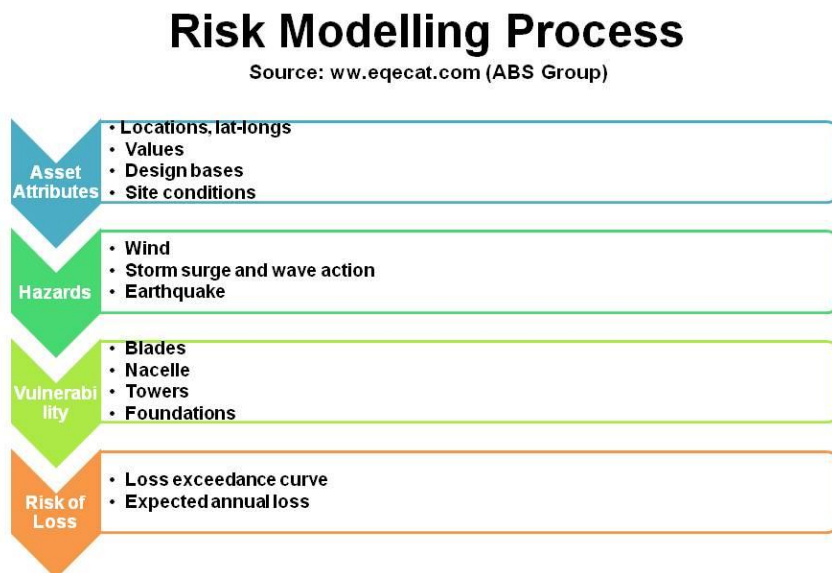


Figure 9 Risk Modelling Process (EQECAT)

4 Sustainable Investment Decisions

4.1 Corporate Governance & Corporate Social Responsibility

Corporate Governance and Corporate Social Responsibility (CSR) are both ethical principles how companies should be managed and how to behave. In several national and international guidelines (UNO, UNCTAD, Code Tabaksblat, IFRS and ISO) and/or national legislations (Sarbanese-Oxley Act) we can find those principles

“Enterprises should take fully into account established policies in the countries in which they operate, and consider the views of other stakeholders. In this regard, enterprises should:

1. Contribute to economic, social and environmental progress with a view to achieving sustainable development.

...
11.

Source: UNCTAD

These rules of conduct often protect human resources (to prevent: child labour, slavery, discrimination etc) and the natural environment (several sorts of pollution and depletion of natural resources); so companies feel themselves more and more responsible for not only creating value in terms of profit, but also to take care of the natural resources and the human resources. Companies strive into developing a better image; to leave a better image to the next generations. In the context of this article the investments in renewable energy production facilities (like wind energy turbines / wind energy farms) are to be placed in this development in society and the business environment.

4.2 Sustainability & DOSIT methodology

Sustainable Innovation with the DOSIT methodology (Berendsen) combines on one hand innovation (product innovation and process innovation) and on the other hand a sound business model (profit as basic condition to regenerate entrepreneurial processes). The philosophical background of the model is based on the principle of *‘rentmeesterschap’* (translated into English like: Stewardship); the manager (being not the owner) of for instance a farm takes not only good care of the farm, but also hand it over to next generation(s) without depletion of the agricultural resources. This principle so well known in the Rhineland business model and the social economic organization of the Netherlands (known as the *Poldermodel*).

DOSIT is a Dutch acronym for:

DOSIT (Dutch)	SESIT (English)
D uurzaam	S ustainable
O ndernemen	E ntrepreneurial
S electie	S election
I nnovatieve	I nnovative
T echnologie	T echnology

Table 3: Core idea in the model is the DOSIT triangle:

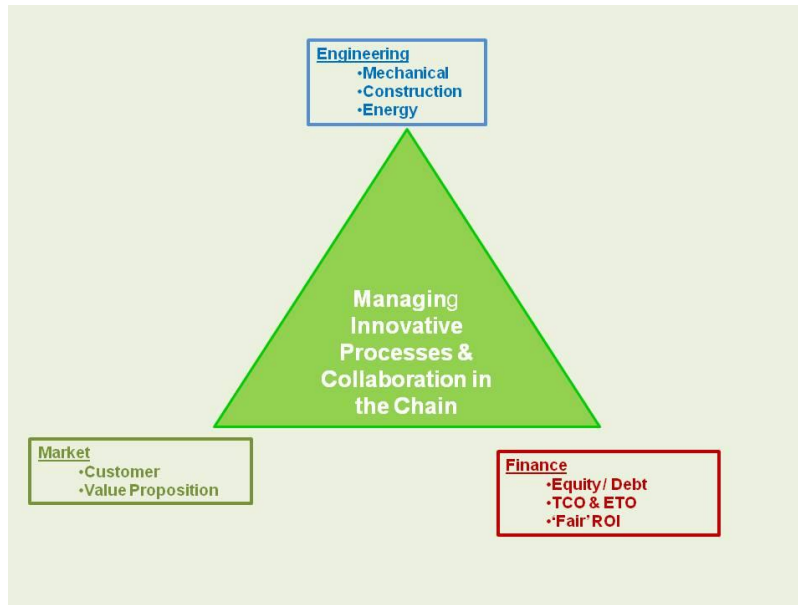


Figure10 MEF Triangle (Based on discussions with Prof Berendsen)

Innovation of products and innovation of processes is often seen as an activity of engineers (see figure 10); and rather is an endogenous process of engineers (they always want to improve products and processes), but for an innovation there has to be a market (demand) and of course it has to be a financial feasible activity (profitability). The role of management is to fine tune / balance the three aspects of the MEF Triangle.

Innovation is not a standalone activity of a company, but often is embodied in the supply chain of the firm; so inbound logistics, production and outbound logistics are the full overview of the innovation.

Leading sustainable principle can be summarized in the triple P principle: People, Planet and Profit⁴.

Leading in the DOSIT approach is that we do not only think in terms of producing a certain product, but also how the product is packed, how it is transported, how to use it in a sustainable way and after the economic life of the product think about the reverse logistics and perhaps the reuse of waste.

Recently (Jonker) new business models are helping to understand monetary and non-monetary (but still valuable for the stakeholders involved) trade-off's for decisions in sustainable investments in alternative forms of energy production (wind energy, solar energy, using waste energy, etc).

Thinking in new business models (Jonker et al). is an approach that is not always very well understood by the traditional financial world, an attempt is made to quantify non-financial profits into financial profits.

A very well-known approach in economics is the theory of external economies and public goods; and the role of the government with taxes and subsidies to influence market allocation (Samuelson). According this approach the role of the government is to encourage the private sector to invest and/or to operate innovative business activities, using direct subsidies for investment funding, tax facilities (accelerated annual depreciation) or price subsidies for clients.

⁴ Profit is sometimes replaced by Prosperity

5 Investment Model

The investment model or capital budgeting model is the pre-final stage of the sustainable investment project; pre-final because the decision makers have the final word. Decision making is difficult and complex in such a project like wind farms. Difficult because the life cycle of the project 20 – 30 years, who can have such a perfect foresight for this period of time?

Complex because the project has several engineering aspects (foundation & construction engineering, mechanical engineering and energy engineering), legal aspects and financial aspects in it.

Bottom line is that the decision makers will have a look at a set of financial and non-financial decision criteria. In the scope of this article we will focus on the financial criteria of the equity providers and the banks (as providers of loans). Non-financial decision criteria can be found in the general parts of annual reports like companies as GE, ABB, Nordex, Vestas, RWE etc.; often based on strategic reasons and/or reasons to learn new technologies.

The financial criteria can be classified like:

- Equity providers (sponsors)
 - Pay Back Period (PBP)
 - Break Even Time (BET)
 - Return On Investment (ROI)
 - Net Present Value (NPV)
 - Profitability Index or Net Present Value Investment Ratio (NPV / INV)
 - Internal Rate of Return (IRR)
- Providers of loans (banks)
 - Debt Service Coverage Ratio(DSCR)

In this article we do not split up the decision model into a CAPEX (Capital Expenditure) part and into an OPEX (Operational Expenditures) part; as we integrated in our financial decision model Cash Outflows (CAPEX and the O&M⁵ expenditures of OPEX) and the Cash Inflows (Revenue part of the OPEX part). Finally CAPEX and OPEX are integrated in the Net Cash Flow overview of the investment model.

5.1 Data & Assumptions

The distinction between data and assumptions in such long term decision models is not always clear, because future data are not completely objective so the decision makers assume certain values. Sometimes it is possible to refer to reliable forecasts of 'independent' bodies of knowledge like the Worldbank, The Economist, IMF, EWEA, IEA etc., but often the decision maker has to use his or her common sense based on professional experience (from the past and/or opinions of experts or specialists in their field of expertise). It helps of course to be clear, where the data are obtained from, how reliable they are and where data evolve into assumptions. In the figure 11 we can observe the structure of a spreadsheet model (like MS Excel) that assist the decision maker to have a structured spreadsheet with clear main steps to the solution.

⁵ O&M costs stands for Operations and Maintenance Costs

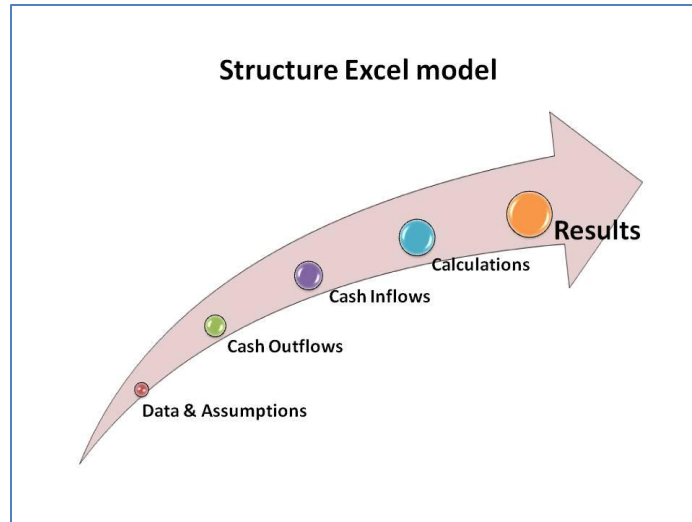


Figure 11 Structure Excel Model(Developed by the author)

Normally we have the following data and assumptions in the financial investment model:

- Investment amount (From the Cash Outflow section / CAPEX)
- Required Financial Structure for the total investment (100%)
 - Equity share or ϵ (For instance: 30%)
 - Debt share or λ (For instance: 70%)
- Expected Energy prices
- Expected Inflation
- Expected Increase in labour rate (wages)
- Expected increase in maintenance costs
 - Volume
 - Price
- Project Risk Beta (β_p)
- Risk free interest rate (R_{RF})
- Interest rate Debts (R_D)
- Required Return on Equity (R_E)
- Exchange rates
- Tax rate = τ (30%)⁶
- Governmental policies
 - Tax facilities
 - Subsidies
 - Per kWh produced
 - Investment amount
- Straight-line depreciation (Economic life wind farm: 20 years)
- Straight-line repayment schedule (Duration loan: 15 years)

All those data / assumptions take a lot of effort and time to get and sometimes insider information is needed from key informers; all the results should be mentioned in the worksheet data & assumptions with their references. Because the discussion about a financial model is not about the formulas, but about the input for the calculations.

⁶ Of course the corporate tax rate can differ per country (we assumed no VAT in the model)

For simplicity reasons we used straight-line depreciation method, instead of more progressive methods of depreciation like Sum of the Years Digits method. Similar we assumed a straight-line repayment schedule of the loan.

5.2 Cash Outflows

The cash outflows of the model consist of three main sections:

- Investment
 - License & Concessions
 - Foundation & Construction
 - Mechanical equipment
 - Gearing box
 - Transmission system
 - Energy
 - Computer & Communication system
 - Electricity system
 - DC > AC
 - High voltage
 - Cable
- Scrap value
 - Remove fee (negative / positive value)
 - Upgrade for new investment
- Maintenance
 - Volume
 - Price

This section is specific for the three main groups of engineers (mechanical engineering, construction and electrical energy) in this project, they provide the financial information for the decision model. Close cooperation between the engineer and the project controller is crucial. Especially regarding the discussion of higher investment amounts, because they will reduce future (expensive) maintenance; as discussed in the section quality costs / total cost of ownership / life cycle costing.

The previous sentence makes it also clear why we should not split up into CAPEX and OPEX budgets; the engineers and the project controller should integrate both budgets to be aware of ETO's in terms of QC/TCO/LCC.

This worksheet cash outflows can of course consists of more sub-worksheets and/or even relate to other files, because a lot of relevant detailed information has to be processed.

For reasons of convenience we assume that the scrap value is zero.

5.3 Cash Inflows

The Cash inflow of the project consists of 2 main components:

- Wind production (with a link to Volume)
- Revenue (Energy contract with the Off taker, normally energy distributor)
 - Volume (with a link to Wind production)
 - Price per kWh

Wind production depends of course of the wind, and the wind depends on the climate, the season, the geographical situation, the height of the wind turbine and the size & shape of the rotor blades. Professional organizations (Like EUROWIND) provide forecasts for wind supply or wind production. In for instance scenario analysis we can use different probabilities of wind distribution (e.g. P50 or P90 scenarios), and so forecast different revenues or sales scenarios for the wind farm.

Normally the revenues are fixed for a large number of years (15 years), because the wind farm company has such a long term contract with the Off taker (often a distribution company for electricity to private households and companies). The contract is often based upon accepting all the electricity produced by the wind farm, so the demand is price elastic (horizontal shape of the demand curve); and the price is fixed per kWh with often a yearly indexation of the price.

So the cash flows are highly predictable, with one limitation: the wind supply. However reliable wind statistics provides the decision makers with reliable expected values for the wind supply per season.

5.4 Calculations

When in the spreadsheet model the worksheet Net Cash Flows (NCF) is introduced, we develop from the previous worksheets Cash Outflows and Cash Inflows; the Net Cash Flows (subtracting cash outflows from cash inflows).

A row or a worksheet Income Statement (IS) has to be developed to calculate the corporate tax (30% of the profit).

We also develop a row of cumulative NCF's to calculate the payback period (PBP) and return on investment (ROI).

Three other rows have to be developed:

- Discount Factors (DF)
- NCF * DF
- Cumulative NCF * DF

Now we are able to calculate Break Even Time (BET) and Net Present Value (NPV).

The Debt Service Coverage Ratio (DSCR) can be calculated using a few rows from this worksheet.

The calculation of the discount factor is based on the data & assumptions worksheet; in fact we calculate a project WACC (Weighted Average Costs of Capital).

This PWACC (Project WACC) is defined like: $R_{PWACC} = R_E * \epsilon + R_D * (1 - \tau) * \lambda$

- R_{PWACC} = Required Project WACC
- R_E = Required Return on Equity
- R_D = Agreed Interest Rate for the loan (debt)
- τ = tax rate
- E = Project Equity
- D = Debt or Loan for his project
- V = Value of the total investment of this project, so: $V = E + D$
- $\epsilon = E / V$
- $\lambda = D / V$
- $\epsilon + \lambda = 1$

R_E (Required Return on Equity) is based on the CAPM model (Capital Asset Pricing Model):

$$R_E = R_{RF} + \beta_P * (R_M - R_{RF})$$

R_{RF} stands for risk free interest rate (normally the interest rate for 10 or 20 years government bonds); R_M stands for the market return for equity investors and β_P stands for the project risk of this off shore wind energy project.

β_P is in fact very difficult to estimate, of course you can check the betas of the equity sponsors and our use betas from similar projects from the past. And perhaps add up to such historical betas the subjective expectation of the decision maker, especially when the off shore project is in a political unstable environment.

In real life of the wind energy sector the CAPM and WACC approach is not really used by professionals, they estimate the expected discount factor by adding up a risk percentage on the expected long term interest rate of the project.

5.5 Decision Criteria

What should the decision maker do? Look backwards (historical data!) or forwards?

Forward looking (decision making!) implies three possible scenarios, according figure 12:

- MR: Middle of the road (12% R_{PWACC})
- PS: Pessimistic Scenario (<12% R_{PWACC})
- OS: Optimistic Scenario (>12% R_{PWACC})

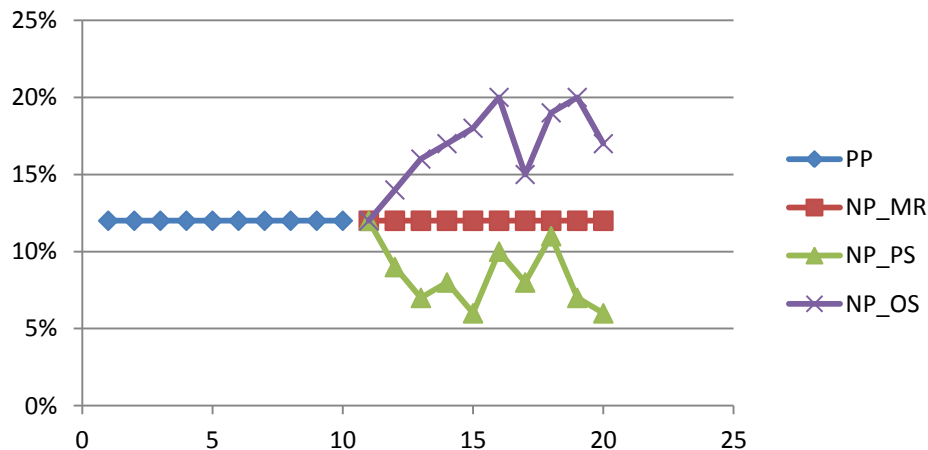


Figure 12: Scenario analyses (Developed by the author using MS Excel)

So decision making is for sure not an easy job, where the decision maker is influenced by non-financial decision criteria (often strategic choices) and (imperfect) financial data.

In the spreadsheet the complete model⁷ is developed for an off shore wind farm project. In this section we will discuss the financial decision criteria.

We distinguish the following financial decision criteria:

- For equity providers
 - Pay Back Period (PBP)
 - Return On Investment (ROI)
 - Net Present Value (NPV)
 - Internal Rate of Return (IRR)
 - Break Even Time (BET)

⁷ You can order the spreadsheet model via the author of this article

- For banks (providers of loans)
 - Debt Service Coverage Ratio (DSCR)

The payback period is an easy to understand decision criterion, namely it looks in how many years the initial cash outflow of the investment in year 0 is recovered by the cash inflows in the coming years.

The return on investment calculates the average profit compared with the average investment; so: average profit / average investment.

PBP and ROI have both as a minus that they do not take into account the time value of money (R_{PWACC}); so actually we compare money flows in year 0 with money flows in year 20. The following decisions criteria do take into account the time value of money.

Net present value calculates every yearly money flow to the moment of decision (year 0) using the R_{PWACC} for the discount factor r ($R_{PWACC} / 100$).

$$NPV = \frac{-CF_0}{(1+r)^0} + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \dots + \frac{CF_{30}}{(1+r)^{30}}$$

When the NPV is positive the investment brings value to the project company, normally decision makers use rules of thumb to assess an investment like this. The investors often look to the relative NPV or Profit Index, the NPV divided by the investment (CF_0).

The internal rate of return is a variant on the NPV calculation, we use the same formula for NPV, but instead of calculating NPV with a given discount factor r , we set as a value for NPV the value zero ($NPV = 0$) and calculate the discount factor r .

$$NPV = \frac{-CF_0}{(1+r)^0} + \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} + \dots + \frac{CF_{30}}{(1+r)^{20}} = 0$$

This is not an easy job for an equation of the degree 20 (it is an easy job for a second degree equation using the well known ABC-formula). In MS Excel we have a special function (IRR) to calculate the internal rate of return, but we have to be aware of the fact that 20 solutions are possible in a mathematical way (so we should for instance neglect negative outcomes of IRR, because interest has always a positive value. Otherwise we would receive interest we are borrowing). When the IRR is above the R_{PWACC} the investment will add positive value to project company.

The break even time is similar to the calculation of the PBP, but instead of using the cumulative NCF we should use the cumulative NCF * DF. Normally the BET is a bit higher than the PBP.

Banks have a different perspective to assess a project like this, of course they take into account the decision criteria for the equity suppliers of the project, but the banks have also an additional criterion to assess the project.

For that aspect the Debt Service Coverage Ratio (DSCR) is introduced, which is in fact a criterion to assess the earning capacity of the project to repay debt service (instalments of the loan and interest payments).

DSCR can be calculated as follows:

$$DSCR = (NCF + \text{Interest Payments}) / (\text{Instalments} + \text{Interest Payments})$$

Banks have (internal) requirements for this ratio, for instance above 1.4 (depending on the wind scenario P50 or P90)

6 Conclusions

The sustainable investment model is in this article adapted for the wind energy sector, the model is generally intended that the context can be easily changed into other issues and smaller (financial) scale.

Other research contexts are: renewable energy systems for houses, motor management system for trucks, small scale solar energy system for houses, etc.

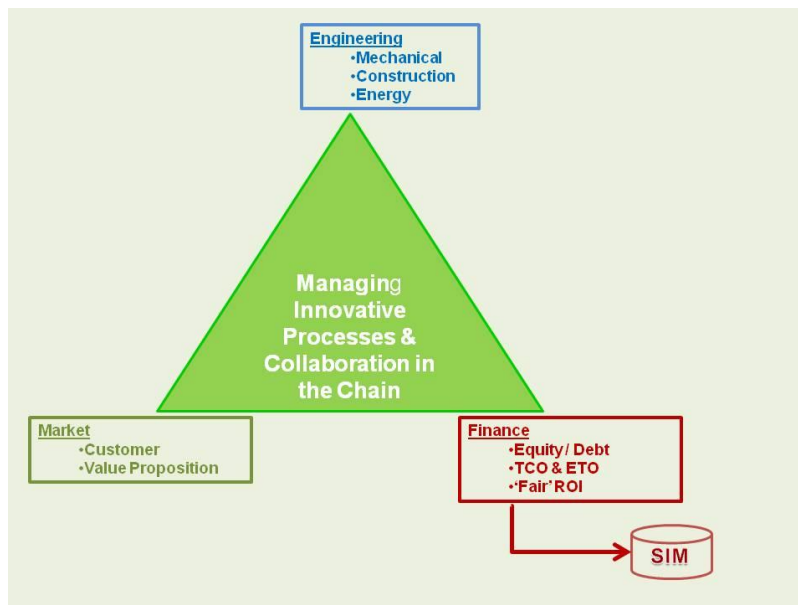


Figure 13: Putting it all together (Developed by the author)

As visualised in figure 13 the SIM model is a result of balancing Market, Engineering and Finance factors in the process of sustainable innovation. The financial spreadsheet model (SIM) is at the end the outcome of this balancing process; a technical derivative of underlying processes, data and assumptions.

We can conclude that investments in sustainable solutions often are not profitable without tax privileges and/or subsidies from the government.

Although the future shortage of fossil resources and/or changing supply and demand patterns between Europe and USA versus the emerging BRIC economies, will also have an influence in the assumptions of such decision model like the Sustainable Investment Model (SIM).

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