Investing in Renewable Energy

A systematic guide to strategic evaluation

1. Summary

1.1. General overview

There is an increasing confusion about "investing in renewable energy", because the range of possible investments is so vast and diverse that misunderstandings are programmed in each discussion. We want to sketch a rough chart of the territory to make discussion, communication and search for investments easier. It is not intended as a full and scientifically researched systematic, but as a simple tool that will help investors and innovators to get a quick understanding.

The main goal for the author is to provide a systematic consulting approach for servicing investors in the search and evaluation of suitable technologies and to provide a clear language to communicate the field of different available technologies, business proposals and innovations.

Note: we will use the term "RES" for renewable energy systems or renewable energy sources.

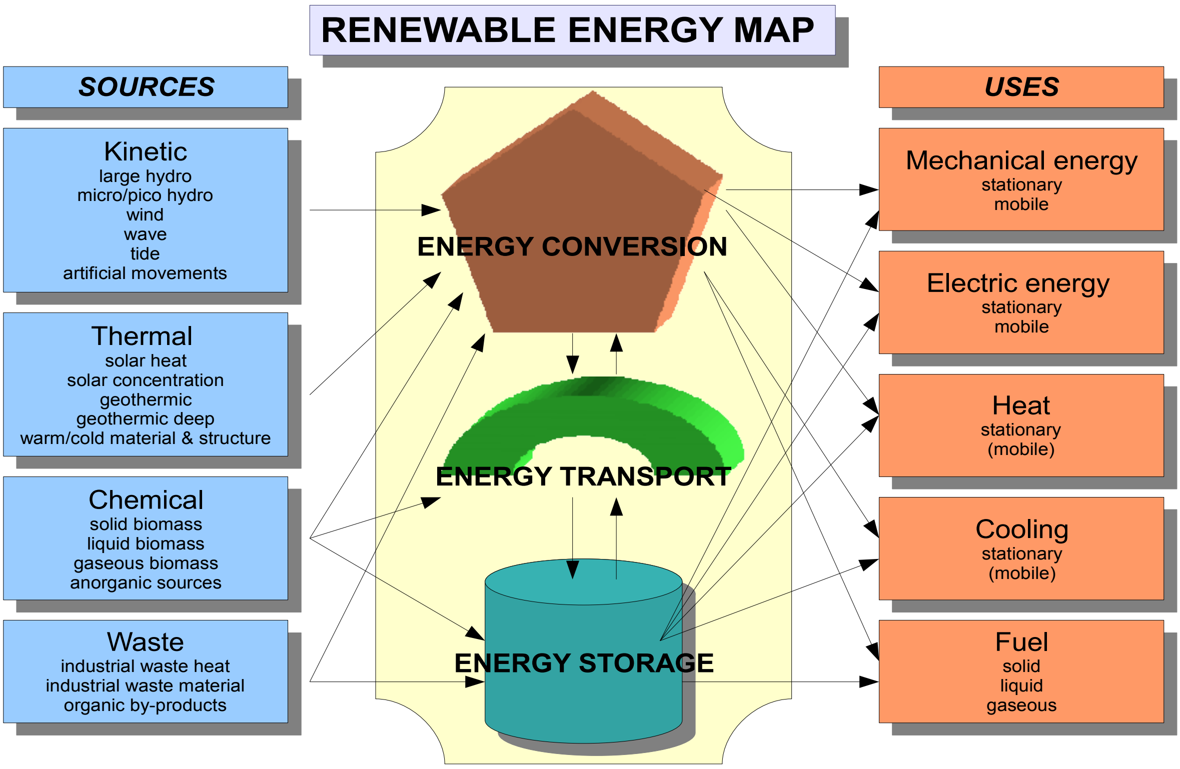
1.2. Conversion, transport and storage of energy

At first it must be reminded that energy cannot be "produced". What is called "energy production" is always the conversion, storage and transport of one form of energy into another form of energy or to another time or location.

You can also call it the matching of available energy sources with the demand in energy. This is an important fact, because it widens the horizon of the investor to the full value-chain of renewable energy: It starts with the enery source, covers the conversion technology (e.g.power plants), the storage and transport of the energy to the consumer and maybe even a second and third conversion (e.g. of electricity into mechanical work or heating or cooling).

If the investor takes in the full span of this process, it is easy to see investment potential in reducing storage- and transmission losses, in improving the conversion (and consumption) efficiencies, as well as the benefit from using all different sorts of energy sources.

1.3. Graphic: the field of possible investments



1.4. Understanding the position of an investment

To make a clear statement about the investment strategy of an investor, it makes sense if the investor simply marks or describes the fields of investment in the "map" of possible investments.

On the other side, technologies and business proposals that look for financing should also be classified using this map.

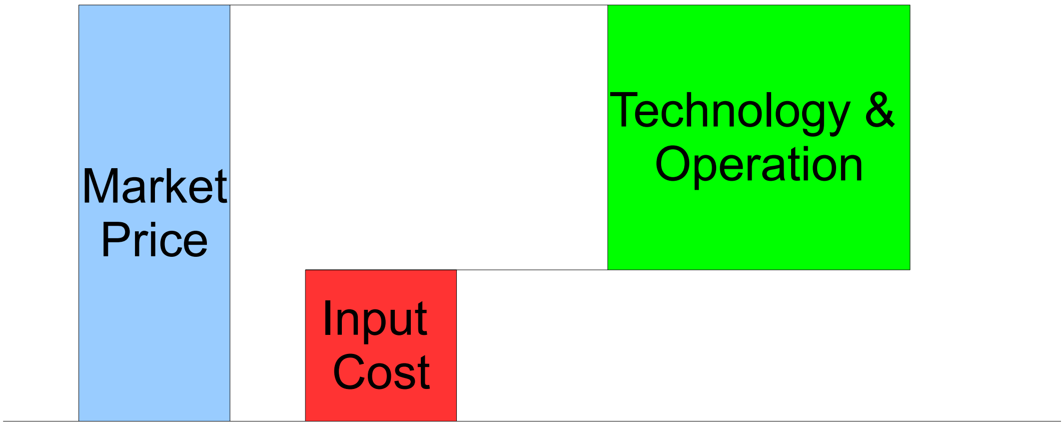
This way a matching between supply of projects and available financing can be made and selections can be narrowed. Communication is much simplified.

1.5. Evaluating the potential of an investment

The evaluation of the potential of an investment can be done in a quick and simple way: On one hand you have the market price for the energy output that is required. On the other hand you have to consider the price of the input factors (e.g.fuel, operating costs). Then the conversion efficiency (including the losses for storage and transmission) allow to calculate the maximum target cost for the conversion technology.

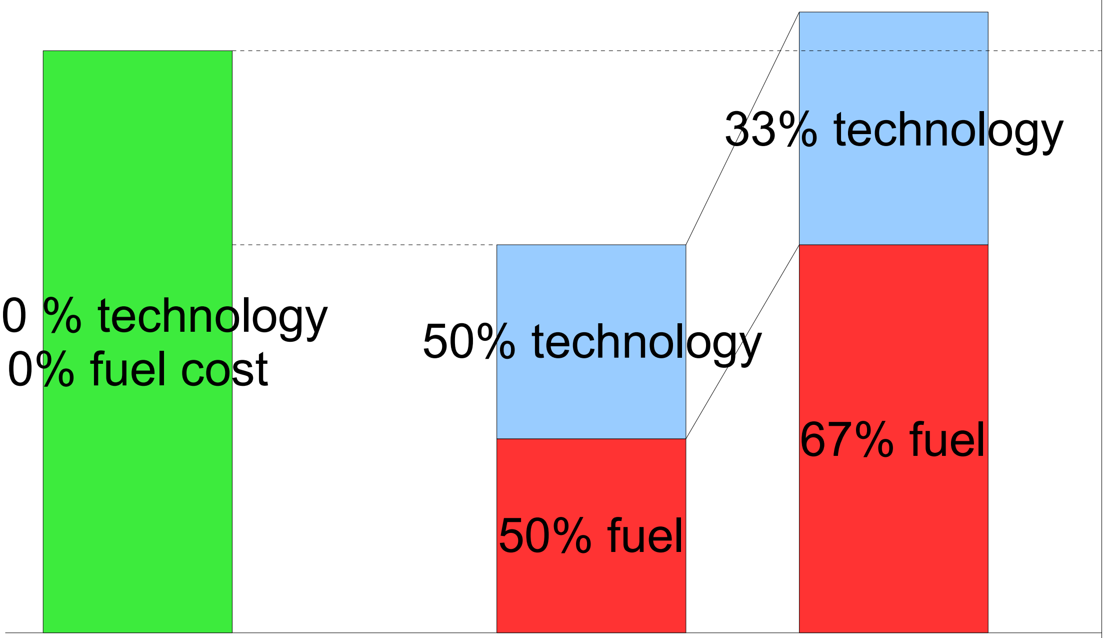
A new idea, technology or source of energy can be benchmarked against this rough framework to understand what are the benefits or where the price for the technology must be to become competitive.

In this resepect it is also important to observe the vastly different market prices depending on time, location and type of customer (utility, industry, private).



Estimation of target of technology cost

Another aspect is to simulate the expected development of conventional (fossile) energy. The relation between fuel costs and current market price show the sensitivity of the market price to an increase of fuel costs. Assuming different price scenarios for the fuel costs in future, it is easy to understand the competitive advantage of a RES-based technology and it's time for break-even with fossile fuel systems.



Impact of fuel costs / sensitivity

1.6. Searching for interesting fields to invest

The same analysis of topic 1.5 can be used in reverse. The markets and energy uses that react the most to increased fossile fuel prices make up for the most interesting chances for new technologies. This allows us to search actively for ongoing research or proposals that cover the identified field. Also financing of completely new R&D activities or development activities to improve performance of existing technologies can be based on this analysis.

1.7. Target markets (# customers, availability of sources, accessability of sources, restrictions, laws)

A very important part of the assessment of a RES business proposal is to understand who will be the future customers. Some technologies (like photovoltaics) can be sold to a large number of private persons and enterprises, each of them decides on his own.

Some technologies (especially for large-scale production) can be sold only to a few customers that are (usually) already in the energy business. This poses the risk that they follow a different agenda, due to their other investments that they have to manage.

Another question is the availability of the renewable resource: is it available for everybody, can it be accessed by everybody or is it under legal restrictions to use it (concessions, ownership of land and special rights etc.). The size of the market can be influenced massively by concessions (e.g. to use wave power, to build windmills or to use geothermic power). The best technology is worthless, unless these problems are solved in a sufficient way. This points strongly towards integrated value chains (technlogy + source + sale of power) and towards single projects for powerplants that make use of a certain technology, but are limited to one or only a few locations.

Following a short overview of some renewable energy sources and their accessability for individuals and enterprises.

Free access	Approval required	Concession required
Photovoltaic	Large PV	Wave and tidal power
Thermal solar	Concentrated solar (large)	Large hydro
Heatpump (near-surface)	Hydro	Windparks (depending on country)
Mini-windmill	Wind	Geothermal (depending on country)
	Biomass	

2. Classification of energy sources

2.1. Renewable energy: new sources, unused sources, underutilized sources

Renewable energies (RES) can be many different sources, it can be completely new sources and principles, it can be sources that are not yet used (e.g. wave power) or it can be sources that are not fully used or that are only used marginally (sun, wind, geothermic etc.). To evaluate the risk and chances of an investment it is important to understand which type of source is used and what are its physical/chemical nature.

2.2. Kinetic energy

Here a list of selected RES:

- Hydropower (run-of-the-river, dams, pump storage dams)

- Windpower
- Wave power
- Tidal power
- Artificially created movements (e.g. dancefloor, vibrations in street surfaces and construction)

2.3. Thermal energy

Here a list of selected RES:

- Solar heat (conventional)
- Solar heat (concentrated)
- Geothermic heat
- Heat stored in natural structurs (soil, rock, water, air)
- Heat stored in artificial structures (buildings, storage liquid, latent heat storages)

2.4. Chemical energy

Here a list of selected RES:

- Solid biomass (wood, straw)
- Liquid biomass (liquid manure, vegetable oil)
- Gaseous biomass (biogas, landfill gas)
- Non-biologic chemical sources (metals, hydrites)

2.5. Waste from other processes

Here a list of selected RES:

- Waste heat from industrial processes, machines, motors
- By-products of industrial processes that are not used, but have a significant energy content (black liquor, plastic, rubber, organic waste, unused biomass like straw)

2.6. Searching for interesting sources: energy available per area of harvesting area

To understand the size and technical effort of an investment in a certain technology it makes also sense to look at the energy density of the input source. The range is extremely wide and includes vegetable oil with a very high content of energy, but also waste heat of only a few centigrade. We have found it useful to look at the energy density in terms of available energy per area of harvesting. It gives an idea how important it is to control or license an area to secure the supply of the energy source. This can be low as in geothermal powerplants, but it also can be huge as for the use of concentrated solar power or in the use of low-grade waste heat or biomass plantations.

3. Classification of energy use

3.1. Mechanical energy for stationary use

Powering of machines, pumping, forming etc. need energy in a mechanical form. This can be supplied indirectly (by motors that convert fuel or electricity into motion) or it can be supplied by processes that create mechanical energy directly (e.g. ORC-driven pumps or Stirling engines etc.). Intelligent combination of source and use of location can make a big impact on energy losses and efficiency of a technology.

3.2. Mechanical energy for mobile use

For mobile use most processes will need a system of storage of energy plus a conversion, most likely by a motor. The mobility will very likely cut off the user from a location that can supply the input energy. Designing systems with high availability and reliability including the topic of re-filling and storage include a much higher challenge, but good and workable solutions provide also a very big chance for investors.

3.3. Electric energy for stationary use

Electricity is a preferred platform for the use in very different consumption processes, because it is universal. Storage is still a problem, but can easier be solved if the use is stationary.

3.4. Electric energy for mobile use

For mobile use electricity is mainly handicapped by the cost, volume and weight of storage. This problem is lower in case the movement is not powered by electricity, but only additonal processes are. Another solution can be the mobile link-up to electric supply like in electric trains. Rewarding investments can be found by searching for low complexity of the required infrastructure and fast and easy handling.

3.5. Heating

To match the demand for heating, all other energy sources can be use in principle. The physically best would be to match it with the lowest-grade heat that is available, instead of burning expensive fuels or using electric energy that carry a high overhead of losses in production, transmission and storage. In this field many different approaches are possible. They range from the insulation of buildings to storage of heat to cover the demand up to complex heating systems and heat pumps.

3.6. Cooling

The demand for cooling is currently satisfied mostly by electric power that drives compressors and pumps. Other technologies are under development and partly already in the market.They make use of waste heat, solar heat, natural evaporation and condensation and chemical reactions. This field is an important consumer of energy today. Cooling accounts for more that 50% of the energy used in supermarkets in Germany.

4. Classification of energy transport and storage

4.1. Storage systems for mechanical energy

Some examples:

- Pump storage dams
- compressed air and other gases
- mainsprings and elevated weights

4.2. Transport systems for mechanical energy

Some examples:

- Pipes
- Gears
- transmissons

4.3. Storage systems for electricity

Some examples:

- Chemical batteries
- Capacitators

4.4. Transport systems for electricity

Some examples:

- Wires
- Mechanical transport of batteries (e.g. included in cars)
- Storage in chemical forms (hydrogen, ammonia, hydrates)

4.5. Storage systems for thermal energy / cooling

Some examples:

- Underground storage in soil, rock, pipes, tanks
- Storage in latent heat media
- Storage in passive or active parts of buildings

4.6. Transport systems for thermal energy / cooling

Some examples:

- Pipes and air-ducts
- Transport of boxes with latent heat media to the user

5. Benchmarking of innovations

A simple way to understand risks and chances of a business proposal or a technology is to do a benchmark against the current mainstream solution that is used. The data for this should be available in sufficient quality to perform a rough analysis at least.

5.1. Market price of the output

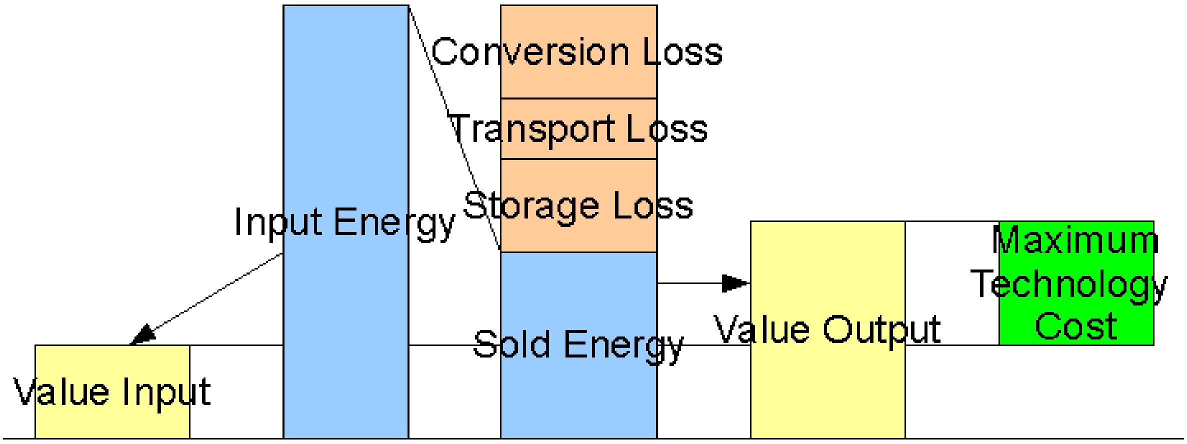
The final product that is sold is to cover the requirements for the use of the energy. Therefore it makes a difference, if the output is required as mechanical, thermal or electric energy. Prices also differ depending on location and timing and if the supply is continuous or not.

The investor has to find out the market price based on what quality and quantity of energy he can supply. In this connection the development of the market price over the lifetime of the investment, but also the effect of subsidies, feed-in-tariffs are very important.

5.2. Conversion efficiency, transport and storage losses

All losses that occur between the use of the input and the output must be taken into account. This includes primarily the rate of conversion that the technology provides, but also other losses like transport storage or lost production that cannot be sold, due to mismatches between demand and supply.

In case of co-generation or polygeneration, two or more such streams with different prices and efficiencies may have to be calculated (e.g. electric power generation and sale of the heat)



Conversion, Losses and Prices

5.3. Price of the input

The input source will often have a price, but sometimes also the price will be zero. This can happen, if wind or solar energy is used. In case biofuels are used, there will be a price for the input resouce. Depending on the situation, it can also be imagined that a license to use wave power or geothermal energy has to be purchased or paid to the state or the landowner. In this case could be counted as input costs. If the amount is fixed, it must be carefully calculated in order not to distort the estimated costs based on different efficiencies.

5.4. Available price-span for technology and operation

Basically the difference between market price and cost of the input is the maximum value added by the technology. It gives an idea how much the cost of the technology can be at maximum and under different requirements of profitability / margins.

This value is especially interesting to understand how much development still has to be done and what scale of production is needed to achieve sufficient learing curve effects to to arrive at a competitive price.

The calculations must always be made before the background of energy price inflation and the expected price increase for fossile fuel. It will help to determine the time when the technology will be competitive with the current mainstream.

An interesting large-scale example of this effect can be seen in the photovoltaics strategy of Germany. The idea is to support the sale of photovoltaics by incentives in order to obtain strong lerning curve effects. The main goal is to reduce the cost of newly installed photovoltaics to a level that is competitive with the end-user price for electricity. Current estimations expect to reach this “grid-parity” for large parts of Europe in 2012 or 2013.

5.5. Sensitivity to increase in input prices

When considering the expected price of energy for the future, it helps very much to understand what is the impact of a change in input prices. If a fossile fuel powerplant is currently producing electricity at 6 ct and the percentage of input costs for the fuel is 50%, it means that the new price after a 100% increase of fuel prices will be 9 ct. For a windmill the input power costs nothing, it will continue to produce power at 8 ct as today.

This analysis will give some indications about the future of a technology that is already in use. It will show the breaking point, where this technology will come under pressure from other alternatives. This is important to assess the risk and chances when investments into improvements ofsuch technologies are concerned.

An example: an investment into improved natural gas turbines may be very interesting, if it means that this technology can stay on the market longer, due to higher efficiencies. But the outcome can also be that by the time the new turbine is ready, nobody is interested to build natural gas powerplants any more.

6. Overview of conversion technologies

FROM / TO	Kinetic	Thermal	Chemical	Waste heat	Electricity
Kinetic	Windmill waterwheel	Pressure heating of gases	Compression of organic material	-	Wind-turbine hydro-turbine wave turbine tide turbine
Thermal	Steam engine stirling engine	Heat pump cooling machine air condition	Reduction of chemicals drying of zeoliths pyrolysis	-	Peltier element Photovoltaic
Chemical	Internal combustion engine	combustion	Biogas biooil carbonication	-	Fuel cell
Waste heat	Co-generation ORC-engine Kalina-process	Co-generation heat pump	Reduction of chemicals drying of zeoliths pyrolysis	-	Co-generation Peltier element
Electricity	electric engine piezo element	Electric heating	Batteries electrolysis	-	Inverter

7. Overview of key components and machine parts

Kinetic Processes	Thermal Processes	Chemical Processes	Electrical processes
Drivetrains / gears	Heat exchanger	carbonisation	Electric engine
transmission	Heat pump	pyrolysis	Fuel cell
windblade	Heat absorber	Pressure treatment	photovotaic
Alt. Winddesigns		Catalytic processing	Peltier element
Alt. Hydrodesigns		gasification	Piezo element
Pressure management (pneumatic/hydraulic)		fermentation	Thermo-acoustic engine
Gas turbine		cracking	
Liquid fuel turbine		Re-combination of hydrocarbons	

		(Fischer-Tropsch et.al.)	
Stirling engine			
ORC & Kalina			
Steam engine			
Flywheel			

8. Supporting technologies with influence on efficiency

Kinetic Processes	Thermal Processes	Chemical Processes	Electrical processes
Low-friction bearing	Solar concentration	Catalytic processes	generator
Low temperature use in thermal cycles	Sun-following mechanics for solar	Electro-chemical processes	Linear generator
Archimedic screw	Thermal cycle	Phase change materials	Permanent magnetized motor
Vortex machines	Pump		Integrated inverters
	Mirror system		supercapacitators
	Architectural integration		Supraconduction
Energy management	Energy management	Energy management	Energy management

9. R&D links

Topic	Research	Organisation
Biomass-to-Liquid		Choren, Shell, BP, VW, MAN
Syngas	PSI,FZ Güssing, TU Wien, TU Leipzig, CZ Akademie d.W.	
Woodgas	Güssing, TU Graz	Atmos CZ
Coal from biomass	Prof.Antonietti, Max Planck Institut Potsdam	
Ethanol + Biodiesel	Uni Dortmund	
Solid biomass	TU Graz,	Mawera (Hard AT)
Biogas	TU Graz, Boku, Uni Heidelberg, Uni Aalborg, DK	Repatec Güssing, FlexBiogas-Boku
Geothermal	Geo-FZ Potsdam	Geoteam Gleisdorf
ORC-Turbine		Turboden, Brescia
Steamturbine	Politechnico di Torino	Rantor, SE, Lesa Berlin, CIAT Wärmepumpen/WT

Special turbines	Tesla, Schnecken, Turbo	Seemann, Haberl, Hsturbo.de
Circular turbine		Privat Nürnberg
PV a-Si	Fraunhofer ISE	
CIGS	Tech.Res.Ctr.Finland, Uni Kassel, Bulgar.Akademie d.W.	Würth Solar
Super Capacitators		EPOD Canada
Suncollektor-Efficiency	Uni Kassel, Arsenal Research, FH Rapperswil, Uni Stuttgart	
Sun concentration		Pneu / Helios Wien
Running river wing		Privat München
Membranes for fuel cells		BWT/Christ, Masterflex, DE, Innovative Membrane Tech.NL
Zeolith		Vaillant, DE
Phase Change Materials		BASF-subsidiary

10.Technologies and business proposals

Available on request / see project list of Xwatt.
Example of short profile: