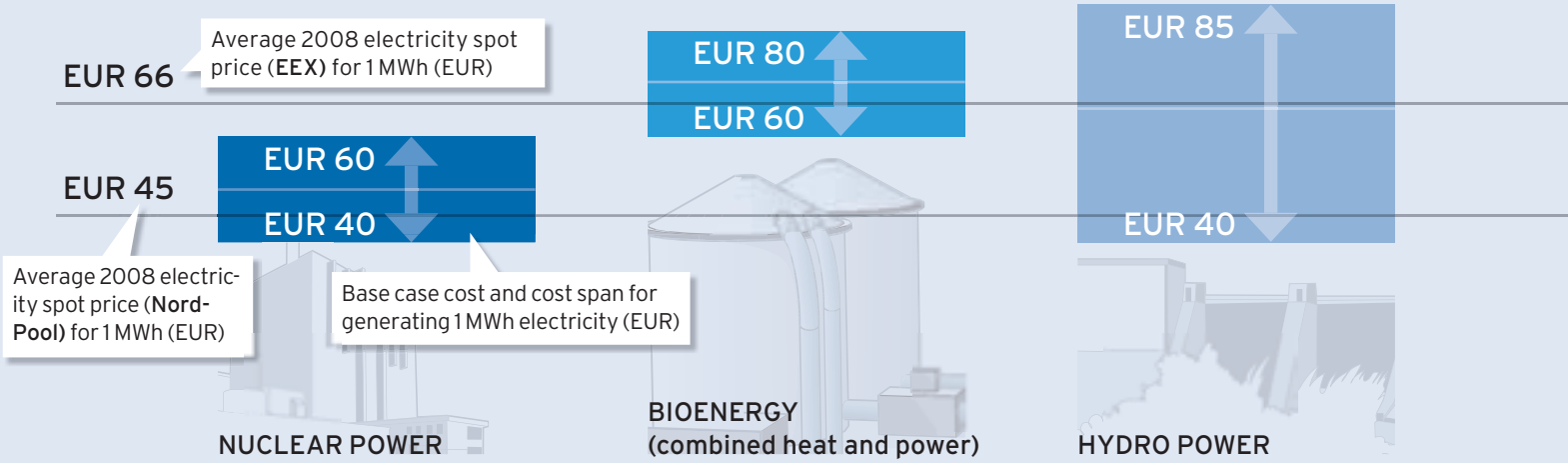
VATTENFALL'S ALTERNATIVES FOR NEW ENERGY GENERATION – PROS, CONS AND COSTS

Vattenfall's roadmap for its future generation portfolio is based on the advantages and disadvantages of the respective energy sources, and their respective roles in the energy system. Cost structures differ for the alternatives and depend on a variety of factors, such as fuel prices and the maturity of technology. Typically, new technology is more expensive, and cost decreases along with increased experience and larger scale. For investments to be profitable, the market price must cover all costs including cost of capital. In many countries, government support schemes and subsidies for renewable energy are being introduced to make these energy sources competitive. The cost calculations in this example are based on external sources and market fuel prices, as well as on Vattenfall's estimations on lead time.



NUCLEAR POWER

In nuclear reactors, uranium is used to generate electricity. Reactors are normally reloaded with new fuel every 12–24 months, during planned outages when maintenance is also performed. Nuclear power is used as base load power in many energy systems.

Main advantages
- Low emissions
- Stable base load power
- Stable fuel supply
- Competitive production cost

Main disadvantages
- High investment cost
- High complexity
- Need for comprehensive safety management
- Spent nuclear fuel is radioactive and requires safe long-term storage
- Environmental impact of uranium mining must be handled

Cost estimate (in this example)
- Capacity: 1,600 MW electricity
- Annual full load: 7,800 hours
- Efficiency: 37%
- Lead time for construction (including permits): 10 years
- Estimated base case cost: ~ EUR 50/MWh

BIOENERGY (combined heat and power)

Biomass fuels are combusted to produce district heating, and often also to generate electricity. Biomass encompasses a variety of fuels, differing in terms of key sustainability aspects and energy content. Many fuels are residual products from forestry and agricultural origin, as well as waste from the construction industry and households (75%–87% is considered biogenic). In some regions, the use of energy crops is increasing.

Main advantages
- CO_2-neutral if combusted material equals regrowth
- Energy conversion from residuals is an added benefit to society
- Often locally available

Main disadvantages
- Carbon neutrality requires regrowth
- Competition for use
- Potential negative land-use changes and loss of biodiversity with increasing demand
- Emissions from transport, especially critical for fuels with relatively low energy content

Cost estimate (in this example)
- Capacity: 35 MW electricity and 65 MW heat.
- Annual full load: 6,000 hours
- Efficiency: 90% (combined heat and power generation)
- Lead time for construction (including permits): 3 years
- Estimated base case cost: ~ EUR 70/MWh

HYDRO POWER

Hydro power plants use the gravitational force of running water to generate electricity. In reservoir plants, water is kept in dams to be able to regulate generation. In run-off river plants, turbines are placed directly in the water stream. Pumped storage plants are used to store energy generated from other sources. In Europe, approximately 75% of potential hydro power has been exploited.

Main advantages
- Low emissions
- Can function as base, peak and regulating power and stored energy
- No fuel cost
- Long economic life

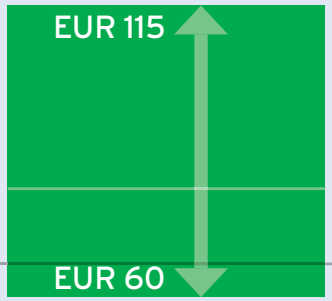
Main disadvantages
- Dependent on water supply, precipitation (rain and snow) and geography (difference in altitude)
- High investment cost
- Major intrusion in landscape, changed ecosystem in rivers
- Dam safety
- Few possibilities to expand

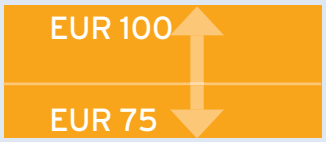
Cost estimate (in this example)
- Capacity: 40 MW electricity
- Annual full load: 4,000 hours
- Lead time for construction (including permits): 4 years
- Estimated base case cost: ~ EUR 65/MWh

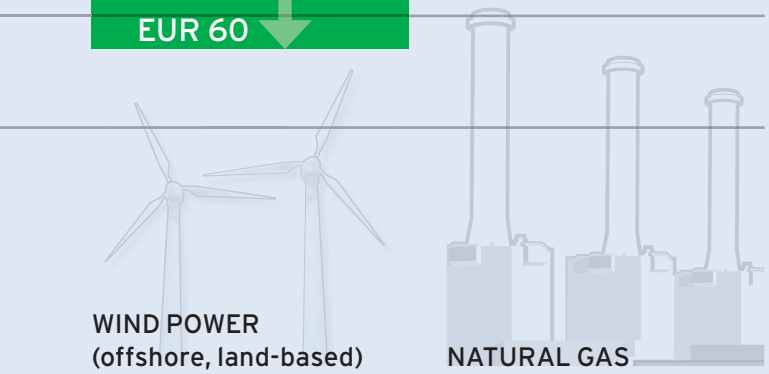
WACC (Weighted Average Cost of Capital, discount rate) 7% . Inflation rate 2%. 2009 price level. Cost of CO_2 EUR 20/tonne.

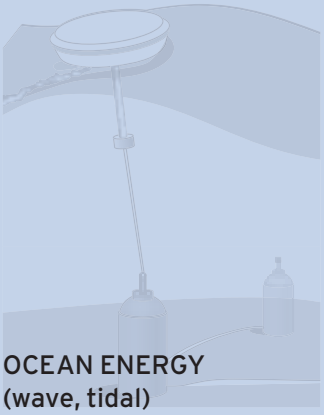
Sources: Elforsk, www.power-technologies.com, www.olkiluoto.info, fuel market prices December 2008, average electricity spot prices 2008 Nord Pool (Nordic) and EEX (European Energy Exchange (Germany).

Developing technologies









WIND POWER (offshore, land-based)

Electricity is generated by wind turbines, often built in clusters called wind farms. Power generation depends on wind conditions. Offshore locations generally have stronger winds, but construction and maintenance is more difficult. Therefore, offshore wind power is more expensive than land-based wind power.

Main advantages
- Low emissions
- No fuel cost

Main disadvantages
- Need for reserve power due to weather dependency (wind)
- Impact on landscape and noise
- Requires significant investments in the grid

Cost estimate (in this example)
- Capacity: 100 MW electricity

Offshore wind power:
- Annual full load: 3,200 hours
- Lead time for construction (including permits): 3 years
- Estimated base case cost ~EUR 90/MWh

Land-based wind power:
- Annual full load: 2,500 hours
- Lead time for construction (including permits): 2 years
- Estimated base case cost: ~EUR 70/MWh

NATURAL GAS

Natural gas is combusted to generate electricity and heat, often in CHP plants. Most new facilities are combined cycle gas turbines (CCGTs), where both steam and gas turbines are used, thereby increasing efficiency. Global demand for natural gas is on the rise.

Main advantages
- Lower emissions and higher efficiency than other fossil fuels when used in CHP plants

Main disadvantages
- CO_2 emissions (CCS for gas-fired plants would be expensive)
- Concerns regarding fuel availability (largest reserves are in politically unstable regions)
- Significant fuel price fluctuations create less stable energy prices

Cost estimate (in this example)
- Capacity: 800 MW electricity
- Annual full load: 6,000 hours
- Efficiency: 60%
- Lead time for construction (including permits): 4 years
- Estimated base case cost: ~EUR 85/MWh

COAL USING CCS

Coal (hard coal and lignite) is combusted to generate electricity and produce district heating. Coal is a predominant energy source in the world, corresponding to 67% of electricity supply. With Carbon Capture and Storage (CCS), the CO_2 from coal combustion can be extracted, liquefied and stored under ground. CCS technology is expected to mature, leading to reduced cost over time.

Main advantages
- Stable base load power
- Low fuel cost
- Good fuel availability from politically stable regions, well functioning market

Main disadvantages
- Environmental impact of coal mining must be handled
- CCS technology not yet ready for commercialisation

Cost estimate (in this example)

The example refers to a lignite-fired power plant. Lead time for construction is ~10 years.

The estimated cost span is EUR 45–85/MWh. The cost estimate will be higher in an early commercial phase. CCS technology is expected to mature, leading to reduced cost over time.

OCEAN ENERGY (wave, tidal)

Energy in waves, currents and tidal streams is used to generate electricity. For example, surface buoys may be used to absorb wave energy. Wave power is predicted to be the next commercial renewable energy source after wind power. Many potential pilot projects are currently in progress, and technology development is expected to reduce costs over time.

Main advantages
- Low emissions
- No fuel cost
- Less weather dependent than wind power

Main disadvantages
- Immature technology still under development, entailing high production cost
- Requires significant investments in the grid

Cost estimate (in this example)

The example refers to wave power. Lead time for construction is ~10 years.

The estimated cost span is EUR 80–115/MWh. The cost is expected to be higher in an early commercial phase. Ocean energy technologies are expected to mature, leading to reduced cost over time.