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Lars Bugge

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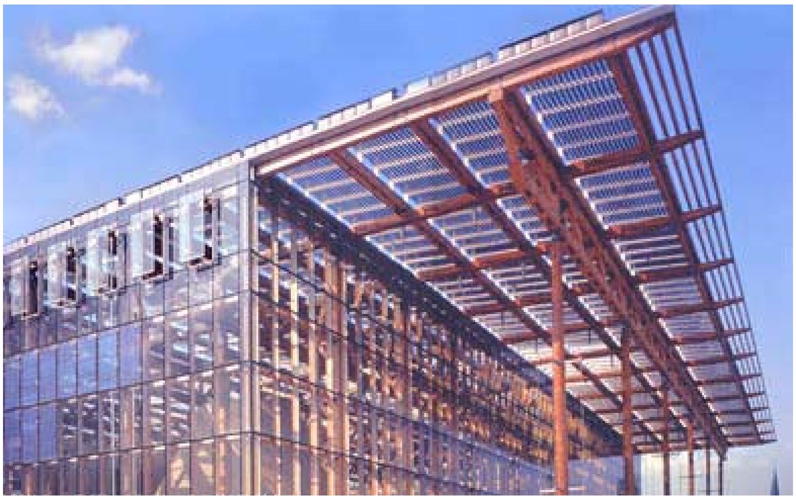
1 PV technology, short status on development

The cost of a solar system is directly proportional to the energy required. Small cabin systems start roughly at a few thousand dollars. A typical household system could cost anywhere from € 9,000 to €36,000. For commercial- and other large buildings, thumb rule cost figures are not common, mainly due to the fact that in such buildings, the PV integration largely is a part of the building design. For relatively simple installations, the cost figures may, however, be a little less than those that apply for household (unit costs).



Blue PV glass laminates, Mont-Cenis Academy, Herne.

Image:SMA

PV Systems containing 100 watts or more generally cost between €4,5 and € 27 per watt, depending on application and quality. Smaller systems are more expensive on a per-watt basis. The cost of the PV modules is typically 1/3 to 1/2 of the total system cost. The average production of each watt of PV is between 2 and 6 watt-hours of energy per day, depending on the season and location. Very dark conditions (e.g., December in the Nordic countries) and very bright conditions will produce energy outside this range. Using typical loan charges and equipment life, the life-cycle cost of PV- generated energy generally ranges from € 0,18 to € 9,0/kWh. (Source BP Solar).

Prices for entire PV systems vary widely and depend on a variety of factors including system size, location, customer type, grid-connection and technical specification. For example, for BIPV systems the price of the system will vary significantly depending on whether the system is retrofit or is integrated into a new building structure. Another factor that has been shown to have a significant effect on price is the presence of a market stimulation measure, which can have dramatic effects on demand (and thus supply) of equipment in the target sector. The cost and complexity of permits and controls on grid-connection can also be a significant factor for smaller systems.

System prices for off-grid applications tend to be greater than those for grid-connected applications, as the latter do not require batteries and associated equipment. In addition, for off-grid applications, provision is sometimes made in the system price for a programme for battery replacement approximately every seven years.

In 2001, systems prices in the off-grid sector up to 1 kW varied from 8 to 20 € per watt - a very similar range was reported for systems larger than 1 kW. This large range of reported prices is likely to be a function of project specific factors. The installed price of grid-connected systems also varied widely in 2001. The lowest reported were approximately 5 € per watt for large scale (> 1 MW) systems installed in Germany, and 5 to 5.5 € per watt in the USA. (Source: IEA PVPS programme) In most cases, however, the real costs are higher than this, we believe 8 € per watt is a more realistic cost estimate.

2 Cost effectiveness of PV in grid-connected applications versus other comparable RE-technology (investment, operation, maintenance)

Aside from PV, there is in principle a number of other power producing RE-technologies. Most important are probably wind turbines and large biomass fuelled power- or cogeneration plants. More uncommon, we find large solar thermal systems (involving steam turbine solutions) and smaller thermal systems where solar energy is converted through use of stirling engines. The latter may be comparable in size and applicability with PV. Such solar systems are, however, not very common and therefore not in practice comparable with PV.

BIPV may be integrated for example in large manufacturing plants, covering thousands of square meters. The most common use of BIPV so far limits itself to commercial buildings, office buildings etc. Larger BIPV installations will be in the range of 1000 square meters, with a peak production capacity in the range of 100 kW. On this background, comparable RE technologies is said to be wind turbines with capacities between 5 and 100 kW.

Due to the difference in the nature of wind- and solar energy, available resources, space requirements, appearance, etc, wind power will, only in few instances, represent a realistic alternative to PV. In some cases though, at places with favourable solar- and wind conditions, it will be natural to consider both technologies. This could for instance be for remotely situated office buildings where wind power installations could stand either beside or on top of the building.

We have found that investment costs for small wind turbines (10-20 kW capacity) are in the range of 2000-3800 € per kW production capacity. (This relatively wide range has to do with variations in tower heights.) The comparable number for PV is around 8000 € per kW production capacity. The annual power production from a PV installation is typically 800 kWh per kWp installed capacity (mid-German solar climate). This means that a wind turbine roughly has to produce around 1000 hours at full capacity annually to compete with the PV-system. We do not have exact numbers with regard to operation- and maintenance costs for wind turbines. But they are significant, especially in comparison to PV.

3 Why choose BIPV?

BIPV give buildings a number of new features. PV-cells turn them into small power plants, they give façades modern expressions as well as showing the public the environmental concern of the user or owner of the building.

3.1 Energy (power) production.

For an investor in BIPV, the energy aspect consist of at least two components, namely electricity to cover internal needs and sale to the grid, and as back up in case of stop in the regular power supply. This gives the power generated different price tags:

- A price tag for PV-power that substitutes power that otherwise is purchased from the grid.
- A price tag for power sold to the grid
- A price tag for emergency power.

In Norway, the power bill to ordinary consumers consists of four main elements, namely the electricity itself, transportation (grid costs), power tax approximately 9% and 24% VAT. The electricity element varies significantly, but constitutes around one third of the total cost. Transport constitutes another third, and taxes one third. By using self produced power, the BIPV owner can value his own production at the same price as with purchased power, including the transportation and tax elements.

When solar power is sold to the grid, the value is largely determined by the market price levels. For Sweden, Finland, Denmark and Norway, this means the spot price at the Nord Pool power exchange. Due to the unpredictable nature of solar power, values are kept relatively low. A thumb rule may then be that a self generated kWh that substitutes purchase of a kWh, is worth three times as much as a kWh sold to the grid, that is without any kind of special sales agreements. Some utilities offer so called net-net settlements, which means that all PV power produced is priced at the same level at which the producer alternatively purchases power in deficit situations.

The value of PV-power produced is seldom sufficient to pay an acceptable return on the PV investments. Special buy back rates for grid connected PV installations have received a great deal of interest as they raise a fundamental issue for the cost recovery of the system investment, and may be very important for the short and intermediate diffusion of the technology. More generally, “green pricing” schemes which apply for PV as well as for other renewable energies have been introduced by a number of utilities in different countries. The buy back rates can be ranked by the level of the rate applied for independent producers of PV power fed into the grid compared to the cost of conventional electricity purchased from the grid. In Germany and Switzerland, PV-producers have received payments as high as 5 times the value of conventional power. These relatively high payments are also guaranteed over a long period of time, between 10 and 20 years.

3.2 Security of energy supply

Emergency power may have rather special rates, according to what requirements that are defined. In some cases emergency power is only needed to operate special types of equipment for short periods of time. This may for example be computers, telecom equipment or lighting. If a PV installation, including a battery bank of some size, can replace a diesel generator, PV technology may be a cost efficient competitor.

3.3 Aesthetics, architecture

In recent history, the various eras are characterised in architecture and building design. Architecture using materials like steel, aluminium and glass in exterior walls have become quite common during the last decades. PV panels and integrated PV solutions offer new possibilities for designers. A building design that points towards future development trends, and at the same time is acknowledged by design critics as giving buildings a character unique to BIPV, may offer substantial benefits for the owner. In such a context, PV may be seen purely as a design element adding to achieve the expression desired by the architect.

3.4 Environmental concerns, interest

Among the renewable energy technologies, PV is perhaps the most user friendly one. Firstly, the product is electricity, the most desired of all energy products. Secondly, PV may be integrated in numerous varieties in buildings or other structures. PV will seldom displace other desired materials or functions in a building. And thirdly, PV does not have negative environmental effects as noise, smell or emissions. In many cases, PV is the only option for actors who want to produce renewable energy, as electricity, within a building.

3.5 Shaping image (carrying out corporate policy, strategy)

A significant portion of the façade covered with PV-cells, will be the defining aesthetic element of a building. The PV-cells will immediately send a signal to a large portion of the environmentally concerned public; “Here is somebody that cares about our future!” In that way, PV installations contribute to the shaping of corporate or organisational image and identity. On this arena PV does not need to compete against other energy technologies, but rather with market activities like media campaigns, etc.

Some years ago, British Petroleum, BP, gave its initials the new meaning Beyond Petroleum. The change points at renewables as main sources of future energy supply. BP’s environmental strategy includes PV, both as manufacturer and supplier, as well as being an active PV user.

3.6 A measure to be among “front-runners” in the energy business

Since the development of PV started in the aeronautical industry, the unit costs have been significantly reduced. In an intermediate time frame, some actors believe that costs of PV will meet the costs of comparable energy sources. With this background, PV projects are performed in order to gain experience and to prepare for the day where PV power can compete in the general electricity market. This might be the case for instance for energy suppliers, utilities etc. One example is the utility in Helsingborg in southern Sweden, where a large PV installation dominates the company’s office building.

3.7 Environmental design criterias

In some urban development areas, certain environmental requirements are laid on the developers. Along with themes like sewage and waste treatment, requirements tied to energy may be present. Selecting PV / BIPV may be the most adequate solution in order to comply with such requirements. PV costs may in this context be viewed like other extraordinary costs such as installing sound proof windows, difficult foundation conditions etc. For example, in PV-NORD; buildings A and B (Holmen/Grynnan and Lysande) are built in Hammarby Sjöstad, which is an urban area with exactly these features.

4 Financing: Elements in creating return on investment

The driving actors behind PV installations can be placed in two categories; owners of buildings who view such installation as integrated parts of buildings, and actors that have special interest in PV in such a way that they invest in PV based on special agreements with owners of buildings. The latter categories may be utility companies, tenants, etc. Since motives for PV investments differ, the values generated will be valued accordingly.

An owner of a building may for example see power sales and profiling as the most important elements, whereas a utility or power company may see generation of so called "green certificates" as most important. Some utilities are also investing in PV as part of corporate policy, to avoid the costs of grid extensions in remote areas, or to counter the effects of demand peaks in hot weather.

4.1 Subsidies, other incentives (a review of incentives in No, Swe, Fin,)

In general, the wide range of fiscal instruments being used to support or promote PV include: reduced interest rates on loans, tax credits, accelerated depreciation, government or regional grants, preferential tariffs and 'green electricity' schemes. The IEA PVPS programme has presented the following table regarding such schemes in the Nordic countries:

Public budget for R&D, demonstration and market stimulation in 2001				
Annual Budget in Thousand USD				
Country	**R&D**	**Demonstration**	**Market stimulation**	**Total**
DNK	629	572	-	**1 201**
FIN	520	-	-	**520**
NOR	1 125	-	-	**1 125**
SWE	1 533	-	-	**1 533**
Note: The costs of obligations placed on utilities are not included in the above table as these are generally passed to all electricity consumers				

It is clear that the budget for the demonstration of technologies remains a small proportion of the total spent in this area, this year about 6 % of the total reported. Although it is not the case in the Nordic countries, IEA reports that the greatest proportion of effort is directed towards market stimulation measures that account for 67 % of budget spending within the IEA countries. It is also interesting to note that while not all countries report spending on demonstration projects or market stimulation measures, consistent programmes for R & D are common.

4.2 Power production (market value)

The power sales may be valued differently:

- According to market tariffs, basically based on Nord Pool spot prices
- Based on a price equal to the tariff(s) at which PV owners purchase of electricity from the grid, that is a substitutional price or – value. This will be the case with a net-net settlement scheme.
- According to tariffs defined in special purchase agreements.
- Generation and sale of "green certificates".

The value of PV power varies a great deal, and is especially tied to incentive programmes offered by governments. The IEA PVPS programme has mapped such programmes and tariffs in OECD countries. In the most favourable cases, PV power is paid by a rate about 5 times the market value, over a course of 20 years.

The Kyoto protocol came as a result of the threat of climate change as due to increased CO2 emissions from the use of fossil fuels. The protocol introduces CO2 emission quotas as a future market commodity. Closely linked with CO2 quotas is the "green certificate" market. Such certificates are issued to producers of electricity from renewable energy sources based on defined criteria. There are reasons to believe that PV will be among RE technologies eligible to earn such certificates.

Since the power sector constitutes one of the largest emission sources, power companies may be forced to generate or purchase green certificates that correspond to a certain fraction of their power generation. As governments are likely to increase this fraction over the course of time, the demand (and value) for such certificates may grow significantly. Today, hydro- and wind power seem to generate the strongest interest, but with PV as a clear competitor / alternative.

The European power sector is characterised by large power plants located relatively far from the end consumer. As such plants and transmissions- and distribution lines represent large investments, power generation closer to the end user may become increasingly attractive, increasing the competitiveness of PV. The value of other network benefits attributed to PV does not, though, appear yet to be recognized.

4.3 Security of power supply (insurance policy)

Some buildings and activities are more vulnerable to power shortages than others. Strong dependence on electricity make users / buildings like hospitals, computer centres and so on install emergency back-up systems, often diesel generators with several hundred kW capacity. Other functions like shopping malls, tourist centres, museums and so on may need emergency lighting in case of fire or other need for quick evacuation. In such cases a capacity of say 20-50 kW may be sufficient and within the range of what a BIPV installation could manage. For other users low quality in grid supply could be strengthened via PV.

Whereas an emergency generator normally has a limited running time, and thereby represent “dead capital”, a PV installation will produce power over the course of its lifetime. In countries where it is permitted, many utilities now offer ‘net metering’, where the consumer only pays for the difference between the electricity generated by their PV system and the electricity purchased from the utility grid. PV as a security of supply measure, combined with a net metering agreement may in many cases represent a favourable option.

4.4 Architectural requirements (creating added values)

Buildings are created in many different ways. In some cases architects and designers have the artistic freedom to quite strongly characterise buildings with their own fingerprints. In other cases a building will represent a monument within a community or a region. In such cases, the cost is not as strongly a focal point as it normally is. In such high profiled buildings, costs for both architectural solutions and materials may be in the upper part of the price scale. In an ultra modern building with exterior covered with glass, aluminium, polished stone, steel and so on could in many cases consider PV modules, only for their appearance. In these cases, the cost of PV will be in the same range as for the alternatives. Furthermore, PV may accentuate the modern or contemporary expression of the building. The main point is that for some buildings, PV may be chosen, mostly for its characteristic appearance, as any other façade material.

4.5 Environmental motives as function of corporate strategy / policy

In general, a number of companies, organisations etc. use their buildings as a tool for creating profile and image. One example here may be the Chrysler building in New York, -that due to its characteristic appearance has been a land mark for decades. If the task is to create an ecological or environmental orientated profile, PV-surfaces represent an option. In such a case the costs for PV should be seen in light of, and alternative to, costs for market campaigns, advertisements, and other PR-activities.

5 How finance BIPV systems ?

5.1 PV; an element or feature, included in building projects.

Judged from the information we have so far, PV-systems are in most cases viewed as integrated building elements. They represent costs the same way other electrical installations do, and have no separate financial background, plan etc.

5.2 Financing via bank loans, etc.

Unlike other building elements, PV systems create values throughout a large portion of buildings lifetime. One could for instance imagine that investors or power companies purchase façade space in order to install PV capacity. Viewed on such a background, it seems natural to have separate financing for the PV system.

Suppliers of heat based on bioenergy, have both in Denmark and Norway, tried to finance mobile boiler houses attached to the customers heating systems. The idea is that the suppliers take care of everything from fuel transport and handling, operation of furnaces, etc. and that customers only pay for delivered kilowatt hours. Legal barriers have proved difficult to finance such schemes, however. The reason is that boiler houses, no matter how easy they are to remove, are seen as integrated parts of heating systems, and therefore belong to the buildings. If an owner of a building for instance go bankrupt, the mobile boiler would automatically be included in the bankrupt estate. Such equipment may therefore not be mortgaged, and consequently close to impossible to finance within reasonable lending terms.

Although integrated in a façade, BIPV-installations may be done in such a fashion that they are relatively easy to remove. Some of the wiring, inverters and other equipment may also relatively easy bring out of a building. But as indicated above, there are few reasons to believe that PV is more bankable than bioenergy schemes. The legal limitations we see here restrict obvious possibilities generate renewable energy “next door” to the consumer. Changes in legal practise, or creating guarantee schemes, (perhaps with involvement from the public authorities), may loosen up this deadlock.

5.3 PV as part of the IT-infrastructure

The reliability and security of electrical supply is sometimes insufficient for operation of complex computer systems. Loss of supply during short periods of time and variations in voltage and frequency cause disruptions or sometimes shut down of such systems. There are reasons to believe that grid related problems lead to a number of costs for the user. On the other hand, the power supply needed to maintain critical functions in computer systems may be in the same range of what a typical PV system with a sufficient battery bank etc. can manage to supply. Cost caused by low quality power supply may be seen in light of investment costs for emergency battery bank, AC/DC rectifiers etc. Once these elements are paid for, a user is “half way” in covering the costs for a PV system? In some cases, the actual power production from a PV system may be relevant, for example if power loss frequently occurs over longer periods of time.