The Impact of Solar Feed-In Tariffs in Germany

Posted by Gail the Actuary on November 5, 2010 - 10:45am
Topic: Alternative energy
Tags: germany, solar pv, willem post [list all tags]

This post is a guest post by Willem Post, known on The Oil Drum as wilpost37. Wil is a consulting engineer and project manager. He has a Master of Science in Mechanical Engineering and MBA degrees. More of his articles can be found on Coalition for Energy Solutions website.

The purpose of this analysis is to show the impact of Photovoltaic (PV) Solar Feed-In-Tariffs (FITs) in Germany. It has the largest installed base of grid-connected PV solar systems in the world, and much data is available about it.

German solar PV in 2009 produced 1.1% of total German electricity, but issues of grid stability are already being raised, as is the issue of excessive cost. Through the FIT, the electrical system paid an average $0.54 cents per kilowatt hour for the electrical power for the electricity it purchased. The cost of wholesale power has varied over the years, but has been much lower than this. In 2009, the cost of wholesale electricity averaged $0.075 at peak rates, or $0.058 at base load rates.

Even this cost comparison may give too much credit to solar. The only real savings from having the PV systems is the savings in fuel, since the generating units used for peaking would still need to be in place, and employees would still be needed to operate and maintain them. The cost of fuel would have been even lower than base load rates.

In this post, I explain these issues in more detail, and talk about some other issues, including the impact on employment, and whether other approaches might provide a better use for funds.

This post is a guest post by Willem Post, known on The Oil Drum as wilpost37. Wil is a consulting engineer and project manager. He has a Master of Science in Mechanical Engineering and MBA degrees. More of his articles can be found on Coalition for Energy Solutions website.

The purpose of this analysis is to show the impact of Photovoltaic (PV) Solar Feed-In-Tariffs (FITs) in Germany. It has the largest installed base of grid-connected PV solar systems in the world, and much data is available about it.

German solar PV in 2009 produced only 1.1% of total German electricity, but issues of grid stability are already being raised, as is the issue of excessive cost. Through the FIT, the electrical system paid an average $0.54 cents per kilowatt hour for the electrical power for the electricity it purchased. The cost of wholesale power has varied over the years, but has been much lower than this. In 2009, the cost of wholesale electricity averaged $0.075 at peak rates, or $0.058 at base load rates.

Even this cost comparison may give too much credit to solar. The only real savings from having the PV systems is the savings in fuel, since the generating units used for peaking would still need to be in place, and employees would still be needed to operate and maintain them. The cost of fuel would have been even lower than base load rates.

In this post, I explain these issues in more detail, and talk about some other issues, including the impact on employment, and whether other approaches might provide a better use for funds.

Background

Prior to 2000 PV solar, FITs did not exist and there were almost no PV solar systems in Germany, because Germany's annual PV solar capacity factor for true-south-facing, fixed-tilt, correctly-angled systems is about 0.115, which makes it a very poor candidate for unsubsidized PV solar power.

By 31 August, 2010, German households and businesses installed about 700,000 grid-connected PV solar systems with a total capacity of 14,680 MW, because of the subsidies and generous FITs in effect starting in 2000.

The FITs are lucrative for the households and businesses with grid-connected PV solar systems. They get to sell all of their PV solar power to the utilities at generous, but declining, FIT rates for 20 years from date of installation. The average FIT rate was $0.54/kWh in 2009. Households buy power for their own consumption from the utilities at about $0.28/kWh, for a gain of $0.26/kWh. Businesses buy power for their own consumption at $0.20/kWh, for a gain of $0.34/kWh.
http://www.energy.eu/

German utilities are allowed to include the additional costs of the FIT regime into their rate base. In effect, the few more wealthy households and businesses are being subsidized by the many less wealthy households and businesses. At present, renewables' FITs add $0.029/kWh to household rates and are likely to add $0.05/kWh in 2011, mostly due to the added PV solar systems in 2009 and 2010.

Businesses are complaining about higher electric bills making them less competitive.

Primary Impacts of Solar Subsides

The main results of the subsidies and generous FITs have been huge investments in PV solar systems and huge FIT subsidies paid to the owners of PV solar systems that produce only a very small quantity of variable, intermittent and expensive power and avoid the emission of a miniscule quantity of CO2.

- During the 2000-2009 period, Germany installed 9,830 MW of PV solar systems at a cost of about 9,830,000 kW x $6,000/kWh (2000-2009 average) = $59 billion. This cost has been dropping. The 2000 PV systems were about $9,000/kW, the 2009 PV systems were about $5,000/kW, and the 2010 PV systems are about 4,300-5,200 $/kW, depending on the type of installation.

  http://www.solarplaza.com/article/booming-german-pv-market-could-cost-ra...
  http://www.gtai.com/fileadmin/user_upload/Downloads/Industries/Renewable...

- For the systems installed during the 2000-2009 period, the FIT amount that has been paid by utilities for the PV solar power fed into the grid from the start of 2000 and that will be paid until the end of 2029 has been estimated at $73.2 billion.

- Germany's installed power plant capacity is about 135,000 MW and its peak power demand is about 100,000 MW. Its power production was 594,100 GWh in 2009, of which PV solar power was 6,578 GWh, or about 1.1% of Germany's production.

- In 2009, 2.48 billion euros, or $3.54 billion, was paid by German utilities for the 6,578 GWh PV solar power produced by an effective installed capacity of 5,950 MW (start 2009) + 1/2 x 3,880 MW (added in 2009) = 7,890 MW. The 2009 average FIT was about $3.54 billion/6,578 GWh = $0.54/kWh. In 2009, the average wholesale rates at which German utilities buy and sell were about $0.058/kWh for base load power and about $0.075/kWh for peaking power.

  http://www.slideshare.net/solarplaza/the-solar-future-de-karl-kuhlman-ca...
  http://rwecom.online-report.eu/2009/ir/3/reviewofoperations/environment/...

In 2009, Germany's PV solar capacity factor was 6,578 GWh/(7,890 MW x 8,760 hr/yr) = 0.095. The low capacity factor may indicate the PV solar panels are aging, dusty, partially shaded by trees, partially snow-covered, etc., and, as about 80% of the PV solar systems are roof-mounted, many roofs may not be true-south-facing, and the panels may not be correctly angled.

If we assume PV solar power is produced from 7 AM to 5 PM, then the average level during these ten hours was 6,578 GWh/yr x 1,000 MW/GW x 1 yr/(10 hr x 365 days) = 1,802 MW, insignificant compared to Germany's peak demand of about 100,000 MW.

Variation of PV Solar Power and Grid Stability

The sma.de website displays a graph of the real-time PV solar power production in Germany during each day of the year. The methodology of determining the display is explained in the website. The website shows 14,680 MW of PV solar was installed as of 31 August 2010, which means 14,680 MW - 9,830 MW (end of 2009) = 4,850 MW was installed during the first 8 months of 2010, or about 606 MW/month.

http://www.allianceforrenewableenergy.org/2010/10/germany-adds-nearly-1-...

This rate of installation is more than twice as high in 2010 as in 2009, because the FITs will be significantly reduced in 2011, making it less profitable to own a PV solar system. Installations planned for 2011 are being shifted to 2010 to beat the FIT reduction deadline. For comparison: US total installed PV solar was 1,256 MW plus 397 MW of concentrated solar power at the end of 2009.

The sma.de website shows the PV solar power production from the 14,680 MW of PV solar systems reached a maximum level of about 5.3 MW (36% of installed PV solar capacity), 3.6 MW (24%) and 7.0 MW (48%) at about 12 noon on October 6, 7 and 8, respectively.

The website shows that maximum outputs at 12 noon vary from about 20% (2,936 MW) to about 60% (8,808 MW) of installed capacity during the summer and from about 10% (1,468 MW) to about 30% (4,400 MW) of installed capacity during the winter.

The rapid build-up of PV solar power capacity will have an increasing effect on grid stability, according to an energy advisor to the German government. (See Grid Aching Under Solar Power.)

PV Impact on Daily Power Demand and Peaking Unit Operation

The Tagesgang website displays a typical power demand curve for Germany. This curve will vary somewhat during the year, but, to simplify the analysis, we will assume the curve is valid for all days of the year, which will not affect the conclusions of the study.

The website shows peaking unit operation from about 10 AM to about 2 PM which coincides with high levels of PV solar production. This means German utilities have less need for peaking units.

PV Solar Impact on Peaking Unit Operation

Peaking units usually are gas-fired, simple-cycle, gas-turbine generators. Their efficiency at full load is about 30%, or about 10,000 Btu/kWh, and at part load about 20%, or about 15,000 Btu/kWh. Peaking units usually operate at about 50% load, otherwise they cannot modulate as needed by demand.

For this study, utility long-term gas contract prices are assumed at $4/million Btus.

In analyzing the total FIT subsidy paid in 2009, we can allocate a part of it to the 10 AM to 2 PM period and the rest to all other hours of of PV solar power production.

If we assume the average PV power output during the 10 AM and 2 PM period of each day of 2009 at about 2,500 MW, and if we assume all of it is fed into the grid, then German utilities save about 2,500 MW x 1,000 kW/MW x 4 hrs/day x 15,000 Btu/kWh x $4/million Btu = $0.6 million/day in fuel expenses.

There are very little additional savings, because the peaking units are in service during other peak periods of the day (see Tagesgang website) when PV solar power is much less. The operating personnel are present whether the peaking units are operating or not.

In 2009, German utilities credited, as required by the FIT scheme, the monthly bills of the owners of PV solar systems on average about 2,500 MW x 1,000 kW/MW x 4 hrs/day x $0.54/kWh = $5.4 million/day for this 10 AM to 2 PM power, or 365 days/yr x $5.4 million/day = $1.97 billion for all of 2009. The FIT amount credited for all other hours of PV solar power production was about $3.54 billion - $1.97 billion = $1.57 billion.

German utilities could have bought the PV solar part of the 10 PM to 2 PM peaking power for $0.075/$0.54 x $5.4 million = $0.75 million/day from the grid, instead of buying it from PV solar system owners for $5.4 million/day.

A drawback of the PV solar power during the 10 AM to 2 PM period is that it is variable from day to day due to cloud cover changes, which means the peaking power purchases by utilities will vary from day to day more so than if the peaking power had been bought only from the grid.

This average level of PV solar power will increase as more PV solar systems are installed. It will have an increasing effect on the costs of owning and operating spinning reserve power plants and on the costs of standby power plants and transmission and distribution systems.

PV Solar Job Creation

By the end of 2009, the German PV solar sector employed, directly and indirectly, about 65,000 people and the thermal solar sector about 15,000 people in production, distribution, installation and maintenance. Employment is higher in 2010, because the rate of installing PV solar systems has increased so that more systems can be installed in advance of FIT reduction deadlines. The sector would employ even more people, but because China is the low-cost PV solar panel producer in the world, most of the panels, at least 50% of the systems' cost, are imported which creates jobs in China, not in Germany.

There are several German studies and at least one Vermont study that conclude jobs created in the PV solar sector reduce about an equal number of jobs in other sectors, because resources, due to subsidies, are shifted to the PV solar sector away from other sectors; i.e., there is no free lunch.

According the Vermont Department of Public Service, VT-DPS, report "The Economic Impacts of Vermont Feed in Tariffs," about $228.5 million will be required to implement 50 MW of FIT subsidized renewables and that 35% of that amount would be supplied by Vermont sources, the rest, mostly equipment, by non-Vermont sources. For example: PV panels from China and inverters from Germany are about 70% of a PV system's materials cost.

The VT-DPS report states:

> There would be a spike of about 550 short-term jobs during the 1-3 year construction stage which would flatten to a permanent net gain of 13 long-term full-time jobs during the operation and maintenance stage. In essence jobs are created in one sector (renewables) of the Vermont economy at the expense other sectors.

It appears using scarce ratepayer/taxpayer funds for a government-subsidized, capital-intensive renewables program that produces just a small quantity of expensive power and reduces CO2 at a high cost per dollar invested is NOT the jobs creation panacea so much talked about by proponents of renewables. See articles liked below:

http://publicservice.vermont.gov/planning/DPS%20White%20Paper%20Feed%20i...
http://www.coalitionforenergysolutions.org/renewables_are_expensive_an.pdf
http://www.germany.info/Vertretung/usa/en/09__Press__InFocus__Interviews...

A Different Political Decision in 2000: Nuclear instead of PV Solar

Nuclear

What if the funds invested in PV solar systems had been invested in additional nuclear power plants? The $59 billion would have bought about 10,000 MW of nuclear power. If they had been started in 2000, they would have been in service by the end of 2009.

The 2010 nuclear power production would be 10,000 MW x 1 GW/1,000 MW x 8,760 hr/yr x capacity factor 0.90 = 78,800 GWh/yr of CO2-free, relatively low-cost, steady, 24/7/365 power. Nuclear plants are designed to last for at least 50 years.

The CO2 reduction of retiring 10,000 MW of coal and lignite plants would be 10,000 MW x 1,000 kW/MW x 8,760 hr/yr x capacity factor 0.80 x 2 lb CO2/kWh = 140.2 billion lbs of CO2/yr.

PV Solar

The 2010 PV solar power production would be 9,830 MW (at end 2009) x 1 GW/1,000 MW x 8,760 hr/yr x capacity factor 0.095 = 8,180 GWh/yr of CO2-free, high-cost, variable, intermittent power, that is "there" only about 10 hrs of the day and not at all at night, requiring fossil, hydro, wind and nuclear power to fill in the gaps.

The systems installed during the 2000-2009 period required a capital cost of about $59 billion, of which the PV panels were about $30 billion and the inverters about $6 billion. PV solar panel output decreases each year due to aging. The panels of the 2000- 2009 systems need to be replaced after about 25 years at a cost of about 25-35 billion dollars for removal and safe disposal of the old panels and installation of the new panels. The solid-state inverters need to be replaced after about 10-15 years at a cost of about 5-7 billion dollars. Such enormous additional investments are rarely mentioned by PV solar proponents.

The CO2 reduction for PV solar power is more complex to evaluate, because it is variable which requires other power sources to operate at variable outputs which is inefficient and produces more pollution per kWh and more CO2 per kWh, just as a car is more efficient and less polluting at steady speeds on the highway and less efficient and more polluting at variable speeds in the city. The CO2 reduction of PV solar can be estimated by using an inefficiency factor less than 1. For the purpose of this analysis, the inefficiency factor is assumed to be 0.75.

The CO2 reduction due to PV solar power would be 9,830 MW (at end 2009) x 1,000 kW/MW x 8,760 hr/yr x inefficiency factor 0.75 x 2 lb CO2/kWh = 12.9 billion lb of CO2/yr. The CO2 reduction will likely be even less because PV solar power will replace mostly gas-fired power sources which emit about 1.2 lb of CO2/kWh.

Conclusions

Based on this analysis, it is difficult to justify Germany's decision in 2000 to undertake the PV solar subsidy based on a review of economic, air pollution or global warming considerations. Instead, it is an extremely expensive way to subsidize an industrial sector, create jobs and reduce CO2.

Because of the large gap between the FIT rates and utility electric rates, it is easy for German households and businesses see that a decision to "go solar" makes economic sense, much to the delight of PV solar vendors, financiers and developers who call this (for them) a success. Spain is having a similar disastrous experience with its PV solar FITs. See this article.

If we are to mitigate climate change at a reasonable cost, we must use technologies that provide the greatest reduction in CO2 per dollar invested. As a renewable, PV solar is among the highest in capital cost per installed kW and the lowest in power production and CO2 reduction per dollar invested.

Capital-intensive investments in inefficient PV solar systems that, without subsidies, have simple paybacks of 20-40 years divert resources from less capital-intensive measures, such as energy efficiency that, without subsidies, has simple paybacks of 1-5 years AND reduces CO2 more effectively AND requires no changes to the grid AND is INVISIBLE. My recommendation would be to do energy efficiency first and renewables later. There is not sufficient money to do both at the same time.

http://repec.rwi-essen.de/files/REP_09_156.pdf

The German government had budgeted a certain amount for PV solar subsidies for 2010. Because of the rapid rate of installation of PV solar systems this amount is depleted.

The German government, already under budget pressures, is finding it politically difficult to rein in the inefficient PV solar sector which will become more harmful to the overall efficiency of the economy as it gets bigger.

The German government, over much opposition, has decreased the FITs at a faster pace than originally planned, and is planning still more rapid FIT decreases, to slow the growth of the sector to a more affordable rate. There were FIT reductions of 9-11% on 1 January, 2010, 8-13% on 1 July, 2010, and 3% on 1 October, 2010. Additional reductions are planned for 2011. These reductions are in addition to scheduled reductions. These FIT reductions caused spikes of 1,461 MW and 1,700 MW installed in December 2009 and June 2010, respectively, to beat the deadlines.

http://uvdiv.blogspot.com/2010/02/german-solar-industry-protesting.html
http://www.renewableenergyworld.com/era/news/article/2010/05/germanys-so...
http://www.solarplaza.com/article/booming-german-pv-market-could-cost-ra...

Supplementary Websites

http://en.wikipedia.org/wiki/Solar_power
http://en.wikipedia.org/wiki/Solar_power_in_Germany
http://www.coalitionforenergysolutions.org/power_capacity_and_producti.pdf