# Renewable Energy: Insights from Germany

*This note by John G. Hollins[i] is inspired by an article in La Lettre du Conseil Français de l'Énergie[ii].*


## Summary

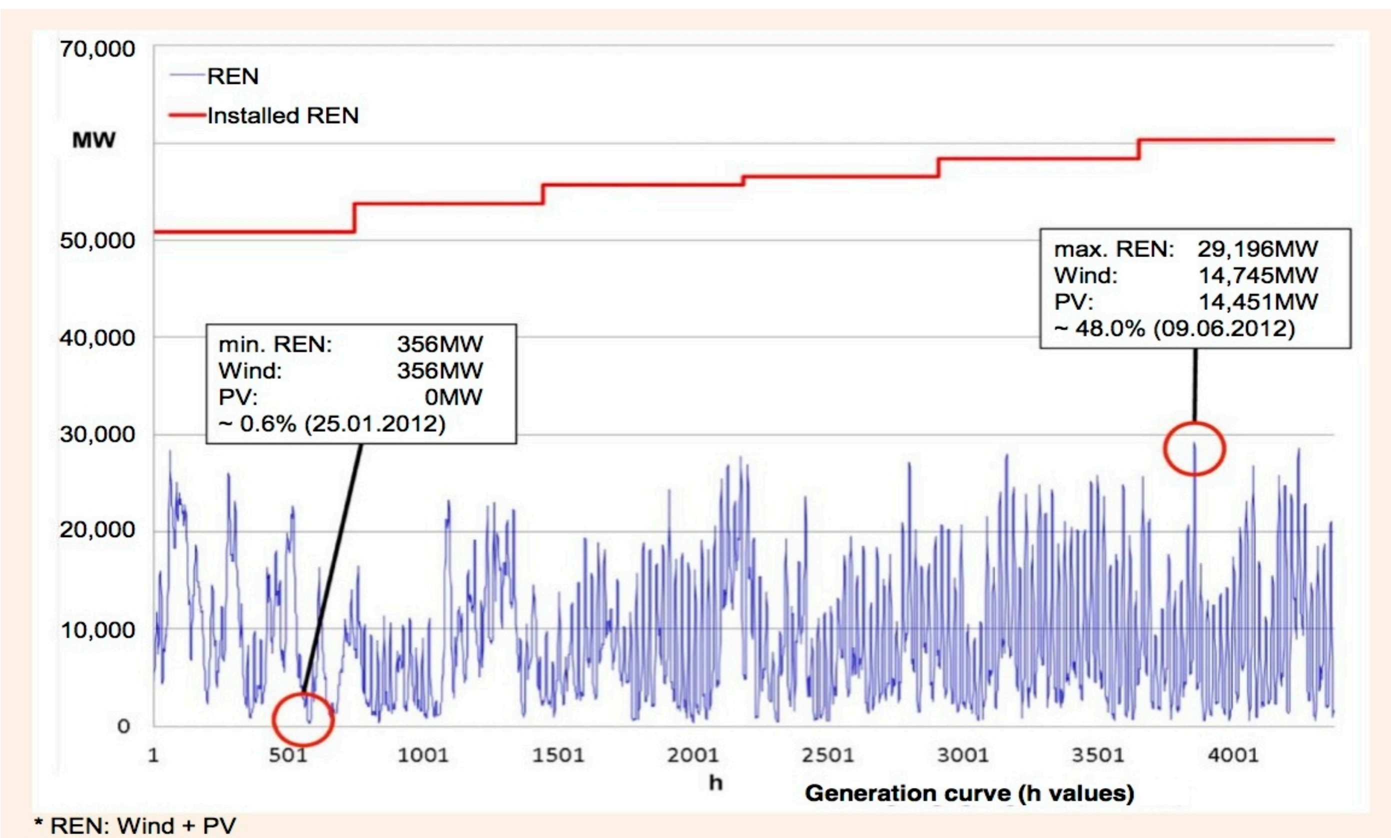
*Germany is conducting a massive experiment by rapidly deploying large numbers of wind-turbine and photovoltaic systems to generate electricity. Combined with a law that requires that these sources be deployed first whenever they are available, the consequences are striking:*

- *Renewables on this scale introduce huge physical volatility into the electrical system and prices, including negative prices, become unpredictable;*
  - *Producers don't just give away their electricity; they pay consumers to take it.*
- *The electrical grid in Europe cannot cope with the new renewables on the German scale;*
  - *But public opinion is firmly opposed to significant additions to the grid.*


## Installed capacity

The graph below shows that during the first six months of 2012, the installed capacity of renewable energy in Germany increased from 50 Gigawatts (GW) to 60 GW, the red line in the graph, half being wind power and half photovoltaic. (1 GW = 1 million kW). Germany is spending about 2 billion Euros (C$3 billion) every month adding to its system, which now (2014) has reached 80 GW. This is a massive undertaking. At this rate, a high-speed train in the Windsor – Quebec City corridor could be paid for in less than a year.

During the same period, the hourly availability of renewable energy (the purple line) varied between a minimum of 0.4 GW (0.6% of installed capacity) on January 25 and a maximum of 29 GW (48%) on June 9.




*Abscissa: hours from the beginning of 2012;* *Graph: E.ON, Düsseldorf, Germany*

## Demand and Supply

During periods of high demand and weak production of renewable energy, 75 GW of conventionally-generated electricity was required to meet the demand, including imports of electricity and coal. On a path to shut down its own nuclear generation, Germany in 2013 used record levels of domestic lignite and coal from the USA. It also imported nuclear electricity from the Czech Republic and coal-fired electricity from Poland.

When demand was low and the production of renewable energy was high, the requirement for thermal generation fell to 17 GW. Under these conditions, the German grid cannot handle all the photovoltaic electricity, and the excess is exported to the European market at low prices. It has been reported that Poland refuses to import wind power from Germany because it destabilizes its system.

## Variability

The graph provides a clear picture of the variability of generation, hour by hour, in a very large renewable energy system with twice the installed capacity of conventional generation in Ontario.

German consumers, however, like Canadians, expect the light to go on whenever the switch is turned. The task for the manager of any electrical system has always been to balance supply and demand, not just hour-by-hour, but instantaneously. This is generally done by adjusting the supply, but can be done by reducing demand, such as a customer in Ontario granting permission to its local utility to reduce the power supplied to an air-conditioning system. In the extreme case, power to an industry or neighbourhood is turned off - a blackout.

The peak demand for electricity in Germany is steady at about 80 GW. The current fleet of conventional generation of 90 GW can comfortably cover this peak demand on its own, which is what happens when there is no production of renewables. When there is production of renewable energy, the conventional generators are obliged by law to cover exactly, second-by-second, the balance of the demand.

The cost of adjusting thermal generation to follow the substantial and unpredictable variability in the generation of the new renewables is so high that producers do not reduce their output only to increase it within minutes or hours. This leads to enormous volatility in the price of electricity on the European grid, including negative prices — producers don't just give their electricity away, they pay the consumer to take it.

The low prices paid when the renewables are producing prolifically have had a perverse effect: it no longer makes economic sense for generating companies to use the most efficient conventional plants: combined cycle gas turbines.

## Emissions

Although 25% of annual demand is met by renewables, the overall result in practice is that more greenhouse gases are emitted in the production of the remaining 75% than were formerly emitted in meeting the full load with conventional generation, without taking into account emissions related to electricity imported from other countries. (The UNFCCC provides for emissions to be charged to the account of the country where they occur, not to the country that uses the services or products that it imports.)

## Social Effect

Vaclav Smil[iii], University of Manitoba, has pointed out that Germany's *Energiewende (Energy U-turn)* has resulted in both higher costs for consumers and higher emission of greenhouse gases and other pollutants.

He also identifies a perverse social effect:

- Homeowners and speculators have been able to profit from guaranteed high prices for photovoltaic electricity, which provide a high, risk-free return to those who have plastered roofs with panels.
- Renters (without roofs and often without capital) cannot enjoy the benefits available to their richer compatriots, but everyone pays higher prices for electricity.
- Large companies are exempt from the burden of rising prices — a decision taken to keep them competitive which will likely be challenged in due course by other countries.

## Investment

The peak demand for electricity in Germany is 80 GW. The current fleet of conventional generation of 90 GW can cover this peak demand on its own. The fleet of renewables already built has a capacity of 80 GW. Germany plans to add a second fleet of 80 GW of renewables. When this is done, Germany will have built and paid for 250 GW of capacity, three times the peak demand. Furthermore, some of the major German industries are planning to cover their own requirements by building for their own use another 40 GW of generating capacity.

The price of electricity to residential consumers currently includes a levy of 6.3 Euro cents/kWh, with VAT, approximately 11 Canadian cents/kWh.

## Analysis of Systems

The Club of Rome for four decades has made the case for long-term analysis of entire systems — addressing economic, ecological, and social factors.

Systems analysis of energy and environmental factors has been developed over a period of more than three decades. For example, the MARKAL/TIMES family of models, developed under the auspices of the International Energy Agency, has national teams in almost 70 countries. Ironically, Germany is a contracting party to this IEA agreement. What will it take for the decision-makers in Prussia to pay attention to their analysts in Bavaria?

## Sustainability

Herman Daly[iv] proposed three conditions that must be met for an economy to be energetically sustainable. The substantial German experience with wind and photovoltaic provides some insight into meeting the second condition, namely, that rates of use of non-renewable resources do not exceed the rate at which sustainable renewable substitutes are developed.

This means that for every Watt of renewable energy installed there has to be a Watt of generation instantly available from another source that can be delivered when the wind is not blowing or the sun is not shining, or both. The full capital cost therefore includes the cost of complementary generators that can follow the rapidly changing contribution of wind and photovoltaic power.

Current wind and photovoltaic technologies can evidently play a role in meeting this requirement, but represent a modest first step. Meeting this requirement in full, and Daly's other conditions, will require a much broader systems approach. It will require advances in technologies — not just in the renewables themselves, but also in storage and the management of grids — combined with understanding and leadership by governments, businesses, and non-governmental organizations.

## Lessons

Jean-Eudes Moncomble, Secrétaire général du Conseil Français de l'Énergie, draws two main lessons from the German experience:

- The capacity of the electrical grid in Europe cannot cope with the new renewables on the German scale, with no prospect for reinforcement of the grid given a high level of public opposition to new construction.
- The costs of adjusting thermal generation to follow the substantial variability in the generation of the new renewables are so high that producers do not reduce their output only to increase it within minutes or hours. This leads to enormous volatility in the price of electricity on the European grid, including negative prices — producers don't just give their electricity away, they pay the consumer to take it.

---

[i] Dr. Hollins was a founding member of the Renewable Energy Resources Branch, Energy, Mines, and Resources Canada and is currently a member of the Canadian Association for the Club of Rome.

[ii] Les lettres du Conseil Français de l'Énergie se trouvent ici : *http://www.wec-france.org/lalettreducfe.html*

[iii] Professor Smil's article may be found at: *http://www.american.com/archive/2014/february/germanys-energy-goals-backfire*

[iv] To be materially and energetically sustainable, the economy's throughputs would have to meet Herman Daly's three conditions:

- Its rates of use of renewable resources do not exceed their rates of regeneration.
- Its rates of use of non-renewable resources do not exceed the rate at which sustainable renewable substitutes are developed.
- Its rates of pollution emission do not exceed the assimilative capacity of the environment.

*Limits to Growth, the 30-year Update; Meadows, Randers, and Meadows, p.254*