
Is Local Energy Supply a Main Road to Sustainability?

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Abstract

The use of local energy production as a strategy to improve energy safety, control costs and mitigate climate change is reviewed. Local energy is in practice equivalent to renewable energy. There are a large number of different sources of local energy production. Some of them, including solar electricity, energy efficient building and biogas production, are in rapid technical development. The use of local energy is estimated to be around 50 % in Sweden. A number of cases, mostly from Sweden and Europe, where local energy has been a strong and important policy are described. Networks of municipalities which work for local energy autonomy are found all over the world and some of them are reviewed. Typically a strong policy for local energy production creates substantial numbers of job opportunities and thus contributes to the local economy, provides social and environmental benefits, improves energy security, and reduces emissions of greenhouse gases.

Keywords

Local energy • Sustainable development • Energy security • Energy safety • Renewable energy • Energy mapping • Distributed generation • Energy autonomy • Energy efficiency • Transition towns • Case studies

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1 Background and Some Definitions

One of the largest difficulties for sustainable development today is the overwhelming dependence of most societies on non-renewable fossil energy supplies (Höök et al. 2010). The consequences of the enormous use of fossil carbon are twofold—first that supplies will come to an end; secondly that the end product builds up and causes environmental damage. For all non-renewable resources the effects of end products are typically felt before the source is emptied; the end product of the combustion of fossil carbon is foremost carbon dioxide causing climate change although there are also a number of other serious pollution problems appearing long before reaching the global peak oil. An additional dilemma is that for most societies the energy use has been tightly coupled with the economic growth throughout the history (Stern 2003) and dwindling energy resources is feared to cause economic decline.

So far the efforts to establish a carbon free economy, not dependent on fossil coal, oil and gas, have been mostly discussed as a global problem and in need to be solved as part of a global agenda. Here I will, on the contrary, ask to what extent it may instead be seen as a local problem and be solved locally. The questions to be addressed in this paper are:

1. To what extent have the possibilities to fulfil the local energy needs by local energy supplies been discussed as an option for policy or strategy?
2. What is the potential of local energy supplies?
3. To what extent has local energy supplies replaced previous external energy supplies?
4. What are the steps needed to achieve that?

Since very few countries, about ten, have large supplies of fossil carbon sources (Alekklett 2012), local supplies in most cases are equivalent to *renewable* energy sources. This does not make the issue of local supplies less valid. Research on renewable energy suggests that globally it is possible to replace all fossil energy with renewable alternatives—wind, water and sun—in a fairly short period (Delucchi and Jacobson 2011). Regardless of the possibility that in a few cases fossil carbon actually is available locally I will here refer to local energy supplies as renewables.

Renewable sources do not, however, need to be local in any advanced meaning. They may often be national, as for example large hydropower plants can even be used by several countries responsible for supplies as is assumed in the *Desertec* project now attracting huge investments for solar electricity in northern Africa, mostly Tunisia. Here, however, I will refer to local as mostly municipal, sometimes regional, or even smaller scale: energy-independent houses or households or neighbourhoods in cities will be considered part of the local energy supplies of local communities (municipalities).

2 Local Energy Supply as a Policy and/or Strategy Option

When searching the web and other documents for policy declarations on local energy they appear under a *variety of names*. Thus, communities which declare their intention to develop local energy supplies may work for Energy independence, Energy autonomy, Energy Self-Sufficiency, Energy self-reliance or to become Fossil fuel free.

As a *strategy* option in the literature on sustainable development it is most often referred to as Distributed generation or Distributed production. It is interesting to note that in the Baltic University Urban Forum project (Rydén 2006, 2008) the most common sustainability strategy option was *rescaling*. Both *upscaling* (e.g. from individual heating of houses to district heating) and *downscaling* (e.g. from district heating to heat pumps) are common strategies. Developing local energy supply may be seen as a down-scaling strategy going from international, import-dependent, energy provisions, to the strategy of managing energy needs on the local scale.

From many discussions with local politicians it seems that the declared *reasons* for developing local energy supplies are dominated by the communities' intention to increase their *energy safety* (World Energy Council 2011). In particular the approaching peak oil with an expected increased competition for fossil carbon based energy (especially oil) is feared. Often the cost of buying external energy, or a feared future sharp increase of costs, is also a reason for developing local energy sources, and a part of developing energy safety. For municipalities and regions (and nations) the climate argument is always or almost always there, but more as part of the initial discussion and not so visible in the actual planning of local resources. The exchange of fossil carbon for renewables is then seen as a mitigation step to combat climate change.

With the German post-Fukushima energy policy—*Energiwende*—this transition towards local supplies has become national policy (Respati 2012). It seems in the first place being caused by the determination to end the use of nuclear power. There are 21 nuclear power stations in Germany, more than decreasing the use of fossil sources of energy—the development of coal-based electricity production is still strong. But the effect is, nevertheless, dramatically increasing local energy supplies through solar cells, biogas stations, wind power, etc.

We also see some more principal discussions on the role of the local energy supply as promoted in the recent full-length movie “The fourth revolution—on energy autonomy” by Carl Fechner in Germany (Fechner 2010) reporting from societies in Denmark, Germany, Bangladesh and Zambia, all on the way to improve their life by using local energy sources. The web-based newsletter *Local Energy* (see localenergynews.com) declares that

higher energy prices and uncertainty of supply are driving communities toward renewables, but the understanding of how to implement renewable energy such that local benefits are maximized is still in its infancy. Therefore Local Energy helps communities develop stronger, healthier economies based on local self-reliance in energy. There is a growing

awareness that continued reliance on energy supplies from outside of the local community – especially oil and gas – poses significant economic risks.

Several networks of municipalities and/or regions promote local energy initiatives all over the world. Examples illustrating this include the USA based Post carbon cities which advise cities how to tackle the problem (Lerch 2008). The sustainable cities and towns campaign, though ICLEI (local authorities for sustainability) and with support from the German Government, runs the Local Renewables Initiative which supports and strengthens local governments in promoting sustainable energy in the urban environment (See www.local-renewables.iclei.org). Activities exist in Europe, but are also important in India and Brazil. The Australian Government supports the Solar Cities network for a sustainable energy future with the aim of reducing greenhouse gas emissions, promoting energy efficiency, adapting to climate change impacts and helping to create a global solution (www.greenhouse.gov.au/solarcities/).

Several cities have independently declared their intention to become energy autonomous. Thus the French city of *Perpignan* proudly announces that “Perpignan has signed an agreement, in the presence of the Minister for Ecology and Sustainable Development, which will encourage a decrease in energy consumption along with the expansion of renewable sources of energy—wind power and photovoltaic solar power. It will allow Perpignan to produce more energy than it consumes.” Similar declarations, but a little less pompous, are found, in Sweden by *Växjö* (one of the first) *Mörbylånga* on *Öland* Island, *Gotland* Island, and many others.

3 Local Energy Supply Today—The Case of Sweden

Clearly, the possibilities for a municipality to provide all energy needed for itself varies dramatically with the circumstances. For Sweden, energy autonomy is probably a comparatively realistic option due to the reasonably small population density, as compared to the more densely populated continental Europe. Sweden today has the largest share of renewable energy in the EU, close to 50 % (Fig. 1). Still there are a number of such projects in Germany, Austria, and the Netherlands. Here we will discuss separately heat, electricity, and fuels (e.g. for cars) and mostly stay within Sweden as an example.

3.1 Heating

In Sweden, the *heating sector* is becoming almost fossil-fuel free (Swedish Energy Authority 2011). Today very few buildings use coal, oil or gas for heating, since it has become quite expensive due to high carbon dioxide taxation. Most houses in the country today are heated by district heating, for which the power stations use biofuels. In the heating sector, thus, the vision of local energy supply is already

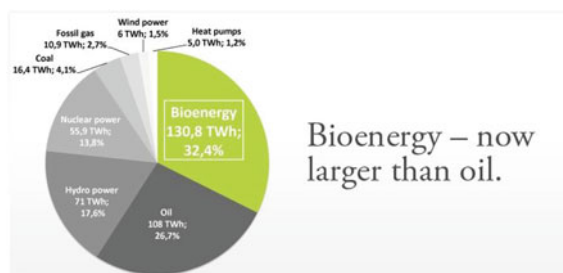


Fig. 1 Swedish energy budget 2011. *Source* Swedish Bioenergy Association (Svebio): www.svebio.se

close to reality. Many households—in 2010 estimated to be 800,000—use heat pumps. These need electricity but are 3–5 times more efficient than direct heating by electricity. Since the electricity in the country is practically fossil fuel free—about 50 % is hydro and 50 % nuclear—it does not contribute much to GHG emissions even if it is not local. Solar panels for solar heating exist, but are less common in Sweden than in southern Europe where they are found on almost every house. Finally, the use of wood chips or pellets for heating is also a growing market.

Energy efficiency measures are an important part of making local energy supply sufficient. Especially in the heating sector where the needed energy may be substantially reduced by energy efficiency projects. In Sweden 38 % of the national energy budget, 150 TWh of a total of 400 TWh, is the energy demand in the housing sector (IVL, Swedish Environmental Institute 2011). An estimated 20 % of that can be reduced by efficiency measures. The experiences from the project *Energy Performance Contracting* (EPC), a European Energy Service initiative, substantiates that. In Sweden (epc-sverige) there are more than 60 good examples (see www.epc-sverige.ivl).

For new houses, *low energy technology* is rapidly spreading, even if very few buildings so far meet a passive energy standard. The additional costs for building a low energy house is small, estimations vary between a few up to 10 %, compared to traditional buildings (Knivsta 2012), and the added costs are rapidly paid back by smaller energy bills.

3.2 Electricity

In Sweden, the electricity produced nationally is about 50 % hydro and 50 % nuclear and thus independent on imported fossils, a situation sharply different from Continental Europe where coal-based power stations dominate. Local electricity production is still in its infancy in Sweden, since the national supply is mostly safe and sufficient. Still, for many reasons, perhaps mostly discontent with the changes

in prices, a number of individuals and local municipalities have developed their own local generation of electricity.

There is a long tradition in *small-scale hydropower*. Several thousand small stations have been in operation, some for up to 100 years, in many municipalities. However, production from these stations is not at all sufficient for the municipalities and often varies much over the year. 4.6 TWh is produced by the 1615 Small Hydropower Stations of the country; that is, those with an installed capacity of maximum 10 MW. Whether the larger national hydropower stations should be counted as local is a matter of definition.

Most important is probably *cogenerated electricity* from district heating power stations. Additional sources include *wind power* stations, owned by municipalities or individuals or groups of individuals. *Solar electricity* from photovoltaic cells on individual buildings, or fields of cells owned by local energy companies (e.g. Sala Heby Energy Company north of Uppsala) is today increasing very rapidly. For the energy independent (see below) local communities by far the most important source today seems to be wind energy.

3.3 Fuel for Transport

Probably the most difficult issue for local energy is fuel for transport. Today imported fossil fuel by far dominates the market. Examples of a different situation today include city buses using locally produced *biogas*. Thus, many municipalities in Sweden use their own biogas, produced from food residues and similar sources. In some areas we see regional buses using locally produced *biodiesel*, from oil seeds to make RME (Rapeseed Methyl Ester) or in FAME (Fatty Acid Methyl Ester). This is not a big share of all fuel in the public transport sector. Bioethanol, partly produced locally, is mostly used for cars. Biodiesel from forest sector's black liquor is rapidly increasing although not as local, but national projects. The share of electric cars and hybrid cars is slowly increasing and so is the energy efficiency of cars in general. A large-scale change to such technologies is still waited for.

3.4 How Much Energy Is Produced Locally?

Estimations of the extent of locally produced energy for Swedish municipalities today are close to guesswork. It is, however, obvious that it is not very low. Knowing that heating in the housing sector accounts for 38 % of the energy need of the country today and is mostly provided from local sources, and that the other two energy sectors—electricity and fuel for transport—is marginally taken care of locally we may make an informed guess. If these are estimated to be 5 % each we will still arrive at a total of 50 % local energy supply in the country. This is in sharp contrast to continental Europe where electricity production is dominated by coal fired power plants, district heating is not the rule as in Sweden, and transport is

based on fossils; we have a clear advantage to explore the potential of local energy supply as a means of increased sustainability.

Municipalities which announce themselves as fossil-fuel free have all made their heating system free of fossils, and, as local electricity production is less complete, it may in fact boil down to fossil-free heating. It should be noted that household waste generation is not fully fossil-fuel free. In 2013, the fossil content of the waste incineration plant in Uppsala, one of the largest in the country, was 13 %, mostly due to plastic waste.

3.5 The Policy Steps to Promote Local Energy

Local-scale energy companies may be private, public or the public-private partnerships. Quite often we see municipal energy companies in which the city has a majority in the company board, while the daily business is run as in a private company. Typically, it is the smaller regionally or locally active companies, not the big international energy companies, which promote local renewable energy production (STUNS 2011).

The projects and investments of the local companies often rely on support from the local municipalities. Thus, the local energy supply typically requires a strong political support. Conditions for a strong local energy policy and steps taken to achieve that, were studied by the IIIIE at Lund University (Vega 2010). The cases reported by her included Växjö, Enköping and Kristianstad municipalities. There are several others, which have at least an equally strong local energy policy. Some 30 of them take part in the project *Klimatkommunerna* (Climate Municipalities), and others in *Omställning Sverige* (Transition towns, Sweden).

4 Some Cases of Communities with Strong Local Energy Policies

4.1 Continental Europe—Austria and Germany

It seems that the small Austrian town of Güssing (see webpages) close to the Hungarian and Slovenian borders, is an extraordinary case. From 1992 within eleven years, Güssing became self-sufficient with regard to electricity, heating, and transportation. It was all the result of building a modern CHP plant which also produces biodiesel based on gasification of woodchips. Thus, heat (and an added district heating network) and electricity were produced locally, as was the fuel for transport. In the process, more than 60 new companies and over 1500 new “Green Jobs” were created and the share of commuters to other regions fell from 80 to 40 %. The value added to the region by sale of “surplus” energy products is over \$28 million per year. Finally, green-house gas emissions were reduced by over 80 %.

This development was initiated and supported by a new mayor elected in 1992, and a Viennese scientist who developed the technology of wood chip gasification. Energy efficiency in the buildings in the town was also drastically improved, by almost 50 %. The approach spread and there are today 27 decentralised power plants within the Güssing County. In Austria as a whole more than 15 regions are, and a further 66 region work to become, energy independent with regard to electricity, heating and/or transportation. This covers 1.7 million inhabitants or 21 % of Austria's population (from www.blogs.worldwatch.org).

Also in Germany one may find extraordinary cases. The neighbourhoods of Vauban and Rieselfeld in Freiburg on the border with France and Switzerland have become, in the process of being rebuilt from a former military base into a residential area, almost energy independent. The area is very energy efficient; new regulations require that new houses use no more than 40 kWh/m² per year. About 50 % of electricity is produced by co-generation power stations which deliver heat to the district heating. There are about 90 small CHP units. 12.3 MW of solar PV panels, found on almost every house, produces 10 million kWh, and 5 medium sized wind turbines produce 14 million kWh annually.

Freiburg has developed a green image with political will and citizen involvement already over decades. It has fostered not only a very special "green culture" but also economic development. The initiatives have attracted about 1500 green businesses with some 10,000 employees; of these 1500 are in the solar energy sector. Austria and Germany appear to be in the frontline of developing fossil independence in Continental Europe.

4.2 Sweden

The Swedish town of Våxjö decided in 1996 to become "fossil fuel free". Våxjö has since built two biomass plants and use for the municipality only green electricity. In 2000 the municipality developed the "local initiatives award" and in 2007 became the winner of the "Sustainable Energy Europe Award". Våxjö is also a frontrunner in low energy buildings. It is clear that there is a political consensus on the fossil-fuel free policy in Våxjö; the members of the city council several times have participated in energy projects run by the municipality.

Many smaller towns and municipalities have a considerable energy independence mostly built on biomass. Thus, Enköping power station has its own energy forest (short rotation *Salix* plantation) and uses only forest biomass. Several farmers in the area use oilseeds to produce biodiesel. Heby municipality, with support from the inhabitants, has started to build fields of solar cells, an investment which continues and becomes more profitable as the investment costs for installations decrease. Several small neighbouring municipalities joined the initiative.

On the larger scale, one should mention *Stockholm Royal Seaport* (Djurgårdsstaden), one of Europe's largest urban development projects launched in May 2009. Stockholm Royal Seaport is planned to house 12,000 new dwellings, 35,000 work

spaces and a modern port for ferries and passenger traffic. An intelligent electricity grid—smart grid—will reduce annual energy consumption to a maximum of 55 KWh per square metre annually. The fully automated system, currently being developed, will fine-tune heating and ventilation systems to run when electricity prices—and energy consumption—are lowest. The construction work started in May 2011. In 2012 the first inhabitants moved in.

4.3 Islands

On the island *Samsø* in Denmark with 114 km² the 4000 inhabitants changed their daily lives for greater energy efficiency. 21 wind turbines generating 28,000 MWh annually have been built to meet the community's electricity demands and public transportation system; the surplus to sell is 10 %. Farmers have adapted their tractors and other vehicles to use ethanol or other fuels distilled from locally grown plants, like canola. The community experiments with electric cars as distances are very short, less than 50 km.

Samsø may become the first truly energy independent island in the world. However, they compete with *El Hierro* in the Canary Islands for this position. But as *El Hierro* is important for tourism they receive a substantial support from outside. A 54 million Euro 11 megawatt wind farm and two hydroelectric projects were created by the local *Gorona del Viento El Hierro* consortium with financial aid from the European Union. It will supply electricity for approximately 11,000 residents, an additional number of tourists, and three water desalination facilities. A hybrid wind/pumped hydro storage system will store surplus wind power by pumping water up 700 m to fill the crater of an extinct volcano to store electrical power. The closed-loop hybrid wind/hydro system was scheduled to be tested by the end of 2011, but was still not complete in early 2013.

5 Some Comments on Technical and Economic Developments for Local Energy Production

5.1 Energy Mapping

The conditions which make it economically and technically viable to produce energy in the smaller and local scale is rapidly developing. There are a large number of possible energy sources on the local level. In a small energy mapping effort in Uppsala County we reached 18 different sources without being comprehensive. Some of them are listed:

- Electricity: CHP using various solid fuels including energy forest, forest waste, solar cells, wind power, hydro power, streaming water power, wave power.

- Heat: Solar panels individual or larger scale, heat pumps, incineration using wood chips, pellets, solid waste; biogas from manure, food residues, wetland plants
- Transport: biodiesel from different substrates, bio ethanol from different substrates, biogas, electricity.

This mapping activity maybe the first proper step when deciding on which technologies to develop for local energy supplies. A few interesting developments are commented on below.

5.2 Solar Electricity

The use of and installation of solar electricity is increasing rapidly, by up to 20 % annually in many areas. It seems as if photovoltaic (PV) has an advantage over concentrated solar power (CSP). The cost of installed MWh has decreased almost 4 times in 2 years, mostly due to massive production in China. Today the investment cost of installation of PV on the rooftop of a house in southern and mid Sweden is paid back in 7–9 years assuming energy costs of 1 SEK per kWh. The installation is then expected to produce electricity for another 20 years, or more. The absence of mechanical parts in a solar cell makes it less sensitive to wear. Research on solar electricity is very intense and it is reasonable to expect new types of cells and lower prices as technology develops and the scale of production increases.

The biggest dilemma with locally produced electricity is the difficulties to store electricity. Only for very limited use may an ordinary battery be sufficient, as we see e.g. in developing countries where the possibilities to use electric lights in the evening when they have a 1 m² PV on the roof has been a blessing in many families. New batteries will come, but in Sweden the most realistic option today is to sell excess electricity to the national grid and get electricity back during the dark hours. In practice, the large hydropower plants provide the storing capacity needed.

5.3 Heating

For heating, by far the best option is to build low energy houses and upgrade existing houses. Solar heating using panels should be profitable but so far have not been increasing much in northern Europe, although it is standard in the south. There are however some exceptions. In Kungsbacka 48 one-family-houses cover 70 % of its annual consumption of hot water from 900 m² of solar panel field, one of the largest installations in the world. The heating capacity in Sweden is not a large problem for most municipalities to provide locally.

5.4 Biogas

Biogas production is rapidly increasing in all of northern Europe even if it seems as if Germany and Sweden have the lead in this development. The investments needed in both countries are supported by state subsidies. In the agricultural sector biogas is used for both heating and electricity in CHP facilities. In the cities in Sweden it is upgraded to vehicle gas and much is used for public transport. In Germany this is less often the case and much biogas is fed into the national natural gas network.

5.5 Transport

Providing transport with energy sources other than fossil oil is the most difficult of the challenges of local energy supply. According to the Swedish Royal Academy of Sciences, the future of sustainable transport will rely on electricity. It is well motivated for the simple reason that electricity is much better for mechanical work than fuel (about 4 times less energy is needed than in a combustion engine). The development of batteries promises that storing electricity rather than the very energy dense oil will be practically possible. At present, the hybrid vehicle is the most energy-efficient alternative.

For combustion engines, biogas is now rapidly expanding. A recent prognosis is that all buses in the country may be run on biogas. Likewise, biodiesel production is rapidly increasing using forest products or oil seeds. A future possibility is to use forest products for the so-called second-generation biofuels, in particular methanol, or turn it into biodiesel.

Among the non-technical developments is a more efficient public transport network to decrease the use of the private car and thus the need for transport fuels in general. This is a development seen in larger cities. To this should be added the increased use of bicycles. This development requires better biking paths in urban areas and better parking options. It is a development going on in many cities at least in northern and partly in Eastern Europe.

6 Research Questions

The question of dependence on locally produced energy is an important one when global efforts to reduce coal, oil, and gas to mitigate GHG emissions look pessimistic. Still the interest from the research community is small. A few of the central questions include:

1. How many local authorities are interested in this option? What are the main reasons for those interested? Today it appears that energy security, i.e. safe supplies, high prices and environmental concerns, in particular for climate change, dominate.

2. What are the best policy instruments on the state level to support the local energy option? So far the German feed-in tariffs (guaranteed energy prices for locally produced energy) have been recognised as very efficient. It was also proposed at the COP 15 in Copenhagen by the UN CSD as the best option for a policy to combat climate change. Many states have also used subsidies to promote transition from fossil-dependent to renewable energy alternatives, including Sweden. Larger subsidies scheme include the Swedish KLIMP project (4 BSEK) concluded in 2012 in which close to 200 municipalities provide 75 % of the funding and the KLIMP 25 % in about 2000 projects. Another even more efficient scheme was the Program for energy efficiency in energy intensive industry (PFE) run by the Swedish Energy Authority since 2004 and now concluded. In this program 110 large companies invested 708 MSEK to reduce energy costs by 400 MSEK (1.45 TWh) annually to avoid tax costs by 150 MSEK.
3. Which is the balance between the actions taken by individuals and the municipality for energy projects? Today much of local energy production is made by households. This refers in particular to solar hot water panels and PV cells on the roofs. But also many households install boilers using wood pellets or heat pumps to reduce energy from outside. One may also mention increased bicycling reducing energy consumption for transport.
4. What is the role of small and local energy companies? Today we see that the large energy providers—Vattenfall, EoN, Fortum etc.—do not support local energy projects in contrary to many of the small companies, e.g. Sala Heby Energy AB (SHE) or Enköping Energy AB (ENEA) etc. STUNS, in which Uppsala University, Municipality, and the County work together, is presently running a project on the role of the small energy companies.
5. To what extent does local energy provision support local economic development? There are many examples of how this happens.
6. Local energy production is just one case of local resource provision. Is there a general lesson to be learned here that localisation of the energy and resource provision is a main strategy for creation of a sustainable future? (In contrast to globalisation and free trade, e.g. in the EU).

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Sustainable Development, Knowledge Society and
Smart Future Manufacturing Technologies

Leal Filho, W.; Úbelis, A.; Bērzina, D. (Eds.)

2015, XVI, 341 p. 105 illus., 57 illus. in color., Hardcover

ISBN: 978-3-319-14882-3