Conference proceedings

Energy degrowth or defossilization?

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2nd Conference on Economic Degrowth

For Ecological Sustainability and Social Equity

Abstract

The global population on the Earth is increasing, as well as the energy consumption per capita. New uses of energy appear (desalination, electrical vehicles, new appliances, etc). The expected levels of consumption will lead to depletion of natural resources in the next years. The environmental damage is linked to the increase use of energy. Efforts must be aimed to reduce the individual and collective demands, and a fast transition to renewable energies is imperative.

In this paper a proposal is presented, by which, every new unit of consumption must be accompanied by a new renewable generation. It has been named as defossilization. With this mechanism, consumers must invest in new renewable generation systems, contributing to the health of the planet instead of worsen the situation, and they can feel better for that. In this way, consumers are conscious of the importance of their consumptions. In addition, the economic repercussion will make the own consumer turn to the use efficient technologies, that allow their high well-fare levels compatible with the required energy conservation.

Keywords

Energy degrowth, defossilization, linking consumption to renewable energies (CLR), CLR mechanism

1 Energy use perspective: World's energy needs

Energy demand is continuously growing with high rates. In particular, an increase in electrical demand during the first half of this century is expected to continue.

The energy consumption per capita is increasing. The global population on the Earth by 2050 is estimated to reach 9.000 million people. Even today, a great part of the population is deprived of elementary services such as electrification and fresh water supply. Developing countries have to improve their situation and look up the rich countries for a better status. It probably means to raise their energy consumption. From a humanistic point of view, populations living today in high poverty conditions, a de-growth energy process cannot be imposed or even presented has a necessary condition.

Energy and water are two resources of outmost importance, especially for developing countries, mainly due to rapidly increasing population and the economic growth (growing need for upgrading their standard of living to an acceptable one).

Clean drinking water is one of the most important international health issues today. The potable water supply to these people also will demand an important amount of energy to desalination. The lack of potable water poses a big problem in arid regions of the world where freshwater is becoming very scarce and expensive. However, water shortage is also becoming a serious problem in some developed countries. As an example, water withdrawal in coastal areas and specific regions in Spain and other Mediterranean countries, where the grown population and tourist pressure increase, has reach dangerous limits.

Although water management strategies, water saving measures and water reuse and reclaim are clearly the first alternatives, desalination has been relied on to provide fresh water for large cities and countries across the world. But current desalination technologies (either membrane or thermal) require large amounts of energy. In the oil rich Middle East region, desalination satisfies close to 50% of the domestic and industrial water requirements. There desalination plants are typically driven by oil or its associated gas. Desalination based on fossil fuels is neither sustainable nor economically feasible in a long-term perspective, as fuels are increasingly becoming expensive and scarce and contribute to the generation of green house gases in addition to various pollutants and particulate matter. The only solution is the extended desalination of sea and brackish water by a sustainable and affordable energy source, supported by enhanced water management and by a more efficient use of water with increased reuse of wastewater and enhanced municipal water treatment. Then, environmental protection through the use of renewable energy must become part of the present and future desalination industry (Bayod and Martínez, 2008).

Mobility is a major driver of economic growth and societal development. A large share of mobility relies on passenger car use – and the use of the passenger car is expected to continue to increase further, especially in developing and emerging countries. Today, transport is almost exclusively dominated by internal combustion vehicles – with approximately 95 % of transport reliant upon liquid carbon fuels derived from crude oil.

There is no other sector which shows such a high level of dependence on one single source of primary energy.

2 Environmental aspects

Environmental impact (damage) is largely linked to the increasing use of energy. The electric power sector is one of the major industries using fossil fuels to generate electricity (Akella et al., 2009). Air pollution is created by several agents: sulphur dioxide, nitrogen oxides, ozone, dust and aerosols, carbon dioxide, chlorofluorocarbons, steam-laden emissions and meteorological inversion. Generation and consumption of energy represents more than 80% of greenhouse gas emissions in the European Union, over 77% of emissions of substances that contribute to tropospheric ozone formation, 66% of the substances that cause acid rain, 81% of particulate emissions and emissions of heavy metals (mercury, lead and cadmium). The impact also includes the generation of waste throughout the cycle of extraction, processing and consumption, toxic waste, water consumption, sometimes irreversible degradation of ecosystems, noise and deterioration of scenery.

Water is a fundamental part of the environment analysis. Water pollution includes any detrimental alteration of surface waters, under ground waters or the marine environment with a thermal or material pollution. Water polluting agents can be solid, liquid, or gaseous that detrimentally alters the natural conditions of waters.

Water pollution occurs primarily from effluents such as water discharges from households, industries, trade or polluted rain, discharge of used oils and liquid substances containing poisonous chemicals including heavy metals (mercury, lead, etc.) and other products like arsenic, zinc, copper nickel, cadmium, etc. We must consider also the pollution by acid rain precipitation.

These negative effects which are mainly not being internalized into the price of fossil resources are not restricted by national boundaries, but affect neighbour countries as well as states far away from the polluting source.

Transport is responsible for more than a fifth of the EU's greenhouse gas emissions and it is the only sector with growing emissions. Between 1990 and 2006, greenhouse gas (GHG) emissions from overall transport (including international aviation and marine) in EU-27 have much increased (+35.8%) while emissions from non transport sectors have decreased (-13.4%) over the same period. Road emissions in EU-27 have actually contributed to 61% of transport emissions increase and accounted for about 71% of overall transport emissions in 2006. Besides, international aviation and marine have shown the fastest growth over the same period (+73%), and weighted 23.5% of overall transport emissions in 2006.

The stored (fossil) resources in our planet are finite. The current rate of consumption is leading to the depletion of those resources: During millenniums the energy has been accumulated and in some centuries we could burn it to smoke. From the previous figures, it is clear that its use impacts negatively the environment. Moreover, risk and problems of security of supply and geopolitical stress may arise.

3 Actions: What can we do?

Energy degrowth? Obviously, the first effort must be aimed to reduce the individual and collective demands. More efficient measures (avoiding the rebound effect) must be taken in consumption and transmission, distribution and generation systems. Besides education in the importance of the limitation of use of limited resources and the need of social equity, a better use of these energies is a must. Education is perhaps the more powerful weapon to combat the rebound effect.

Reduction of extraction of limited natural resource, waste and emissions is another key. That is, reduction of environmental and social costs, meeting all basic human needs and ensuring a high quality of life.

Then, the reduction of energy consumption in a global perspective is a very difficult task. The search for another economic system, which includes full respect for natural resources and environment, remains therefore imperative. We need a transition to more efficient energy model, with emphasis in energy conservation and de-fossilization (reduction of fossil energies): the use of energy that has not been ever accumulated, virtually unlimited, and that is continuously arriving and that currently we do not take advantage of it, simply return to space.

Then, the two pillars of our future energy policy are energy conservation and renewable energies.

3.1 Efficient consumption/ energy conservation

We can not just passively wait for the total depletion of resources. Conservation of our main source of energy, the non-renewable sources, is imperative. There are currently cost-effective technologies that allow us to maintain an energy saving activity levels and wellbeing. And we must continue to develop and implement new technologies for energy conservation.

Demand side management, efficiency improvements, and electric load reductions are important factors to address. On the other hand, consumption patterns should shift towards the demand for ecological and socially benign products. Assessing consumer behaviour is a crucial prerequisite for changing our energy system to sustainability and for renewable resources being able to contribute a large part of the national and global energy demand.

Experiments with electricity customers indicated that consumers are indeed quite responsive to conservation incentives and disincentives (Edinger and Kaul, 2000). There is a vast energy saving potential through setting up incentives for consumers to use their energy efficiently.

Load management must be the first step in reorganizing the energy system, and it always is the most cost-effective alternative to cut down the load side first before investing in renewable technologies.

The efficiency of appliances to convert electricity into energy services is increasing steadily, and still has improvement potential. For instance, lighting is responsible for 14% of EU electricity consumption. Lighting with more efficient lamps is an activity that permits directly the reduction of the demand. Modern lighting solutions are 50-100 times more efficient than candles. In the same way, with current technology, over 80% savings in lighting can be achieved, and the lamps can last even 15 times longer than the standard equivalent. Energy use for individual lighting applications can be reduced by a factor 5 or more: dimmable lighting systems, ensuring exactly the right amount of light in the right place at the right time.

Improvements in electrical motors, in more efficient transformers, distribution systems, or in control systems are other examples. In motor driven systems (pumps, compressors, fans, washing machines, electric trains), it is possible to reduce losses by 30% on average. Distribution transformers, one of the most efficient machines ever designed by man, can still reduce losses through the use of amorphous iron.

In the generation of electricity, the very efficient systems of cogeneration and tri-generation plants are successfully installed in hospitals, hotels and office buildings. If those buildings are located in water scarce areas and near the sea, the possibility of including desalted fresh water in the multi-purpose generation process is highly attractive. Therefore, electricity, heat, cold and fresh water can be produced simultaneously in a decentralized form.

Losses in refrigeration have been reduced historically by a factor 5, from the levels at the end of the 80's to the best available technology in class A+ appliances.

Modern high temperature heating solutions for industrial processes can in some cases save up to 80% of primary energy and up to 60% of CO_2 emissions through their efficient use of primary energy. With heating controls for building energy management, ensuring buildings are only heated when needed.

Continuous progress and improvements in the desalination technologies have made it a feasible alternative and quite competitive against water imports or transportation. Valero et al. (Valero, 2001) proved that the cost of the desalted water is similar to the transferred one.

Electricity is just an energy carrier, which due to its high quality, can be converted with high efficiency into practically any energy service. Using electricity instead of other energy carriers can save primary energy and CO_2 emissions. The use of high speed electric trains instead of air transport reduces primary energy use per passenger and km by a factor 3 and CO_2 emissions by a factor 4. For example, an electric vehicle can be about 4 times as efficient in converting primary energy into transport services (Eurelectric, 2004).

Using electric trains instead of diesel trains reduces CO_2 emissions by a factor 4 and primary energy use by a factor 2. Electric vehicles are more efficient as vehicles with internal combustion engines.

Efficient heat pumps, drawing heat from the underground require 20-40 kWh of electricity to supply 100 kWh of heat; they typically reduce final energy demand for heating by at least a factor 3 and primary energy demand by at least 25%. With induction heaters for cooking, 90% of (final) energy goes in the pan, compared to 55% for gas-fired cooking.

The electric car offers significant environmental benefits, especially in urban areas. Electric vehicles have zero tailpipe emissions, but there are, of course, emissions involved in the production of electricity. One major benefit of electric vehicles is the "displacement" of harmful air pollutants from urban to rural areas, where population exposure is lower. Noise levels are also lower, particularly in urban driving conditions.

Another major advantage of electric vehicles is their energy efficiency. With a tank-to-wheel efficiency in the range of 60 to 80 %, they outperform conventional cars four-fold. Generally, electric vehicles show greatest energy savings at low speeds and in situations involving frequently-changing driving dynamics, which is another reason why cities are a prime target market.

Electric vehicles will only have a positive impact on the environment if they replace a significant amount of the mileage driven in conventional cars. An increasing defossilization of the transport sector is essential. The main problem is that the successful market introduction of vehicles with electric driving mode is highly dependent on the availability of a battery technology that allows reliable on-board storage of electric energy.

The energy demand of battery production is assumed to be significant, although the quantification of environmental impacts of battery production, recycling and disposal have not been investigated in greater detail as battery technology is still under research and no data on the final composition of automotive batteries is available.

On the other hand, energy storage has a very important strategic value in future electricity networks. It can allow the reduction of spinning reserves to meet peak power demands, by storing electricity, heat and cold, which is produced at times of low demand and low generation, and releasing it when energy is most needed and expensive.

The low cost of power generated by fossil fuel plants has made this inefficient use of energy economically cost-effective. Efficient integration of this distributed generation requires network innovations. A development of active distribution network management, from centralised to more distributed system management is needed. Information, communication, control infrastructures will be needed with increasing complexity of system management (Bayod, 2009).

On site production reduces the amount of power that must be transmitted from centralised plant, and avoids resulting transmission losses and distribution losses as well as the transmission and distribution costs, a significant part (above 30%) of the total electricity cost, due to the fact that generation buses and consumption are closer.

3.2 Defossilization

The adoption of more efficient energy use patterns and techniques can perhaps help us to reduce overall demand but we will still need to find new supplies of energy. The low cost of power generated by fossil fuel plants has made this inefficient use of energy economically cost-effective.

We need to sustain fossil-based industries for their industrial applications, rather than as primary sources of energy. Oil is used for lubricants, dyes, plastics and synthetic rubber. Coal products are used to make creosote oil, benzene, toluene, ammonium nitrate, soap, aspirin and solvents. Natural gas is an important desiccant in industry and it is used in ammonia, glass and plastic production (Abbott, 2009). But conventional energy sources based on oil, coal, and natural gas are damaging economic progress, environment and human life. Renewable systems convert free resources in electricity, with a wide social support, without using fossil energies (defossilization).

Renewable energy technologies rely on the use of natural energy resources such as solar radiation, the winds, waves and tides, which are, by definition, naturally replenished. From them, we can obtain both electricity and heat. Fortunately, the renewable resource potential is large, and the economics of the conversion technologies are beginning to look reasonable (Evans et al., 2009). Almost every area on the Earth receives enough energy for its development. Solar energy potential alone has been found to exceed the total world energy demand by several orders of magnitude (the theoretical solar potential is 3,900,000 exajoules per year, some 7.000 times greater than the global primary energy demand). Wind has an important potential too.

In the renewable energy systems, every kWh invested in their construction, operation and maintenance, considering even the recycling and restoration processes is returned multiplied by 10, 15, 20, -the so called Energy Return Factors, or EROIs- without harmful environmental consequences. Technical efficiencies and economic cost-effectiveness of modern small-scale renewable power generation technologies have improved impressively over the last decades.

Photovoltaics and Solar thermal power are relatively new technologies which have already shown enormous promise. The environmental benefits of their use are the reduction of impacts (air pollution, lower greenhouse gas emissions, lower impacts on watersheds, reduced transportation of energy resource and maintenance of natural resources for the long term (Jefferson, 2008)..

Both distributed rural and centralised urban demand can be covered by renewable energy technologies. The decentralized characteristics of solar energies may play a significant role for power supply in rural areas were grid electricity is not available and in centralised urban demands as well. PV and CSP plants can be used exclusively for power generation in grid connected installations and contribute to the reduction of the consumption of fossil fuels.

Distributed solar generation technologies in many cases provide flexibility because of their small sizes and the short construction lead times compared to most types of larger central power plants. If besides electrical power it is necessary to satisfy drinking water demands, the combination of these systems with desalination methods offers very attractive and efficient solutions. With few environmental impacts and a massive resource, solar energy offers a great opportunity to the sunniest countries.

Although still more expensive than fossil fuel generation, renewable energies show advantages due to their modular character and their ability to add new capacity incrementally and adjustably to the current energy demand. From an investment point of view it is generally easier to find sites for Renewable Energy Systems (RES) than for a large central power plant and such units can be brought online much more quickly. Capital exposure and risk is reduced and unnecessary capital expenditure avoided by matching capacity increase with local demand growth.

As PV prices declined rapidly, photovoltaic became an option for powering residential housing located off the grid and are today at the turning point of becoming cost-effective even for grid- connected applications

Roofs present a large potential of suitable areas for installation of photovoltaic (PV) plants. Flat roof PV installations have the advantage of being able to be optimally positioned with support structures, and the inclination angle can be adjusted. Building-integrated systems offer cost reductions in both energy and economic terms over centralised PV plants, especially if the costs of avoided building materials are taken into account.

Other important aspect is locality, i.e. improved utilization of local resources. Distributed energy generation may also promote local business opportunities, and develop products and services based on local raw materials and labour. This, in turn, causes a need for high quality education.

3.2 Linking consumption to Renewables: the CLR mechanism

The global energy demand is expected to grow. An energy system based on renewable resources is not feasible without reducing the consumer load side by energy efficiency efforts and by using the appropriate energy form to produce energy services.

The question that arises is not how to meet today's electricity demand with renewable technologies, but how to adapt our energy demand to a feasible amount of power that could be provided by renewable resources.

Public support is growing for renewable technologies. Public opinion polls have shown a preference for energy conservation, energy efficiency, and renewable energy resources. There are a significant number of customers who are even willing to pay higher prices for clean energies, although the restructuring debate has often leaned in the direction of how to decrease prices.

On the other hand, the costs of solar and wind power systems have dropped substantially in the past 30 years, and continue to decline, while the price of oil and gas continue to fluctuate.

In the following, a new mechanism is presented. By the Consumption-linked to-Renewables mechanism (CLR), every new unit of consumption must be accompanied by a new renewable generation. When a consumer decides to buy any equipment or appliance, the total consumption must be evaluated and a clean generation unit must be acquired at the same time.

Acting that way, consumers are conscious of the quantity and importance of their consumptions and the obligation of cancelling them. As they must invest in new renewable generation systems, they contribute to the health of the planet instead of worsen the situation, and they can feel better for that. And, due to the economic impact of their consumption, they will tend to use efficient technologies that allow their high levels of well-fare compatible with energy conservation.

4 Case study: Linking an electric car to a new photovoltaics system.

In this section, an example of application of the CLR mechanism is presented.

Let´s suppose we have to buy a new car. We can choose to buy an electric car or a conventional car. An average annual passenger car travels a distance of about 20000 km per year, and the energy cost of an electric car is 0.16 kWh/ km. The annual energy cost would therefore be of some 3200kWh/año.

In a population of central Spain, this amount of energy can be supplied by a photovoltaic system with a capacity of less than 2.5 kWp. Therefore, any vehicle consumption would be offset by the installation of such power. We should also consider that the average life of the car is well below the panels (estimated at 25 or 30 years).

We have to consider also the energy required in the construction of the car. It takes about 20.000kWh (73 Giga-Joules) of energy to manufacture a vehicle. This is less than 10 percent of the total lifecycle energy consumption of a conventional vehicle, but with the lower consumption of an electrical vehicle, this quantity is above 50% of the total lifecycle energy consumption. With the 2.5kWp PV installation, this quantity of energy is recovered (in central Spain) in 6 years.

Besides, the actual PV technologies allow PV systems recover the energy needed in their manufacturing, transport and installation in less than 2 years.

Therefore, with the 2.5 kWp PV system we would get electricity not only for that vehicle, but also for the energy consumed in the production of the car and the PV system and some extra electricity for other uses.

In economic terms, with the present prices of PV installation, we would need an upfront investment of some 7500-8000 euros for the PV system. Assuming the life time of the modules 25 years, it means a yearly cost of some 300 euros/year, a much lower cost that the annual cost fuel needed with a conventional car. In fact, the economic saving in fuel allows paying the PV installation (and recovery money) in the lifetime of the car.

But we have some other important advantages: a much lower energy needed, obtained from a clean resource, without using any natural reserve, avoiding CO2 emissions and other contaminants (cleaner vehicle) and fuel transport.

The energy cost of a conventional car fuelled by gasoline is 0.6kWh/km, i.e., 3.75 times more. If this linking consumption to renewable generation is applied to a new conventional car, the capacity of PV needed reach 9 kWp. The upfront cost needed clearly disincentives these less efficient vehicles.

The Spanish government is committed to have one million electric or hybrid cars on the Spanish roads by 2014. One measure to achieve this goal is to provide consumers who buy an electric car in Spain with a rebate of 15 % of the price of the vehicle.

Instead of that the government could incentivise (or even create the obligation) the installing the PV required according the mechanism above related. 1 Million new electrical vehicle would mean an extra installation of 2.5GWp. A similar quantity of PV systems was installed in Spain in 2008 (just in one year!!!) This quantity is below the objective presented by the Spanish Photovoltaic Industry Association (ASIF) for that date. The plan of the Spanish government is to reach 13GW in 2020, while the initial estimation of ASIF was to reach 20GW by 2020. Linking this capacity to new electrical vehicles is totally possible.

Nevertheless, this is only an example of application of the CLR mechanism. Appliances as TV sets, washing machines, etc could be linked with renewable energies in the same way.

5. Conclusions

The current rate of growing in energy demand is not sustainable. Efforts should be aimed to energy conservation and, where possible, to decrease the energy consumption. However, in a short time, there exists still the need of providing energy to those countries which are developing. An energy degrowth process can cannot be imposed to those developing countries or even presented has a necessary condition. Some alternatives must be provided.

The electric power sector is one of the major industries using fossil fuels and, in consequence, damaging the environment. Although the first effort must be aimed to develop more and more efficient technologies, bearing in mind to avoid of the rebound effect, and to reduce the individual and collective demands, the opportunity given by the renewable energy sources has to be observed. A fast transition to renewable energies is needed. The Consumption-linked to-Renewable energies mechanism (CLR) has been presented in this work. With the CLR mechanism, every new unit of consumption must be associated to a new renewable generation. Within this proposed framework, consumers would invest in new renewable generation systems when buying any equipment. At the same time, they will surely tend to use efficient technologies that allow their consumption compatible with energy conservation.

The ideas presented in this paper try to contribute to the energy degrowth process, understanding it as a necessary defossilization process.

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