Cogeneration & On-Site Power Production

Tax energy wastage - not carbon dioxide

A global tax on wasted energy - especially the heat discarded by thermal, power-only generation plants - would be a powerful incentive for generators to begin to replace inefficient plant with CHP stations. ***Aleksandar Kovacevic*** *makes the case for such a tax and outlines its likely effects.*

The least efficient sources of energy today are those that are centralized. The waste heat they produce is simply released into the environment. Although the direct contribution of released heat to global warming is negligible, these sources have the side effect of low energy efficiency - a major contributor to climate change.

On a global scale, burning coal and oil to generate electricity produces more than 8000 TWh of electricity a year while releasing over 13,000 TWh of waste heat into the environment. If that waste energy were eventually used, it could produce the electricity equivalent of 2200 TWh of useful energy or increase power generation capacity today by almost one quarter for the same level of emissions.

Taking into account all fossil fuel plants (coal, oil and natural gas), Greenpeace[1] argues that only 38.5% of fuel energy is converted into electricity, while 3.5% is lost through transmission and distribution (T&D), and about 13% through inefficient end use. But these are average figures. In many developing countries, energy systems are even less efficient.

The International Energy Agency's recently published World Energy Investment Outlook argues that almost half of available energy assets will be replaced by 2030, while total electricity generation capacity needs to be almost doubled by that time. Investments over the next decade will lock in technology that will remain in use for the next 60 years.

In 2003 more people were living in urban areas than rural. By 2030, 60% of people will be urban dwellers. Their need for energy services is a driving force behind energy investment. Infrastructure investment expenditure could amount to 9% of the GDP of low-income countries and to over 5% of (the larger) GDPs of wealthier countries. Urban infrastructure is the most difficult to refurbish, restructure or replace. Solutions for urban transport, housing and energy supply are likely to be locked in for decades to come.[2]

In its World Energy Outlook in 2002, the IEA warned that under business-as-usual, CO_2 emissions would grow by 69% by 2030 - at a rate faster than the growth of energy supply. Fast growing developing countries would burn more carbon-intensive fuels to support economic growth. Despite the higher efficiency of modern technologies, delayed investments and the prolonged life of existing facilities could create an even more difficult situation than projected.

Sir Nicholas Stern, in his Review: The Economics of Climate Change, warns: 'Using the results from formal economic models, the Review estimates that if we don't act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more. In contrast, the costs of action - reducing greenhouse gas emissions to avoid the worst impacts of climate change - can be limited to around 1% of global GDP each year. The investment that takes place in the next 10-20 years will have a profound effect on the climate in the second half of this century and in the next. Our actions now and over the coming decades could create risks of major disruption to economic and social activity, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century. And it will be difficult or impossible to reverse these changes.'

The IEA's World Energy Outlook 2006, the latest, contrasts the alternative policy scenario with the reference scenario, which is roughly the development of ongoing trends. The alternative policy scenario comprises hundreds of measures that are already under consideration by governments and international institutions.

This exercise in the World Energy Outlook 2006 demonstrates that policy measures could have considerable effects on global warming. However, the IEA calls for much stronger action in what it calls the beyond-the-alternative-policy scenario (BAPS). In short: strong policy instruments that are flexible and easy to negotiate are needed as soon as possible to stimulate significant change in investment patterns. Furthermore, these instruments should improve security of energy supply, have a positive impact on the economic growth of developing countries and facilitate poverty reduction. I would add that applicable policy measures must be robust and simple to implement with built-in economic mechanics.

Energy from fossil fuels will become more expensive in one way or another. The use of most of the instruments in discussion today would have this simple outcome: energy services will be increasingly expensive for end consumers. Discussions on carbon taxes have become complex and technical. It has already been argued that the available mechanism to price carbon emissions is not sufficient to cope with ongoing tendencies. An abatement mechanism needs to be strong and must facilitate real change in the way we produce and use energy. In other words, it has to hurt. It must throw some facilities out of business and help others to enter the market, compete and win. In addition to being carbon efficient, new facilities must be more energy efficient to facilitate economic growth and competitiveness. If something serious is to be done now, it must be done with the knowledge and resources that are readily available. More efficient facilities today would set an efficiency threshold for future technologies and investments while the competitive advantage of renewable energy would be preserved and enhanced. What can be done?

make use of waste heat

Available technologies, engineering capacity and demand usually provide various options to allow the capture of heat that would otherwise be wasted. However, economic initiatives are relatively insufficient. As the wealth generating potential of useful energy is many times greater than its current cost including the cost of carbon credits or eventual carbon taxes, additional cost could easily be factored into the end-price of energy services. Depreciated plant has considerable economic advantages over newly built plant: its cost structure could easily accommodate additional sales taxes or sustained competition. As long as energy demand grows and competition is not pressing, plant owners can run a plant at low efficiency and accept higher fuel costs.

Consider a plant that runs at a real fuel efficiency of 30%, and say it has a competitor of efficiency 38%. That is roughly 30 percentage points better. If the first plant is fully depreciated, its low capital costs will make it sustainable if demand is high, despite the competitive advantage of the competitor at a relatively high level of utilization. And if there is a long-term fuel supply contract or if coal or lignite mines are attached to the plant, there is no apparent way in which a more efficient market entrant could put this plant out of business, so there is no reason for the existing plant owner to invest in refurbishment or re-powering. The eventual use of waste energy will remain a distant theoretical opportunity.

From the perspective of the public, waste energy has an opportunity cost. Each kilowatthour of waste energy costs at least a quarter of the electricity market price. That is the cost of roughly the amount of electricity needed to produce low-temperature heat with a modern heat pump. If a consumer is supplied by waste heat, that amount of electricity is going to be saved. Releasing waste energy into the environment - as heat or any other form - is equal to losing the opportunity to produce some electricity. The immediate consequence is a need for additional (most probably fossil fuel) plant to produce that electricity. Burning more fossil fuel means, of course, producing more carbon dioxide at public expense.

In the case of a heat-only energy source, its opportunity cost to the public will be at least equal to the electricity it could generate in CHP mode while preserving the same heat output, which is again one quarter. In other words, each kilowatthour of low-temperature heat produced from fossil fuel is actually a missed opportunity to produce at least 0.25 kWh of electricity. In both cases, these wasted opportunities should be taxed to cover losses to the public.

A waste-heat tax

A waste heat tax (WHT) would not be a simple indirect tax. Since waste heat depends on technology and efficiency, the tax would have to be asset specific. A WHT will have an allocation effect: energy investments will be directed toward more efficient solutions; closure or upgrade decisions will be more likely to consider efficiency and public interest; and energy prices would better reflect the real costs of generation, providing investors in renewable sources with the price competitiveness they need and consumers with suitable signals. It would be cheaper to make use of waste heat in small, distributed generation units. Thus excessive size and centralization would be penalized.

A WHT would be a simple, flexible tax. Taking into account the weighted average price per megawatthour of electricity at the wholesale market in a particular region, a public authority could tax each fossil fuel plant a quarter of that price per megawatthour of energy it wastes. Waste energy is plant specific and could easily be calculated as a difference between the energy content of consumed fuel and the electricity delivered to the grid or consumers (plus eventually delivered steam and heat). Most fossil fuels are now traded by energy contents in giga-joules or BTUs. It would be easy for a tax authority to calculate wasted energy.

A plant of 30% fuel efficiency that sells electricity at the market price (say US$100/MWh) would attract tax on its electricity sales of $58.3/MWh (70 MWh of waste heat times $25/30 MWh delivered). At the same time, a CCGT plant with 55% fuel efficiency operating in the same market and selling at the same price would be taxed at $20.5 per megawatthour delivered.

A WHT could be progressive and adaptive. Large amounts of waste produced today would produce a higher WHT burden in the following period, making electricity more expensive and therefore producing a higher WHT burden per energy unit over the next period. And vice versa: if less energy is wasted compared with total electricity generation, there will be a lower WHT burden for each kilowatthour produced. While a WHT is being introduced, electricity prices are likely to rise to cover the tax expenditure. Furthermore, just as other climate change instruments are gaining ground - making electricity more expensive - a WHT is likely to increase. Plants are aging and their efficiency will eventually decrease, so the WHT burden on such a plant is likely to increase.

If a country neglects its energy industry, aging and inefficiency are likely to increase pressures for new investment and competition. Investments would stream towards markets served by the least efficient energy industry. Countries with high barriers to entry and insufficient investment regimes could suffer problems and find a motive to improve their investment climate. It would be very difficult to provide the energy industry with subsidies large enough to offset the effects of a WHT in the longer term.

Adjustment periods for a fixed value of WHT per MWh should be sufficiently long to allow real efficiency improvements to materialize. And WHT must be predictable. If WHT is fixed for, say, 4 years and then adjusted according to the weighted average market price of electricity during that time, then taking into account that electricity price developments could be well modeled, a WHT would be a predictable mechanism that is likely to affect investment decisions. Fast growing energy industries and countries with strong growth rates of energy consumption that divert investments toward more efficient or renewable technologies would gain an advantage. Their WHT burden will be lower because of the higher efficiency attained and higher weight of electricity production during later years in the mix.

Likely effects of the WHT

Options to make use of waste energy are readily available. Plant owners could choose between various options to make commercial use of waste energy and therefore avoid WHT. Conventional options such as the use of waste heat for district heating or district cooling have been used for many years. Waste heat could be used to pre-dry coal or lignite - which is likely to result in better efficiency and reduced pollution - as well as to power a device such as a Stirling engine. Low-temperature steam power generation technology is soon to become commercial. It needs a large market to develop its full commercial potential. Recycling energy, as some people call it, is already an industry in itself. It deserves better governance to develop its full potential and deliver considerable public benefits.

Renewable energy could be used to decrease the tax burden. A plant owner could choose to use some renewable energy alongside fossil fuel. This would decrease the amount of waste energy from a fossil fuel power generation cycle. Co-firing of biomass with coal or lignite would have such an effect, as would the use of solar thermal applications within the steam cycle of the main plant. At the same time, waste heat could be used to dry biomass before co-firing. A WHT would only apply to waste energy that originates from fossil fuels, in other words, the relationship between fossil fuel input and pro rata useful energy output.

The introduction of a WHT would stimulate the production of additional final energy from the same amount of fossil fuel. Additional electricity equivalent produced from the same volume of fossil fuel would have the same effect on climate change as if that amount of electricity had been produced from renewable energy sources - but at a lower investment cost. The total potential of this mechanism could be larger than the entire amount of electricity generated today by renewables. Countries are struggling to achieve renewable energy targets in their energy mixes. These targets are usually modest, say 20%. A WHT mechanism would stimulate investment that could technically produce about 25% additional electricity at the same level of consumption of fossil fuel.

The introduction of a WHT would further stimulate investment in renewable energy. As a supplement to Kyoto or Kyoto-like mechanisms and other renewable energy support policies, a WHT would increase the market price of electricity in a particular market by roughly 30%-50% that would make most of the existing renewable energy technologies competitive. Furthermore, a number of technologies to improve the energy efficiency of the fossil fuel cycle could boost the efficiency of renewable energy too. If these technologies become more widely available and affordable, investment expenditure in renewable energy applications would reduce.

A WHT would affect investment decisions now and for a long time in the future. Although electricity demand has low price elasticity, high electricity prices are likely to affect investment decisions on both the demand and supply sides. Consumers are likely to select more efficient lifestyles and more efficient appliances as well as retrofit their buildings to consume less energy.

Investors in fossil fuel plants are likely to select more efficient technologies and to structure investments in a way that makes use of waste energy. Distributed energy is a proven concept that can do that. The waste of energy in T&D could be taxed in due course and would likely make T&D more expensive. Operators would try to avoid situations in which high losses occur, such as during peak hours, and would become more open to using distributed energy to reduce loads and improve the use of existing assets. Smart grids and smart metering are already well known technologies that can reduce grid losses. A WHT would be a strong impetus for consumers to invest in micro-generation, for which the technology is available.

While the CO_2 market is volatile and exposed to political risks, a WHT is likely to affect competitiveness and electricity prices in a consistent way and over the relatively long cycles associated with the structure of existing generation assets.

In the age of the risks associated with climate change, governments need more capacity to alleviate the consequences of climate change and pursue active public policies. There is a need for more vigorous development of technology, and more research should be done in the public domain. Some governments may choose to increase excise taxes on liquid fossil fuels or introduce taxes on vehicles to match the tax burden on electricity generation and other energy services. The tax administration for both WHT and these additional taxes would be relatively simple or would be implemented within the costs of an existing tax system. Some governments could choose to focus resources to alleviate fuel poverty by improving the energy efficiency of the poor.

A global initiative

A WHT should be introduced on a global level, otherwise it could distort international markets in an undesirable way. Countries that avoid the introduction of this tax would have the advantage of exporting energy-intensive goods such as aluminum. From another perspective, a WHT is a country-specific instrument; its amount would vary depending on the energy efficiency and configuration of a particular energy industry. Countries in which the efficiency of use of fossil fuel is higher and in which the share of renewable energy in the energy mix is larger would have a competitive advantage. Developing countries would experience a greater impetus to invest in energy efficiency and renewable energy and would overcome barriers for other mechanisms related to climate change. Energy security could be improved as a consequence of the better use of fossil fuels.

Furthermore, countries with better investment climates would be able to attract more investment in short periods of time and improve efficiency. A suitable period of time (for example two years) would be required for countries to prepare for the introduction of a WHT, including for restructuring the energy industry and improving the investment environment as well as the legal and institutional framework. Technology vendors could use the same amount of time to speed up the commercialization of appropriate technologies. To make the entire process predictable, a clear international commitment would be required. The application of a WHT would create jobs and improve efficiency both in developed and developing countries. What matters is the quality of governance, and that is not necessarily a privilege of wealthy countries. In many respects, a WHT could be viewed as an instrument to foster economic development. However, it does emphasize the effects of bad governance: a higher cost of energy, a lower competitiveness and lower employment would create pressure for improvement.

A WHT could be introduced via a protocol in the UNFCCC. WADE, with its collaborating organizations, could volunteer to draft such a protocol as part of its practical contribution to the desires stated at the G8 Summit in Heiligendamm. A simple and transparent WHT mechanism could foster investment, motivate governments to remove energy subsidies, further liberalize electricity markets and demonstrate commitments toward more efficient energy use and the fight against climate change. Taking into account Europe's demographic trends and the maturity of its energy industries, the European Union needs to capture as many opportunities to genuinely improve energy efficiency as quickly as possible. Better energy efficiency would improve security of supply and create a new generation of infrastructure that will serve an aging population and ensure the predictability that is needed. The European Commission is well placed to consider a WHT and its eventual promotion as a way of fostering the effectiveness of a range of measures already in place.

A WHT would help if things get worse. In the case of natural disasters, disturbances and governmental failures causing reactions in international energy markets and increases in fuel prices, an increase in WHT could be delayed, thus allowing the immediate relative decrease of the WHT burden. At the same time, the application of a WHT would increase budget revenues at a given level of administrative expenditure. A mechanism that is predictable, it would improve the governance capacity and credit worthiness of countries.

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References

1. Energy (R)evolution, Greenpeace, figure 6

2. Kensington Investment Group's The Case for Infrastructure, June 2007

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Cogeneration and On-Site Power Production September, 2007
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