inenco

understanding energy

Carbon Shock 2050

Meeting our long term carbon reduction targets

August 2009

Inenco Group Limited

CHALLENGE 2050

Carbon Shock 2050

Executive Summary

This report forms a companion piece to our previous work on the risks of an energy shortfall in the years before 2020. This earlier report “The Generation Gap” demonstrated that without major investment in supply or management of demand, there is a risk of insufficient electricity generation to meet our future need.

Carbon Shock 2050, looks further into the future and considers the additional requirements of meeting the 80% reduction in carbon emissions that the UK Government has established.

Whilst there are many ways to address this new challenge, we have recognised that the overall level of engagement from businesses and consumers will affect the likely approach. If solutions have to be imposed then it is probable that they will be simpler and more far reaching in their impact, than those which have been created through a collaborative and proactive effort.

Working from this starting point, we have created two potential scenarios. Firstly, The All Electric Model, shows an approach that could be imposed. Secondly, The Integrated Energy Model, demands concerted action across many stakeholders and a willingness to accept change in order to deliver the necessary reductions.

The All Electric Model, would demand major investment in order to generate the required supply capacity, including a massive increase in the delivery of renewable sources. It completely removes the reliance on fossil fuels for inland use. Furthermore, it would, at minimum, require a wholesale restructuring of the way that energy supply is regulated both for generators and consumers. This may even extend to a change in the ownership of the supply industry.

The Integrated Energy Model would also require major investment, assuming that there was a wider acceptance of the necessary changes. However, this would leave some other elements of our energy economy largely unchanged.

Reviewing the implications of these scenarios illustrates the need for all stakeholders to come together immediately to start work on solutions. By accepting that compromise and collaboration is essential, we can create an approach that offers the widest possible support and hence the probability of delivery.

The time for debate about whether the carbon reduction targets are deliverable is over and the time for action is now.

Michael Abbott

Managing Director
Inenco Group Limited

1. Introduction

In March 2008 we produced our report “The Generation Gap” which examined the issues of energy security, particularly in relation to electricity in the years to 2020. The report showed how, without significant action, the UK faces the prospect of electricity shortfalls before 2020.

As we look further into the future, alongside the issues of energy security, the need to reduce emissions of greenhouse gases, particularly carbon dioxide (CO_2) becomes increasingly critical to mitigate the risk of catastrophic climate change.

“the need to reduce emissions of greenhouse gases particularly carbon dioxide becomes increasingly critical”

Climate change is a global issue. Through international agreements, for example the Kyoto Protocol, and through national action, Governments around the world have responded to the threat it poses.

The UK has taken a particularly active approach. Lord Stern was commissioned by the Government to quantify the risks of climate change and produce a series of “carbon budgets” setting out milestones for emissions reduction. The culmination of this work was the recommendation that a carbon reduction target for 2050 should be an 80% decrease compared to 1990 levels.

The setting of the target and the fact that we need to significantly reduce our emissions, does not address how the challenge will be realised. We must be realistic about the level of reductions that an evolution of our current business processes and domestic lives can deliver.

This realisation, that a revolutionary change to our energy economy will be needed to meet the emissions reductions targets, is one of the major drivers of this report. We are forced to seek more radical solutions even though the scale of the impacts of these solutions is much more far reaching.

“We are forced to seek more radical solutions”

Furthermore, there are emissions from a number of basic industrial processes as well as from agriculture and waste management which are more difficult to address. This means that emissions from electricity, heat and transport will have to decrease by more than 80% to meet the overall target. (See Appendices for calculations).

We face a massive challenge and have to find solutions which are technically feasible, socially acceptable and work within the limits of potential investment. We now turn to look at the scale of the task before suggesting two potential scenarios.

2. Sizing the Carbon Reduction Challenge

To understand the scale of the challenge we must review the progress to date as well as identifying whether there are sources of emissions which are more difficult to reduce.

The provisional figures for emissions of carbon dioxide in 2008 have recently been released. The headline figure shows a reduction of 2% in 2008, bringing emissions to 89.7% of 1990 levels.

" a reduction of 2% in 2008 bringing emissions to 89.7% of 1990 levels"

Table 1 : CO_2 emissions by source

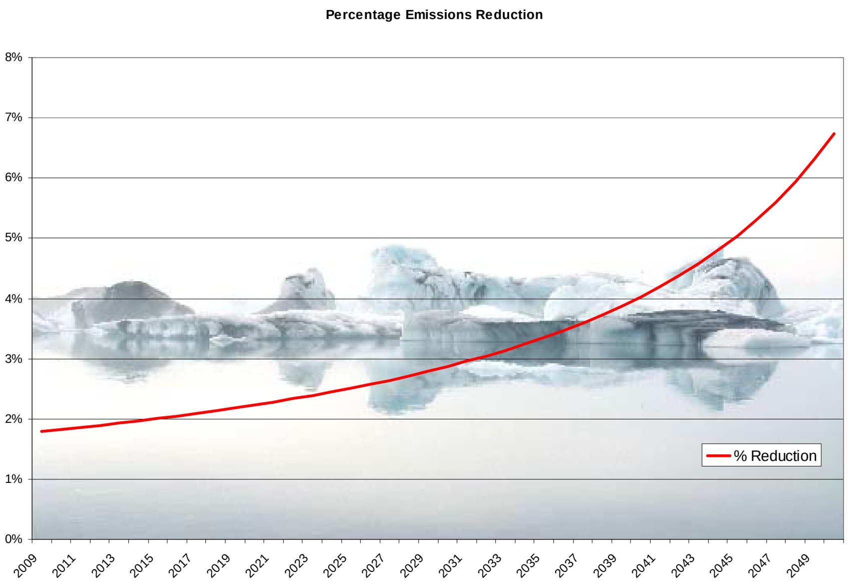
	2006	2007	2008p
Power stations	181.2	177.3	171.3
Energy industry	32.6	32.3	31.6
Other industrial combustion	94.6	93.4	88.6
Domestic	79.8	76.1	80.0
Commercial and Public service	21.3	20.6	20.8
Agricultural and forestry fuel use	4.3	4.1	4.1
Transport	133.6	134.9	131.6
Other sectors	5.5	5.7	5.7
Total excluding NET LULUCF	**552.9**	**544.3**	**533.6**
NET LULUCF	-1.8	-1.8	-1.8
TOTAL INCLUDING NET LULUCF	**551.1**	**542.6**	**531.8**
Percentage change (year on year)	-0.4%	-1.5%	-2.0%

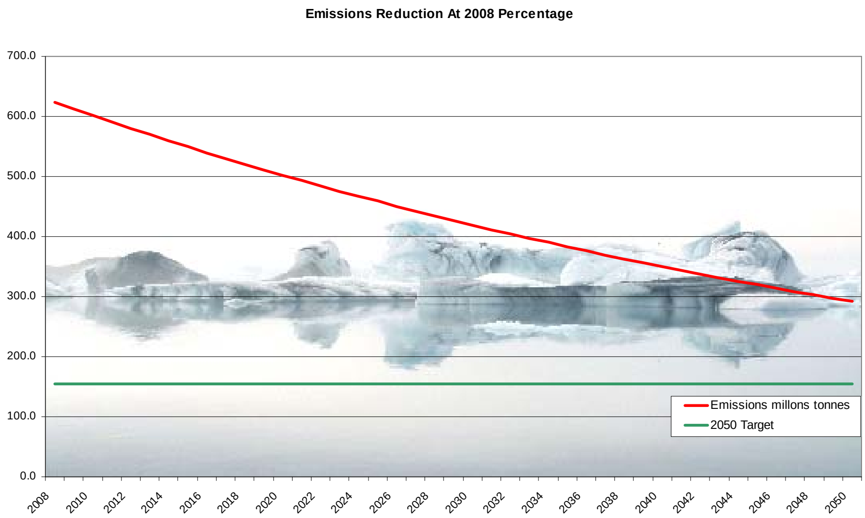
Source: DECC Note 2008 figures are provisional

Taking these figures, we can perform some simple projections of the 2050 level of CO_2. If the absolute reduction in 2008 is maintained, then by 2050, emissions would be well below 20% of the 1990 level. If, however, the percentage change is maintained the final figure would fall more than 100 million tonnes short of the target. (See Appendices).

"the final figure would fall more than 100 million tonnes short of the target"

The graph below shows how the percentage reduction in emissions would have to grow to meet the 2050 target. In general for systems which are changing in a gradual way, the amount of change tends to level off over the long term. In relation to the reduction of carbon emissions, we would expect to see the percentage reduction falling over time until the system reaches a floor level.





The second graph shows how emissions would decline if the 2008 percentage reduction were to be replicated up to 2050.

We are unlikely to see the increasing percentage reductions that would be required to meet the 2050 target. We can also see that this leads to the conclusion that some form of step change is required in emissions reduction in order for the target to be met.

" some form of step change is required in emissions reductions for the target to be met"

Turning to the question of emissions which are more difficult to reduce, we need to look at the other contributory greenhouse gases, particularly methane and nitrous oxide, as well as carbon dioxide.

Whilst it may be possible for all emissions to be addressed, those from direct industrial processes, agriculture and waste management are intrinsically more difficult. We have assumed that the industrial process emissions are maintained, agricultural emissions can be

reduced by 50% and those from waste management can be cut by two thirds.

Taking these assumptions into account then we can calculate that around 62 million tonnes of carbon dioxide could be classed as intractable. This means that from the remaining emissions we need to look for a reduction of 87% rather than 80% in order to meet the targets. (See Appendices).

So as we look towards scenarios which would be capable of delivering the emissions reduction for 2050 there are some key features that are required:

1. Due to intractable emissions, the reductions from addressable sources (electricity, heat and transport) must be 87% and not 80%.

2. Meeting the target will require a step change, or a series of such changes in reducing emissions.

"reductions from addressable sources must be 87% not 80%"

Our scenarios must therefore be bold and far reaching. This will inevitably mean that the scenarios will cause major impacts in political, economic and social terms.

3. Scenarios For Emissions Reduction

As we have discussed, we need to identify options for progress which can create step change, in other words, radical action. The scenarios we are going to present have been built around this need for action.

" based on current consumption the UK requires about 1.8 Petawatt hours (annually)"

Based on current consumption, the UK requires around 1.8 Petawatt Hours (1.8 trillion kwh) to provide its total energy needs. (See Appendices for this estimation). Electricity currently accounts for about 25% of this consumption

It is clear that without control of consumption, any scenario will find it hard to provide sufficient energy with a net footprint (ignoring emissions from renewable sources) of less than 100 million tonnes per year.

There are many details from both scenarios which would need to be worked out and the description that follows is very much an overview. We are seeking to illustrate the depth of change that will be required rather than produce detailed proposals.

We have not included the development of any energy sources which do not currently have at least trial operations in progress. Nuclear Fusion, for example would provide a large resource of zero carbon energy but is still in the research phase.

A primary driver that we identified was the degree of proactive development which takes place. This involves organisations and individuals working together to speed the rollout of technical solutions and to make the changes in behaviour that will be required.

" A primary driver that we identified was the degree of proactive development"

If this proactive approach is not taken then we have to look at the possibility of government taking a mandatory approach. In this situation we would expect to see a scenario which would require less structural change even though the impact on organisations and individuals might be significantly increased.

Our two scenarios are:

(i) The All Electric Model (AEM)
(ii) The Integrated Energy Model (IEM)

For each of the scenarios we have set out the underlying rationale, cover some of the technical requirements and then review the likely impacts on the political, economic and social environments.

Both scenarios recognise the need to radically decarbonise the provision of electricity, heat and transport, although they approach this objective in different ways.

" the need to radically decorbonise the provision of electricity, heat and transport"

3.1 The All Electric Model

3.1.1 Rationale

As we outlined earlier, evolutionary change is unlikely to allow us to meet the 2050 targets. For many individuals and organisations, once the no cost and low cost actions have been taken, there is likely to be resistance to making investments focussed on emissions reduction alone.

In this situation, in order to deliver its targets, Government will be forced to use mandatory powers to maintain progress. We can expect any such legislative approach to seek a model which minimises the technical development required. We would also expect that the basic approach to administering other mandatory schemes, taxation for example, would be used.

" a model which minimises the technical development required"

From a technology perspective, electricity is an attractive form of delivering energy. It is relatively easy to distribute, well understood and managed through large organisations. It is also easier to directly decarbonise because much development has already taken place to create low carbon generation.

This scenario, therefore, sees all energy requirements delivered either directly through electricity or from the by-products of electricity generation.

3.1.2 The Energy Economy Under The AEM

Based on the total consumption of energy and the proportion which electricity contributes, we can see that a crude estimation is that low carbon generation would have to not only replace all existing supply but increase fourfold.

There is no question that consumption limits would have to be imposed, alongside seeking to massively improve the efficiency by which electricity is delivered and used.

" no question that consumption limits would have to be imposed"

Generation of the required electricity

There are three large-scale sources which could be used to provide the majority of the required capacity. We would expect that all three sources would have to be utilised, they are:

1. Nuclear power
2. Coal and gas fired generation with carbon capture
3. Large scale renewables – offshore wind and wave power

The current programme for nuclear power will primarily replace existing capacity which is due to retire from service. This programme would need to be radically increased.

There is a debate about the amount of available fuel for fission reactions with estimates varying between less than one hundred years to many thousands. Clearly if there is a worldwide adoption of nuclear power then fuel scarcity poses a risk in the future. As such, it may be necessary to view this source as an intermediate option rather than a feature of the very long term mix.

The UK still has very large reserves of coal although the closure of the mining industry in the 1980's and 1990's means that major investment would be needed to return to the levels of productions that were seen historically.

"The UK still has very large reserves of coal

Nonetheless, the development that has taken place in carbon capture does offer the potential to see coal-fired stations playing a role in the generation mix. The same technology applied to gas fired stations would also be valuable although there are concerns about the longer term security of gas supplies.

In relation to renewable energy, the scale of the demand would mean that the only technologies capable of delivering the required power would be offshore wind and wave installations. With turbines under design to deliver 7.5 MW, then with sufficient construction there is the prospect of such sources taking a key role in the generation mix.

"With turbines under design to deliver 7.5MW such sources could take a key role in the generation mix"

To smooth out the availability factors of renewable energy, there would have to be a major increase in the use of pumped storage facilities. These facilities would primarily be driven by off-peak capacity to be released when the available wind and wave generation was delivering less energy.

We will discuss the issues of investment when we consider the economic impacts but from a practical perspective, two major issues stand in the way. Firstly, there is a shortage of the specialised construction equipment and labour to install the level of capacity required. At present, this would push the contribution of wind power well into the 2020's or beyond.

The other issue relates to the transmission of the electricity that is generated. This is a current constraint on development and for renewable energy to take a key role construction of the so called "supergrid" would be essential.

It is important to recognise that there would be a requirement to install many thousands of turbines and there will also be issues to overcome about the impact on local communities and effect on military systems, particularly radar.

The transmission issues for offshore generation would only be one side of the distribution requirements. The transfer of most other consumption to electricity will mean that the networks for homes and businesses may need to be strengthened to carry the extra load.

It is our contention, however, that developing all these three streams would enable sufficient electricity to be created to meet the demand assuming that consumption was strictly controlled. We will now consider how this scenario would impact on the direct delivery of electricity, heat and transport.

"sufficient electricity can be created to meet demand if consumption was strictly limited"

3.1.3 Reaching the 2050 Vision

Electricity:

The long-term vision would be for there to be a secure supply of low carbon electricity. The majority of this would continue to be delivered through grid supply. To make major changes in emissions, particularly in the middle years of the period to 2050 there may have to be a trade-off between security and reductions.

If this occurs, then it may be required for organisations and even individuals to have either some level of energy storage, or on-site generation. These devices will enable the supply to be maintained at times when the available grid supply is low.

For different size businesses and different types of residential properties, the means of delivering this backup supply will need to fit the practical constraints of the building. Clearly, the opportunities and appropriate technologies will vary widely between densely populated urban areas and the rural environment.

In order to ensure that consumption can be managed, there will have to be a universal rollout of smart meters to all consumers and businesses. This will include the requirement to put sub-meters on any organisations in shared accommodation.

" there will have to be a universal roll out of smart meters"

In addition to its use for billing, the data from these meters will be used to ensure that consumers and organisations remain within their consumption limits. In addition to the information being provided to supply organisations, it is likely that some form of government agency will also want access to the data.

Heat

There are a number of potential sources for heating. Combustion driven heating (gas, coal or oil) would not be permitted because of the emissions. Direct electrical heating would be possible, although this is classed as an inefficient method (perhaps 40% less efficient than other sources). To minimise the amount of direct heat required there are three alternative sources.

“Combustion driven heating would not be permitted”

Combined heat and power systems (CHP) which might be used by some organisations can deliver significant heat outputs as well as generating the balancing electricity discussed earlier.

Given the fact that there will be no use of gas however, there will be an issue with providing sufficient fuel. In rural areas, anaerobic digestion can deliver biogas and some organisations or large consumers (farms for example) may be able to source sufficient biomass to burn directly. There is also the possibility of producing a biogas of sufficient quality to burn directly for heat.

For the majority of urban businesses and consumers this will not be possible. In these cases it may be more practical to look at energy from waste but on an industrial scale. A large CHP plant can burn a wide range of material, generate useful amounts of electricity but more importantly, large quantities of heat.

Unfortunately, it is far harder to move heat energy compared to electricity, but as long as the plants are sited close to areas of urban density, then district heating schemes can provide this heat to both businesses and homes. Furthermore at the scale that these plants operate (approximately 100 MW of total output) it may be possible to install carbon capture equipment, again allowing the use of coal as a co-firing fuel source.

“ it may be possible with carbon capture to use coal as a co-firing fuel source”

This type of major CHP plant can provide baseload heat for a sizable community but there are also opportunities to top this up with other renewable sources, namely ground source heat pumps and solar water heating. Both these methods require the input of electricity but as this is coming from very low carbon sources the whole system can be considered as renewable.

Transport

Perhaps the most visible changes under this scenario will occur with respect to transport. Oil based fuel vehicles will be phased out completely to be replaced over time with electric vehicles.

"Oil based fuel vehicles will be phased out"

This will initially be through a wider rollout of hybrid vehicles but in the longer term the switch to entirely electrical models. There are already a number of commercial examples of these electric vehicles in operation for both commercial and domestic use.

Commercial models in everyday use have a range of up to 150 miles on one charge and carry up to 12 tonnes. Domestic vehicles are generally small and designed for city use. There are some notable exceptions. The Subaru Tesla offers a 300 mile range and a top speed of 120 mph but at a price tag of $50,000 it will not be available to all.

"Commercial models have a range of 150 miles and can carry 12 tonnes"

If we assume that development will continue then it is likely that vehicles will be produced that can replace most of those now on the road. The main question is whether the existing 40 tonne lorries, that are the mainstay of long distance deliveries, can be easily replaced.

Whilst you may be able to make a journey from London to Leeds, for example, in your Tesla at the same speed and in the same level of comfort as a petrol driven car, at the point where you run out of charge you face either the need to stop for an hour or change the battery.

The infrastructure will need to be in place to allow electric vehicles to operate in the same way as existing petrol and diesel ones.

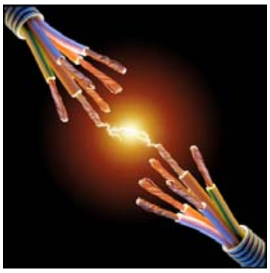
It's possible to imagine a motorway service station in the future. For those who need to move on quickly there would be the option to switch to a fully charged replacement battery. This would be relatively expensive because of the labour required to keep the flow of vehicles moving. For those who are stopping for a meal then there could be access to charging points, whilst they eat, at a lower price. Finally for those using the overnight accommodation this service might be included in the charge.

Other than large purpose built sites, mostly by motorways, it is hard to see how the local service station can make the recharging process economic. Instead charging facilities will need to be installed at homes and places of work. For the large numbers of city dwellers with on street parking this model poses extra issues. It would seem likely that some form of communal facilities will have to be provided.

“ it is hard to see how the local service station could make the recharging process economic”

Recharging sites would be very heavy consumers of electricity and it is likely that they will require dedicated connection at high voltage to minimise heat losses.

The widespread use of electric vehicles would be supported by improvements in the use of mass transport systems, particularly rail systems for heavy freight transport.



3.1.4 Implications of the AEM

Political

This scenario requires the imposition of significant change which will impact on consumers, businesses and the energy supply industry. The existing gas industry would be reduced to supplying the generation industry providing carbon capture is delivered.

At the same time, as electricity becomes the single critical energy source, the need for assurance of supply stability will become ever more important. This raises a significant question about the ownership of the electricity industry. Can it realistically continue to be held in commercial ownership when the entire energy economy is reliant on it.

“ the need for assurance of supply will become ever more critical”

It seems likely that on this basis that government will need to take at least the generation side of the electricity network back into public ownership. Alternatively it would be necessary to assert such a strong regulatory regime that it would be equivalent to public ownership. This would obviously be difficult for existing generators to accept. The cost of such a buy-out would stretch to many billions of pounds.

"The cost of such a buy-out would stretch to many billions"

For domestic and business customers, the imposition of a new regulatory regime will create new pressures and compliance costs. In addition, there will be the risk of action being taken in the event of failure to remain within limits.

For Government, this will necessitate the setup of new administrative functions to both manage the setting and monitoring of limits. There would also be the need to create an enforcement function. No matter which party holds office, the centralisation of power is not unwelcome.

As with most other imposed regulation there is likely to be significant resistance as was seen with initiatives like the poll tax. Issues which raise strong public opinion, are often used as bargaining chips in political manoeuvres. It would be a disaster for the long term targets if the approach and mechanisms were changed with each change of government.

"It would be a disaster for the long term targets is the approach and mechanisms were changed with each change of government"

For this reason it would take an all party agreement that the approach was going to be followed through. Within the political arena, such agreements are rare but it would be an essential precondition.

Economic

We have already outlined that there are some huge costs which would have to be bourne to put this scenario into operation. We can summarise the main investment areas:

a) Renationalising the electricity industry
b) Winding down the gas and oil businesses
c) Building new generation capacity
d) Building new grid capacity
e) Creation of electric vehicle charging network
f) Migration from fossil fuel vehicles to electric vehicles
g) Installation of universal smart meters
h) Creation of administrative functions

i) Installation of back up capacity

At the same time, the limitation of capacity in the medium term it is likely to mean that electricity prices will rise. In addition, many of these changes will require substantial investment in the private sector.

" in the medium term it is likely that electricity prices will rise"

As with all substantial investment, it will have to be paid off. This is likely to roll through into increased prices for many goods and services.

This is not an exclusive feature of the AEM. At heart, the cost of decarbonising energy use has to be met and this cost is eventually passed on to consumers. There is big question to be answered here. Where costs are imposed on a top down basis like this, and there is little option for consumers to avoid the increases, it becomes a regressive tax. How can this issue be mitigated so that the most vulnerable members of society do not bear a disproportionate share of the cost of carbon reduction?

There is also little doubt that many large businesses would see massive increases in profitability. This profitability would then find its way into the hands of the wealthiest members of society.

Social

The economic impacts we have just discussed are likely to cause significant social impacts. It will drive further polarisation between the richest and poorest. Whilst it may cause social unrest, it does not upset the basic capitalist model of economics and as such the effect is likely to be relatively minor.

"It will drive further polarisation between the richest and the poorest"

More impactful will be the imposition of mandatory consumption limits, and perhaps this will be made more difficult because consumption will be monitored by government.

These changes are likely to create significant resistance. This will be set against the more nebulous target to reduce emissions. The basis of the scenario is that this target alone has not motivated change.

3.1.5 Evaluation of the AEM

Taking all of the requirements and implications of this scenario, it seems reasonable to suggest that it is technically feasible, although the costs are likely to be very high.

It is attractive as a centrally imposed scenario because it is amenable to central administration and can be applied reasonably consistently across all regions and socio economic groups.

"It is attractive as a centrally imposed scenario because it is amenable to central administration"

At the same time it represents a high risk approach. It relies on political unity and contains elements that are likely to create stiff resistance in a country which guards privacy jealously.

The fundamental question is whether the mandatory element would be strong enough to motivate the changes that will be necessary to reduce emissions. If early action does produce a change in attitude then it may be that a softened version of the scenario can be followed, reducing some of the least palatable impacts.

It is also possible that the suggestion that such a scenario would be imposed will be enough to push sufficient consumers into voluntary action such that it never needs to be actually implemented.

3.2 The Integrated Energy Model (IEM)

3.2.1 Rationale

The basis of this scenario is a high general level of support for the delivery of carbon reduction targets. The result of this support is the willingness to engage voluntarily in action to reduce emissions and to make the changes in behaviour that will be required.

Just like the AEM, this scenario demands control of consumption and the decarbonising of energy supply. Unlike the AEM, the IEM takes a more balanced and decentralised approach to energy supply. This can be achieved because the proactive steps towards

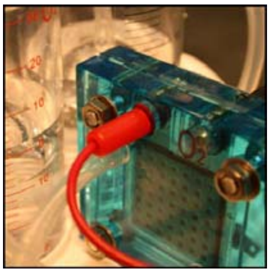
"The IEM takes a more balanced and decentralised approach"

the reduction of consumption allow a less drastic approach to be taken.

Many of the technical approaches are similar but there are also major changes. This is most obvious in the energy used for transport. The scenario posits the use of fuel cell technology driven by methanol rather than directly though hydrogen.

"The scenario posits the use of fuel cell technology"

Creating this model will demand an innovative approach to pursuing business objectives and the recognition of the value of collaboration.



3.2.2 The Energy Economy under the IEM

The major feature of the IEM is that it supports the creation of a decentralised energy supply industry. Whilst there will be a requirement to provide large scale electricity generation this will be be at a level closer to the present demand.

As with the AEM, generation will come from a mixture of nuclear, coal (with carbon capture) and large scale renewables. At the same time there will be a greater level of investment in local schemes that produce electricity and heat but delivered directly rather than through the main grid.

There is an evolving path of energy supply and a closer linkage between the different sources. As an example the carbon emissions captured from coal fired stations can also be used to create fuel for transport. Whilst this means that the carbon will be released to the atmosphere there is a double release of energy for the same amount of carbon.

It is this interlinking which sets the IEM apart from the AEM. It does, however, make the energy economy much more disparate and less easy to exert control upon.

"It is this interlinking which sets the IEM apart from the AEM"

It is our contention that the IEM can represent a viable scenario, delivering sufficient change to meet the reduction targets.

3.2.3 Reaching the 2050 Vision

Electricity

As we mentioned above, the level of generation required will be more akin to present levels, although it is likely that some increase will be required to power new processes.

One key element of this scenario is the requirement to generate a large baseload. This will be used to deliver fuel for transportation that we will discuss later.

The most likely source for this baseload is nuclear power. It provides a very consistent output and is intrinsically low carbon. The majority of the peak load would be produced by the same clean coal technology and large scale renewables as for the AEM.

“The mostly likely source for this baseload is nuclear power”

At the same time the total load required will be reduced by the installation of localised generation. This will be facilitated by the positive attitude to carbon reduction. Objections during the planning phase will be much reduced allowing a variety of systems to be implemented.

Whilst some of this investment will be in onshore wind, the low availability of such installations will push investment towards technology like anaerobic digestors. The local community will be encouraged to help provide the organic feedstock required in return for subsidised energy. To provide sufficient feedstock, it may be necessary to look at the use of sewage as an input.

It is expected that many of these systems will run on the basis of cost recovery or even using Trust status, or through the action of local authorities. Without the demands of corporate profitability then supplies from these facilities can provide power at cheaper rates with the potential to provide social tariffs.

“Without the demands of corporate profitability these facilities can provide power at cheaper rates”

It must be recognised that such an approach will require changes to the way that finance is made available for renewable energy projects. We will discuss this matter in more detail later.

Smart metering will be extensively fitted but with a focus on providing the business or householder with detailed information to enable energy saving measures to be put into place.

Heat

The more widespread use of local renewal generation, especially through the anaerobic digestion or biomass systems will make much more heat available close to the point of delivery. This may be through larger, local authority run, systems that can deliver heat to whole communities or through smaller systems serving local users.

The same additional sources of renewable heat as described under the AEM will be used. It is expected that the use of heat pumps and solar heating will have a far more extensive rollout. Investment in these systems will be higher as a reflection of the stronger commitment to meeting the reduction targets. These technologies will be especially important in very remote locations that are too far from district heating schemes.

To ensure there is sufficient heat available, it may be necessary to use direct electrical heating despite its inherent inefficiency. Alternatively, providing other emissions are reduced, it may be possible to use fossil fuel resources, especially gas and coal to provide some heat energy.

" it may be necessary to use direct electrical heating despite its inherent inefficiency"

Transport

This is the area where the integrated nature of this model is the most obvious. It is expected that there will be some uptake of electric vehicles but this will be only for local journeys. This is because there is unlikely to be any pressure for the creation of the recharging networks described under the AEM.

The main technology that will replace fossil fuel will be the fuel cell. Fuel cells are currently installed in a number of low volume production vehicles including light commercials and buses. There is, however, one critical issue that must be overcome before fuel cells have wider roll-out. This relates to the fuel source, hydrogen.

Hydrogen is currently produced from fossil fuels, but there are alternative processes, using electrolysis and various catalytic pathways. In the case where there is a ready supply of low carbon

"Hydrogen is currently produced from fossil fuels" electricity, off peak nuclear or from offshore wind arrays, then electrolysis whilst inefficient. would be an acceptable process.

Hydrogen also has issues in term of its delivery and storage within a vehicle. The very high pressures needed mean that storage tanks are very heavy and pose a risk in collisions.

"hydrogen has issues in terms of both its delivery and storage"

There is however an alternative option. Some simple organic chemicals, methanol for example can be used as a hydrogen carrier. This requires the construction of a more complex fuel cell but methanol is a liquid at room temperatures with similar properties as petrol. Whilst fuel tanks need to be plasticised to hold methanol, with some amendments the existing fuel distribution and delivery networks could continue to be used.

Methanol is currently, like hydrogen, produced from fossil fuels. There are alternative processes either using biomass or through the syngas process using carbon dioxide and hydrogen.

This offers the intriguing possibility of using fuel production to actually take in carbon dioxide, in the longer term directly from the atmosphere. In the medium term the carbon dioxide produced by the carbon capture facilities of coal fired power stations could be used.

The drawback of the methanol fuel cell is that it releases carbon dioxide. This is in smaller proportion, perhaps in the range of 25-50% lower than the equivalent petrol engine but must be dealt with none the less.

If we envisage a development pathway, using carbon capture supplies would significantly increase the energy provided per kilogramme of carbon released whist totally renewable processes were established. At this point vehicles could become carbon neutral.

"using carbon capture supplies would significantly increase the energy yield per kilogramme of carbon released"

3.2.4 Implications of the IEM

Political

The IEM, with more complex webs of interdependence will be much more difficult to administer. With groups of many sizes, commercial and not-for-profit taking part, developing a regulatory framework to ensure that targets are hit will be very complicated.

This complication arises from identifying who would carry responsibility. In an environment where consumers and businesses were actively engaged in seeking carbon reductions, enacting the type of legislative control seen under the AEM would be very hard to justify and liable to create an even stronger reaction.

Politically, therefore, the IEM looks much more like the existing model with high level targets, but little stake in controlling delivery.

" the IEM looks much more like the existing (political) model

A key question for Government under this scenario, is the role that is played in supporting the investments necessary to produce the smaller scale local initiatives. By making low cost finance available, a huge impetus could be provided and improve the viability of many projects.

Another area that would be significantly increased in this model would be the need for heath and safety evaluations of the local projects. If waste materials, particularly sewage, are used then there is a clear public health issue if they are not managed properly. A major increase in the numbers and skills of inspectors would be required.

Intrinsically, this scenario would represent the smaller change to government operations, but with no increase in the control of emissions reduction. Whilst this may not be a part of any overt policy, the scale of the targets may make this an uncomfortable position.

Economic

Estimating the economic impact is far harder with this scenario. The costs will be spread much more widely and the loss of some economies of scale will undoubtedly increase the price of some projects.

At the same time, the fact that many projects will be run on a not for profit basis will mean that the energy supplied could be a lower cost, and therefore the impact on consumers could be lessened.

" impact on consumers could be lessened"

In terms of the major energy industries, there will be changes on a similar scale to the AEM. The fossil fuel industry will decline although this may take longer as initially fossil fuels will be used to deliver the methanol required for transport. Additionally, the fuel delivery infrastructure would be retained.

With a lower dependence on the electricity industry there may be less need to implement the nationalisation that the AEM would require. Generators would also benefit from the opportunities to produce the transport fuels close to power stations. We would expect to see existing oil companies moving to invest in this fuel production.

“Generators would also benefit from the opportunities to produce transport fuels”

The concerted action to reduce energy consumption would mean that the overall investment required to deliver a low carbon alternative would be less than that required for the AEM. As a result it would be easier to deliver the levels of energy security that would be required.

Additional costs would, however, come in the provision of local infrastructure to deliver energy from the smaller plants. This would particularly be true in the case of heat.

The basic picture then is a model that stays similar to todays’, with a diverse base of investment and commercial organisations retaining large parts of the infrastructure. There is no doubt that as with the AEM, investments will have to be repaid and energy prices will have to rise to cover these costs.

Social

Whilst the political and economic landscapes would see less change under the IEM, the social environment will see radical change. We have assumed that whilst there is a much stronger willingness to take responsibility for carbon reductions, the practical aspects will be considerable.

“ under the IEM, the social environment will see radical change”

Reducing consumption will require changes to lifestyle across many areas. Some examples are:

- The management of waste will have to change to provide the feedstock for local generation. This does not just require the greater sorting of materials but also the acceptance of the use of sewage for energy production.

- The attitude to the construction of energy production facilities will have to relax significantly. Many sites struggle with objections during the planning process and these would have to be eliminated.

- Clear choices will have to be made about the energy costs of day to day activities. Sourcing food and other goods will have to be more localised with less choice to reduce food transport miles.

- The use of electrical equipment in the home would have to be more carefully managed with the possibility that whilst some energy intensive equipment is in use, other items will not be able to be switched on.

This level of change will require continued effort which can often be an issue. In general, people will be vigilant for an initial period but over time this declines and convenience reasserts itself. This scenario therefore demands that the principles by which modern life has been lived will need to be rewritten and it is likely to take time to become the new norm.

"This level of change will require continued effort which can often be an issue"

3.2.5 Evaluation of the IEM

This model can be seen to be technically feasible. One key element of feasibility is the ability to produce sufficient fuel to power the transportation.

For the UK, with 34 million vehicles we can estimate that somewhere around 30 – 40 billion gallons of methanol would be required each year. (See appendix for the calculation). Compare this with the US production of ethanol which is around 5 billion gallons and it is clear to see that production must rise very substantially. We do not, however, consider this to be an unreachable goal.

" 30 -40 Billion gallons of methanol would be required each year"

Of more concern with the IEM is its reliance on the individual to be committed to emissions reduction without reaching the stage of commitment fatigue. This poses a significant risk to the scenario and suggests that the totally unlegislated approach may not be possible.

4. Discussion and Conclusions

The scenarios we have explored have been set up to be provocative. The contrast, between an authoritarian top down approach and an almost *laissez faire* approach centred on the desire of the public to reduce emissions, is stark.

Whether either of these scenarios comes to pass is less relevant than the fact that decarbonising the UK economy by 2050 will demand changes of the scale of those in the scenarios.

“decarbonising the UK economy will demand changes on the scale of these scenarios”

What is clear is that for the UK to be successful in meeting the 2050 targets, a number of key factors will have to fall into place:

- **Motivation**: A fundamental acceptance of the need for the target alongside a determination to achieve it. It must be recognised that no individual or business can maintain this motivation over a long period, and hence a mixture of threat and reward will need to be employed.

- **Technology**: Existing items will have to be made much more energy efficient. New technology will have to be developed particularly in relation to mass production of new energy source equipment.

- **Investment**: There is no doubt that this process will come with a massive price tag. It will run into the hundred of billions. Whilst this investment will be spread over a long period it might well represent over 1% of the total UK GDP over the next 40 years.

“This investment may represent over 1% of UK GPD over the next 40 years”

- **Legislation**: Enforcing targets will not be sufficient. The achievement of the targets will require new attitudes to flow through into other areas, particularly around planning and investment. Without real government support the targets will not be met

- **Willingness to change**: Both businesses and consumers will have to accept new ways of conducting their everyday lives. Some sectors will see major increases in activity, and others may be wound down. As the markets shift then businesses and employees will have to be willing to shift with it.

It is interesting to note two softer factors appear in the list. Furthermore, it is our contention that these factors represent the most important and perhaps the most intractable barriers to meeting the targets.

There is no simple answer to addressing these issues. For businesses there is the prospect of generating new revenues from the array of work to be done. This will be incremental for some and represent a chance to migrate for others.

“For consumers there is a much less attractive proposition”

For consumers, however, there is a much less attractive position. As we have already discussed, whether directly through energy costs or through increased costs of other goods and service, the cost of the carbon reductions will have to be bourn. In addition, especially for those whose skills do not match the new requirements, there is the possibility of losing their employment.

The benefits which will compensate for these costs are, however, diffuse and may not be seen at all. If the UK remains isolated in pursuing reductions at this level, then greenhouse gas levels will be largely unaffected and the problems of global warming will still occur. It is also an investment for future generations but these so called “jam tomorrow” benefits are poor motivators without very strong commitment.

“ building the new energy economy has to be done and these costs have to be paid for”

There is no doubt that the investment in technology development and building the new energy economy has to be done and that these costs have to be paid for. The question is, over what period do these costs have to be repaid and how much interest is due on them.

As part of its strategy to address the current recession, government has made funds available for businesses to continue to service debts. This scheme could be extended to allow the local energy projects to be delivered. Local residents could be given a stake in the project in return for active co-operation in its building an operation. These stakes could be redeemed against a reduction in the cost of the energy they provide.

In the final analysis, success in hitting the 2050 targets will depend on the creation of an abiding and active desire amongst the public to reduce emissions. There are few examples of this level of focus and certainly not over the length of time that will be required.

It will largely fall to organisations, and to a lesser extent Government, to find the motivating factors that will encourage the public to make energy saving both attractive and the norm. We believe that the first step in this process is for organisations to demonstrate that they are willing to work together to find new solutions to carbon reduction.

“It will largely fall to organisations to find the motivating factors that will encourage energy saving”

The reduction of carbon emissions is critical to our future and there is no doubt that it comes at a heavy price. As with other threats a positive outcome demands that there is a widespread feeling that everyone is in the same situation. Business and Government will have to demonstrate that they are accepting the same level of hardship and not simply loading all of the costs onto consumers.

As part of our commitment to modelling this new behaviour, we have established the Challenge 2050 programme. This provides an opportunity for organisations to share knowledge and identify opportunities to work together to save energy and hence reduce emissions. To join the programme, an organisation will need to agree to share information and best practice and to actively seek collaboration.

In the coming months we will be drawing this knowledge together to establish a more detailed blueprint for co-operative carbon reduction and publishing this blueprint in a new report.