Energy Planning and Sustainability

The Integrated Resource Plan for Electricity 2010-2030 (IRP2011) is a 20 year plan that looks at the projected demand for electricity and uses certain assumptions to derive a plan to meet this demand.

Mike Roussos
is a renewable energy developer who also consults to many businesses on energy issues and other general management issues. He has run a variety of companies in the past, in industries ranging from mining to information technology to legal insurance to retail. He has also assisted Government in setting up and running a range of new initiatives at local and provincial level.

It is an attempt to anticipate the need for electricity, and set up a cost-effective, reliable and hopefully sustainable way to supply us with this electricity. 'Sustainability' refers to the need to take into account the impact of various ways of generating this electricity: its impact on our environment, on our health, and on our planets ability to cope with all the Green House Gas (GHG) we are spewing into the atmosphere.

Such a plan must re-examine: How we use electricity how much we use and what we use it for. These are all questions about the energy-intensity of the ways we grow our economy in order to meet all our needs. They are critical questions, but they cannot be addressed in the context of an IRP for electricity. They are part of the broader question of how South Africa uses- all types of-energy. The broader Energy Resource Plan that this IRP should be a part of, has yet to be finalised by government (it's apparently 'in-process' at the moment) and as such, a number of these key issues are left open-ended in this IRP.

This article will examine how this IRP was formulated, how reliable its predictions are, to what extent it addressed the sustainability issues and what "trade-offs" it made on the way and why.

Any discussion of new ways of meeting electricity demand must take into account the reliability of the technology being used to generate such electricity, as this will definitely impact on Eskom's ability to guarantee security of supply (its ability to 'keep the lights on'). This article will also comment on some of the debates about renewable technologies and their reliability sometimes referred to as their 'maturity'.

The question of cost is critical to the final decisions made about what to build, how to build it and how to pay for it. This article will also make some comments about the ability to finance the development plans being made in the IRP and raise some questions about the way forward.

The IRP Process

Formulating a 20 year plan is a very imprecise exercise, which is subject to many assumptions that have to be made about key variables; assumptions about how much the economy will grow and the impact this will have on electricity demand. The list of key assumptions is very long and contentious, and includes the electricity intensity of future economic growth (will we build more electricity guzzlers like

This is why there is so much controversy around who has access to the process; who has the opportunity to influence the process; and who is chosen as an expert to assist the Department of Energy (DoE) in its determinations.

the Aluminium smelters or more factories that require comparatively little electricity to function), the price elasticity of demand for electricity (how sensitive electricity consumption is to changes in the price of electricity), and how much electricity can we save using Demand Side Management (DSM) measures (how much can we rely on efforts to introduce energy-saving measures, to bring down the overall usage of electricity?).

Many of the inputs into the IRP process are subject to interpretation and introduce opportunities for interest groups to push the decision in a direction that suits their constituency. This is why there is so much controversy around who has access to the process; who has the opportunity to influence the process; and who is chosen as an expert to assist the Department of Energy (DoE) in its determinations.

The DoE ran a far more consultative process than had ever happened before. Many of their critics have pointed out that this happened in fits and starts, depending on how much pressure was being exerted on them: but whatever the reason, they started setting the framework for a much more consultative process. The consultation process began with a debate around the assumptions and moved onto a set of scenarios that were examined as part of the process that led up to the decision about the final mix of technologies - and the timing of their introduction. This then led up to the plan that was presented to the Cabinet for their approval.

After a lot of pressure, this Cabinet Plan was presented to the public for discussion and comment. This resulted in many criticisms and many suggested changes. Public commitments were made regarding revisions of the scenarios, particularly of the pricing, and regarding consultations that would take place after these changes had been made.

Once the revisions were made by the DoE, the new recommendations were taken straight to the Cabinet and final approval was given. It only became public once it had already been approved and the finished product was then published. This raised a lot of questions about the legitimacy of the process and of the value of consultations when there is no commitment to take account of the results of such consultations.

An examination of the recommendations may help to clarify some of the problems that arise from such a process.

The building of scenarios is done using a piece of software that allows one to model various technology options over a predefined period, to determine the most cost-effective mix. In this case the mix included the traditional fossil fuel options (coal, gas, diesel), the newer renewable options (wind, biomass/gas, solar PV & CSP, hydro) and nuclear. This was modelled over a 20 year period. The model allows one to stipulate costs for each technology over the entire period, that is, you can stipulate that the cost will rise, drop or stay constant - over the period. The initial set of scenarios included fixed costs for the renewable technologies. It was assumed that they would stay constant over the period -apart from inflation which is excluded from the model. This is contrary to the experience of massive and on-going cost reductions as these renewable technologies achieve higher levels of penetration. It also set the costs for nuclear at levels that were far below those that emerged from various actual tenders or construction projects over the past few years.

Long term planning inevitably impacts on the interests of different stakeholders within the economy. An obvious example is that of coal. We have a lot of coal in this country and many people rely on the coal industry for their livelihoods–for jobs or profits. When international concern about GHG emissions led to plans to remove coal from the list of options that should be included over the next 20 years, the lobby groups swung into action. Some of them, like the trade unions who are concerned about the jobs of their members, engage openly in debates about the future growth of the economy and how this will affect the coal workers and what alternative jobs could become available within green industries. They use their support base and their access to the ruling party to ensure their views are taken seriously. On the other hand business owners intervene in other ways. They have access to money and the influence to assert their views in the process. They send various experts, who work for them, to participate in working groups that formulate the options and influence the decisions. They demand opportunities to brief the Cabinet to ensure it is aware of the consequences of making various decisions and they also have the resources to draw up extensive and persuasive presentations on the consequences of various choices.

This is all part of the normal process of democratic engagement and debate – as long as it is transparent and open to challenge by other interest groups. The problems arise when this happens behind closed doors, when experts are seconded from business groupings with a clear interest in the outcome - without counterbalancing experts from the other side, when unreasonable access is given to those with the resources or the political clout to demand it.

The problems arise when this happens behind closed doors, when experts are seconded from business groupings with a clear interest in the outcome - without counterbalancing experts from the other side, when unreasonable access is given to those with the resources or the political clout to demand it.

The IRP process can be challenged on the basis of many of those pitfalls, and needs to be carefully examined so that the next IRP corrects those defects.

IRP2010 Recommendations – The First Set of Scenarios

Cost and reliability tend to dominate as the key criteria in such a process. This ignores the contribution that different technology mixes will make to the devastation being wrought by global warming. Such externalities must increasingly become the most important consideration in such decisions. We need to understand what impact our choices will have on the survival of the planet. These choices have to be made in the context of what we can afford; in the context of the need to grow the economy to fight unemployment, poverty, hunger and disease. Global warming cannot be fought in one country. The danger is that this is used as an excuse for us to do as little as the worst of our neighbours.

At Copenhagen our President committed South Africa to various target reductions in GHG emissions, with some conditions attached. The targets derive from the Long Term Mitigation Scenarios (LTMS) done for the Cabinet, which projected various growth paths and the impact of each type of growth on GHG emissions. These projected the following figures for GHG emissions under the Growth without Restriction (GWR) scenario - bearing in mind the Electricity sector is responsible for about 50% of total emissions.

Copenhagen Agreement

	GWR	Elec. Contribution	Reduction agreement
2020 target	720 Mt	360 Mt	34% down to : 238 Mt
2025 target	880 Mt	440 Mt	42% down to : 255 Mt

When the IRP scenarios were run, these targets disappeared from the documentation and other targets were substituted. Initially a 275 Mt target by 2020 was utilised, which was later changed to 275 Mt by 2025. This represents a very different reduction from the 'business as usual' (or GWR) scenario. 275 Mt by 2020 is a 24% reduction; down from the 34% reduction South Africa committed to. 275 Mt by 2025 means that we do not reduce emissions below 'business as usual' at all for the whole period from 2010 (when the commitment was made) up to 2025. We then try and achieve a 38% reduction from then on; down from the 42% reduction. This change was never justified and the documentation made it sound as if this target will enable South Africa to meet the targets committed to in Copenhagen.

This inevitably pushed the total costs up as a large proportion of the existing 'polluting' plant was not being used – and new 'clean' plant was being built to bring down the emissions. This was, to a large extent, due to governments' refusal to review the decision to build Medupi and Kusile.

One of the emission-reduction scenarios removed many of the new coal plants and replaced them with 11GW of wind and 9.6GW of nuclear. This was done to meet a lower emissions target than was possible with the GWR or 'business as usual' technology mix (with coal comprising the vast majority of generating plant). This scenario dropped emissions to 275 Mt by 2018 and kept it there from then on. In the 'base case' it was 286 Mt in 2018 and went up to a high of 381 Mt by 2030. The total capital cost rose by 9% above the capital cost of the base case to R860.5bn.

A more 'extreme' emission-reduction scenario was then explored. This introduced much more wind (17GW) and introduced it two years earlier (by 2015). This pushed the emissions down to 220 Mt by 2020 (better than the target of 238 Mt) and kept it there for the whole period. The capital costs rocketed to R1250bn – a 58.3% increase above the base-case. This was used to demonstrate the impossibility of such 'radical' emission targets and was used to justify a shift to the conservative targets introduced in the final IRP plan (275 Mt by 2025).

This conclusion ignored the fact that the earlier introduction of wind 'stranded' many of the existing coal assets – thus creating an absurdly high reserve margin (the percentage of unused generating capacity). It rose to 72% due to the un-utilised coal plant. This inevitably pushed the total costs up as a large proportion of the existing 'polluting' plant was not being used – and new 'clean' plant was being built to bring down the emissions. This was, to a large extent, due to governments' refusal to review the decision to build Medupi and Kusile.

This result was also due to using incorrect costs for the renewable technologies. The costs used ignored the yearly drop in price for these new technologies, as installations increased around the world. Some of these errors were corrected after the public consultations, including correcting the low price of nuclear in the early scenarios. This also impacted on the result above.

The first round of scenarios included DSM targets that were very conservative: even Eskom had estimated that around 3 times that level could comfortably be achieved. DSM refers to measures like replacing incandescent light bulbs with compact fluorescent bulbs; replacing electric geysers with solar ones etc. The Enhanced DSM scenario increased this target by a low increase of 45%. The analysis dismissed this option as too risky as it was difficult to achieve, and the benefits were too small. The emission levels of this scenario were not very good - 302 Mt in 2020, 332 Mt in 2025, and 376 Mt in 2030. But it did manage to drop the capital cost to slightly below that of the base-case (–1.62%). The IRP plan dismissed it as an unrealistic option.

An analysis of this scenario reveals that it included more coal than any other scenario – just a tiny bit less than the base case – and no wind or solar. This is what led to the high emissions in this scenario: hardly a fair test!

An analysis of this scenario reveals that it included more coal than any other scenario – just a tiny bit less than the base case – and no wind or solar. This is what led to the high emissions in this scenario: hardly a fair test!

The Second Round of Scenarios – After the Consultations

The nuclear costs in the model were increased by 40% to take account of criticisms of the first round of models. Although this is a big correction, it is arguably still far too small. This was convincingly argued in the submission made by Greenpeace to the IRP consultation process: they quoted the costs of a number of new nuclear installations around the world -using estimates from rating agencies Standard & Poor's and Moody's, they put this cost at around $7500 / kW – which is more than double the figure used in the first round of scenarios. The cost of de-commissioning the nuclear plants - a cost that has been, very conservatively, estimated by the International Energy Agency (IEA) to be R 2700 / kW of existing plant) has not been taken into account at all. This would add at least 10% to the original costs used by the IRP.

Notwithstanding these problems, when a least cost analysis was run using the new costs (increased for nuclear and reduced over time for solar), this generated some interesting results. With the emission target set at 275 Mt by 2025 - the model recommended not including any nuclear, including very little coal, 15.8GW of wind, 8.8GW of solar PV and 8.75GW of solar CSP. The capital cost of this scenario was lower than most of the first round scenarios (except the base case and the Enhanced DSM ones).

Despite this, in the final 'adopted' IRP, the DoE and their expert panel decided to ignore this result and 'force in' 9.6GW of nuclear as a 'safe' and 'reliable' option. They excluded most of the solar CSP plant (they dropped it to 1GW by 2030 – from 8.75GW). They dropped wind from 15.8GW to 8.4GW and kept the target emissions at the high level of 275 Mt by 2025. They announced that this would result in 275 Mt being achieved by 2025 – but did not publish a year-by-year emissions column in the "Policy-adjusted IRP" table detailing their chosen scenario (which introduced doubts about their claims).

IRP Decisions

Nuclear	9.6 GW
CSP Solar	1.0 GW
Solar PV	8.4 GW
Wind	8.4 GW
Coal	16.383 GW (including Medupi & Kusile)
Emission target	275 Mt by 2025 – kept at that level until 2030

This was in line with the approach adopted by the DoE throughout the consultation process – where nuclear was treated as non-negotiable – as something that had been decided by Cabinet and was not open to question or reasoned discussion. This approach does not inspire confidence and raises all sorts of questions about the motives underpinning such a decision.

How reliable is Renewable Energy – can it ever replace Coal or Nuclear as a Base-load Resource?

Renewable energy results in intermittent generation, as it is reliant on the sun shining and on the wind blowing: it only works when those 'resources' are available.

Can the shortcomings of intermittent sunshine and inadequate wind be dealt with by a grid operator? These are not new problems, but they are often exaggerated as we have very little experience of managing a grid with significant quantities of such plant.

The grid is run by the 'system operator' – whose job it is to ensure that the projected demand is met by the grid, every hour of every day. This obviously creates some anxiety for those whose job it is to 'keep the lights on'. They tend to be conservative when faced with having to choose between relying on the resources they have always used and whose peculiarities they know and feel comfortable with, versus changing to new 'unknown' technologies. This will not change unless and until we build up a different experience base in this country.

Can the shortcomings of intermittent sunshine and inadequate wind be dealt with by a grid operator? These are not new problems, but they are often exaggerated as we have very little experience of managing a grid with significant quantities of such plant. In the first place, they pose little problem when the grid includes a small percentage of such intermittent plant, and we can draw on international experience to determine at what levels this can become a real issue. This will not be a problem for us for some years to come (Eskom has estimated this level to be at around 15-20% of total grid capacity).

Once a comprehensive wind map has been compiled for the entire country, it becomes possible to guide the installation of 'wind farms' to maximise the overall yield from all such sites. This uses the basic principle that once we know when, where, at what speed and at what height above the ground the wind blows, we can plan a wind grid that will give us a defined resource at a very high level of reliability – whenever we need it. Let me give an example: Once we have the wind map and have built our wind farms accordingly, we will be able to guarantee that of the 10GW of wind farms that we have strategically placed around the country, to maximise the overall availability of the entire wind-plant establishment – AT ANY TIME we will be able to rely on (for example) 6GW being available to the grid.

This is a relatively simple exercise that takes into account the wind map and depends on having built the wind farms in the correct locations, with the turbines at the correct heights, and then doing a statistical analysis to determine the percentage we can rely on – at any time of the night or day – with a high degree of accuracy.

What about solar? The sun does not shine at night and it is very difficult to determine how much sun-energy we can rely on at any point in time during a specific day of the year. Clouds may blow over and ruin our forecasts; freak rainstorms (or sandstorms) can wreak havoc with our attempts to predict how much power we can generate at any point in time.

This is less of a problem if the quantity of solar power on the grid is relatively small – and again we can rely on international experience to guide us regarding the 'hurdle percentage' of solar on the grid.

The situation is different for solar CSP plants as these are thermal plants i.e. they do not generate electricity directly but collect the suns heat and then use this (as a substitute for coal) to heat water to run a generator – that then generates electricity.

Base-load is a term used by system operators to describe generators that can be relied upon to carry the bulk of the load on the grid – day after day. The term refers to the fact that once these generators are on, they tend to run reliably, until we run out of fuel or until they suffer from an unexpected and infrequent breakdown. The above discussion explained how wind can become part of the base-load of a grid – even if only to a limited extent (i.e. less than the built capacity of the total wind-plant).

What about Solar? The only way it can really become part of the base-load category would be if it could be stored efficiently and cost-effectively. This is not possible (at this point in time) for PV plant – batteries are far too expensive to be a practical option for PV power stations. The situation is different for solar CSP plants as these are thermal plants i.e. they do not generate electricity directly but collect the suns heat and then use this (as a substitute for coal) to heat water to run a generator – that then generates electricity. Fortunately heat can be stored much more cost effectively and more efficiently than trying to store electricity. CSP solar – with enough storage – can therefore be described as 'base-load' plant. The only problem with this is the high cost of the electricity generated by such a plant, at this point in time.

The dispatch-ability (how quickly it can be switched on when needed) of generating plant is also of concern to a system operator. This is critical in allowing them to deal with fluctuations in the expected demand that occur suddenly and unexpectedly.

A nuclear power station is very reliable once it is switched on and running (barring any spanners being thrown into the works – or any tidal waves, earthquakes …) but nuclear power stations take a long time to get up and running and are thus of little use in dealing with demand spikes (even if we had a few spare ones lying around). Coal-fired power stations are also very reliable once they are up and running – but they take – depending on the size – at least half a day to get up and running from scratch – and are thus of little use in dealing with short term fluctuations. Wind energy is not really dispatchable, except that there may be some excess capacity available from the aggregated total we calculated as a portion of the total plant built around the county. But this needs further examination and study. Solar PV is not dispatchable as it cannot be stored cost-effectively. It is only available when the sun is shining.

Solar CSP can be stored and although the current overall cost is high, this technology represents our best hope of achieving a long-term solution to our need for sustainable clean energy that is available whenever we need it.

Certain kinds of gas or diesel powered turbines can be started up in only a few minutes. They burn fossil fuels and can be very expensive to run (especially the diesel OCGT ones). They are very useful when the demand changes unexpectedly and the system operator has to do something quickly to stop 'black-outs' or grid crashes. Gas turbines emit less GHG's than coal during their combustion process, but cannot be considered 'clean energy'. Recent studies; using the fact that methane is a vastly more potent GHG than CO_2; and the fact that gas pipelines historically leak a demonstrable amount of methane into the atmosphere; argue that using gas may even be more problematic to global warming than the use of coal.

Unless this installed base increases rapidly in the coming years, this technology may be relegated to the sidelines – even though it is probably our best chance of creating a base-load (and dispatchable) technology within the Renewable arena.

The reliability of solar (PV and CSP) and Wind technologies are not really in question. These are all stable technologies. Exponential increase in installations is leading to more experience and ongoing improvements to the technologies being used. Wind turbines have been built all over the world and the experience underpinning this technology is large and stable. CSP solar that utilises a 'trough-based' configuration has a large installed base and is accepted by most banks as 'tried and tested' technology.

The tower-based CSP plants are more efficient as they allow for higher temperatures to be generated. This also helps enormously when the heat they generate is stored for use when the sun is not shining. Sadly this technology does not have a very high installed base and is still regarded by many banks as a relatively risky technology. Unless this installed base increases rapidly in the coming years, this technology may be relegated to the sidelines – even though it is probably our best chance of creating a base-load (and dispatchable) technology within the Renewable arena.

What about Cost? Isn't Renewable Energy very Expensive?

Eskom claims that its average cost, incurred in producing electricity, is around 56 cents per kWh. Most of us pay a lot more than that, as we get our electricity via the Municipalities, who treat electricity as an additional way of extracting money from us.

This is not an accurate cost to use for comparison with renewable electricity. It includes all the old plant that was built many years ago and has been completely 'written off' in Eskom's books. Our comparison should be with the costs of running a grid with 'new-coal' plant – like Medupi. This cost would include the cost of writing off the capital it cost to build this new plant. I have calculated the cost of electricity from such a plant as being around R1.14 per kWh of the electricity it produces over a 30 year life of such a power station. Currently the government (via Eskom) is offering to pay IPP's 80 cents per kWh for biogas electricity, 84 cents per kWh for landfill gas electricity, R1.07 for biomass electricity, R1.03 per kWh for hydro electricity, R1.15 for wind electricity and R2.85 per kWh for solar (PV and CSP) electricity (these prices were calculated over the 20 year life of the contracts they stipulated in the tender). This shows that some of the renewable energy sources are much cheaper than new coal – but they are not available in very large quantities.

Wind costs around the same as the cost of the 'new-coal' electricity – but solar is a lot more expensive.

This cost would mean that if we install large quantities of solar on the grid today – it would cost a lot more to buy electricity from the grid. Solar electricity is dropping in cost year by year – as more and more of it gets installed, but right now it is relatively expensive. How do we bring down these costs? Every government that has embarked on this path (India, Brazil, China etc) has stressed that they want to participate in the international economies of scale with the decreasing costs. At the same time they have launched a drive to create a local industry to build a big proportion of the plant in their own countries, as this is what will really bring the costs down in their countries.

No-one will build a local factory to produce PV (or CSP) plant unless they are convinced that there is a future for the renewable energy market in this country. Market confidence regarding the future prospect and size of such a market, is a critical component of any anticipated renewable industry in South Africa.

Conclusion

This process has raised many questions that need to be addressed if we are to introduce a sustainable energy mix that contributes appropriately to our attempts to create a local green economy:

- Does it make sense to use a growth forecast that is arguably excessive in order to 'lower the risk' of building too little plant?

- Can we afford to casually dismiss options that allow us to build less new plant by reducing our energy consumption via higher DSM targets – as they are 'too risky'?

- Faced with a history of incompetence in the promotion of such DSM options by the bodies responsible for introducing them on a large scale – can we afford to allow such incompetence to force us to dismiss such 'cost-effective low-hanging fruit' as 'too risky'?

- Can we afford to opt for a nuclear path - despite its being excluded by the very same 'least-cost' model that was previously used to demonstrate that nuclear was a better option than any of the renewable options (now that a more realistic cost for nuclear has been put into the same model and the model excludes nuclear – we override the model and force nuclear in?)

- Can we afford to allow questions to be raised about the integrity of our process when we keep finding new reasons to promote the option that costs the most, thus creating the greatest opportunity for tender manipulation, despite world-wide concern about its continued implementation in the light of the Fukushima disaster?

- Can we afford to allow the introduction of renewable energy to happen in such a haphazard manner – with insufficient regard for the need to control:
  - The sustainability of such options in the long term (relating to critical issues about the possibility of storing the renewable energy)? and;
  - The localisation aspects of the roll-out relating to both the technology used and the skills required to producing and maintaining such technology locally?

- Can we afford to chuck out our previous commitments regarding GHG reductions on the basis of such a flawed process thus condemning us to higher levels of emissions?

- Can we afford to allow profit to overrule sanity in our struggle to preserve what is left of our chances of preventing global warming – here and internationally?

- Can we afford to keep making decisions on the basis of 'piecemeal' data – of relatively short-term thinking – of insubstantial plans regarding the financing of such options?

We need to learn the lessons from the mistakes that were made in this process - to ensure that the next round of IRP planning results in the development of a comprehensive long-term plan that encompasses both the manufacturing and the generation side of things. This can only happen if a comprehensive assessment is made of the two processes – with open and honest debate underpinning some real long-term planning.

This is not an academic or a financial exercise: success in this area will make a significant contribution to our struggle to find an alternative development path that also encompasses a sustainable energy path.