COMMISSIONER: Good morning and welcome back to topic number 2, the national electricity market structure and operation and I welcome back Mr David Swift from AEMO. Mr Jacobi.

MR JACOBI: The Commission's first public sessions addressed the key driver of change in energy policy and the response to climate change. The second topic, the national electricity market and structure and operation addresses how that market has already changed and is expected to change in the future. The network, once the province of large-scale generators linked to end consumers by transmission and distribution has already undergone significant change. At a physical level the most noticeable transformation in South Australia has been the widespread deployment of generation through solar PV at the end of the distribution system and the widespread deployment of renewable technology, particularly from wind and assuming South Australia to include commercial solar PV in place of other forms of generation. At a market participant level, solar PV has already transformed the role of consumers in to generators of electricity both for themselves and exporters of electricity in to the grid. It has seen the distribution networks transferring surpluses of electricity at the neighbourhood and substation level.

Distributor generation alone has significant implications for the types and extent of transmission and distribution infrastructure that will be needed, and also how it would be paid for in South Australia in the context of the NEM, but more important change that has not yet been realised is imminent. The future deployment of on grid and in home storage, new technologies in metering, smart metres, changes to tariff structures, including capacity based pricing, will alter the respective roles and power of end users and generators. It is against this context that the Commission must consider the potential viability of the supply of energy from nuclear fuels in South Australia. To that end, it is important to understand how the network currently operates, what the network of the future is anticipated to look like and the role the network would play. To that end, it will hear from the market operator AEMO, ElectraNet, SA Power Networks who are respectively the owner and operator of South Australia's transmission and distribution assets. And finally, the Australian Electricity Regulator. The Commission calls, once again, Mr David Swift of AEMO who was introduced on Monday as the executive general manager of corporate development at AEMO. We welcome David Swift.

COMMISSIONER: David, I might open with a gentle off break, what about a quick overview of the origins of the NEM - - -

MR SWIFT: Mm'hm.

commissioner: - - - and then roll in to the AEMO role.

MR SWIFT: Yes, thanks. The National Electricity Market arose from the

competitions reforms of the 1990's in Australia. It was a joint initiative of a group of participating jurisdictions and sought to introduce competition and drive electricity efficiency. The techniques used were to disaggregate the industry, to separate it in to regulated and competitive components. So to use competition where you could and regulation where you couldn't, to drive more efficient outcomes for Australia. Key part of that is to provide a third party access regime which allows other parties to connect to the grid and establishing a market which allows generators to participate in despatch and retailers to source energy for their customers in a competitive environment. Obviously to back that there was also the requirement to bring in regulation of the monopoly elements of the chain. South Australia, Victoria, New South Wales and the ACT participated from the start in December 1998. Queensland and then Tasmania joined as interconnectors were built to those jurisdictions. The Commonwealth is also a participating jurisdiction due to its offshore regime.

MR JACOBI: Perhaps we can go then to the specific role that AEMO plays within that marketplace.

MR SWIFT: Thank you. If I just refer the Commission to the slide, the overall structure of the governance of the energy markets in Australia comes under the COAG Energy Council which is a council of all energy ministers in Australia. That provides a policy oversight and they coordinate any changes that are required to the law. Underneath the COAG Energy Council we have the Australian Energy Regulator, the AER, look after economic regulation and compliance with the rules. The Australian Energy Market Commission, the AEMC who are responsible for maintaining the rules and rule changes and undertaking reviews as asked. And the AEMO, the Australian Energy Market Operator who operate the market and the power system. Looking particularly at AEMO, we have a role of gas and electricity market functions. In particular, in terms of electricity for this inquiry, we are the wholesale market and power system operator for the whole of the grid. We are responsible for emergency management. We are responsible for retail markets that allows people to change, give retail choice, change their retailer. We provide a range of electricity planning functions. We have the long term electricity forecasting down as far as the TNSP connection points. We talked about some of our forecasts on Monday. We are the national transmission network planner and we provide a range of information, particularly around reliability and we talk a little later about the electricity statement of opportunities as one of our responsibilities.

An area of potential interest to the Commissioners that we also provide a range of functions under the South Australian advisory functions. That actually carries on work that was done previously by the electricity supply industry planning council that was merged in to AEMO.

MR JACOBI: What is it you advise specifically on, in relation to South Australia?

MR SWIFT: There is a range of publications and monitoring that is undertaken there, looking at the development of the grid in South Australia, reviewing the proposed investment in the network and providing information on the next developments in the power system.

MR JACOBI: I was hoping we could quickly address the key features of the physical infrastructure in the NEM and I think we have got a slide to that end.

MR SWIFT: Yes. Well, the national electricity market is underpinned by one of the longest continuous transmission systems in the world; it's over 5,000 kilometres from north or Queensland to South Australia. Across that grid we have close to 50,000 megawatts of generation tagged on to that and about 19 million customers who are supplied by that grid.

MR JACOBI: Given the physical characteristics the system has, for the purposes of the work that AEMO does, are there other relevant international comparatives, or is the Australian NEM really a unique structure?

MR SWIFT: Well, no there has been a lot of energy market reform around the world. I'm familiar with reforms in the United Kingdom, in large parts of the US, in Canada, in Korea. There are many places where electricity markets and combined grids like this operate. The Australian market of course has some unique features in terms of the design of the market and also the physical underpinning the grid. When you just look at it like that, you can see it actually pretty much follows the coast which is I guess the story of Australia and its population. We are mostly around the coast, so it creates a very long, skinny network which would look quite different than say a network in the US or Europe which would look much more like an integrated net.

MR JACOBI: Do other characteristics such as population density affect the ability to use overseas comparatives with respect to the Australian … I'm here most concentrating on the physical network as opposed to the market structure that underpins the - - -

MR SWIFT: Yes.

MR JACOBI: - - - generators interact?

MR SWIFT: Yes, the network has – we often talk about interconnectors and the reason we talk about interconnectors is that there are gaps where there is not a great deal of industry or population load. So that creates a case where the – for instance, just looking at it, you can see the concentration of load in south-east

Queensland and then a gap as the powerline goes right down to the sort of greater Sydney area. So you have this kind of character that has spaces in between where there is not a great deal of load or generations. Makes it a unique system to operate in some respects.

MR JACOBI: Can I move now to the AEMO's observations about the changes in the generation mix within the NEM, perhaps over the last 15 to 20 years.

MR SWIFT: Yes. Well, looking at that slide you can see that earlier in the market black coal was the dominant source of energy, brown coal, particularly Victoria, being the next and a significant amount of hydro. Natural gas there shows as a relatively modest 9.6 per cent and there was no wind at all in the NEM in 2000. By the time you get to the most recent pie chart I've shown there, 2015, the total generation in the NEM has grown significantly from about 36 and a half thousand to 50,000 megawatts in total. The relative contribution of coal has reduced. The natural gas has significantly increased the proportion, doubled the proportion that is has of the total market share and wind generation has now built up to a significant 7 per cent there. So there has been a shift in the structure of the NEM as a whole.

MR JACOBI: I understand, certainly looking at those charts, that the wind and gas generation has grown and grown at a rate that's in fact greater than the growth in overall generation. I'm just interested to understand whether there are identified any key drivers to those changes, both with respect to wind and gas.

MR SWIFT: Yes. Perhaps if we start with the wind generation first. Wind generation has been driven by the renewable energy target or RET scheme. The RET scheme was introduced by the Commonwealth government over 10 years ago. It has had several adjustments but what the RET scheme does, it splits into two bits. There's a large-scale renewable energy target which actually provides additional funding and incentive to build renewable energy of classified types, and it so happens that over the last decade wind has been the most economic option for meeting that target and so has grown rapidly funded by that scheme.

Natural gas is driven by a couple of things. One is that in a market context the value of the energy generated varies quite significantly through a day and over a year and a natural gas fired plant has the opportunity to get in and out of the market and generate when it's valued by customers where that's needed. So that has grown the natural gas component. It has also been driven by technology. The so-called combined cycle gas turbine plant is a very efficient generator. There's one in South Australia at Pelican Point but a number across the grid and those machines have the highest thermodynamic efficiency of the generators in the marketplace.

MR JACOBI: Those pie charts don't show – I don't think they show solar PV. We've had other evidence in the Commission's hearings about the growth in solar PV. Do you have any observations about the drivers for its growth?

MR SWIFT: Yes, that's correct. We talked about solar PV in our evidence on Monday when – by a quirk of the way that we classify things in AEMO we look at solar PV on rooftops as being netted offload. So certainly solar PV has grown significantly over the last decade. That has been driven by two factors. The renewable energy target has a small-scale scheme which – actually, a small generator scheme which provides funding or incentive for rooftop solar but also in many states there has been generous feed-in tariffs applied in the past to help grow that industry. Solar has now come down in price to the extent that with much more modest subsidies we expect it to continue to go and we are now getting applications and we have our first constructed utility scale solar. So I expect it won't be too long and we'll start to see a wedge on that pie chart that is actually utility scale solar.

MR JACOBI: I think the second chart now shows, as at 2015, that there's 50 gigawatts of installed capacity. I'm just interested to understand – AEMO publishes information with respect to surpluses of generation capacity.

MR SWIFT: Yes.

MR JACOBI: Where does it see the position at present?

MR SWIFT: Over recent years we've seen demand flatten at the same time as we've seen significant investment in new generation, particularly renewable generation, wind and solar, and that has led to surpluses. There are various characterisations of how much that surplus is but certainly numbers of thousands of megawatts. Last year AEMO saw about 5000 megawatts of surplus. We are seeing generators across the NEM respond to that. They are changing their mode of operation or retiring plant from the market entirely.

We're particularly interested in South Australia. You would have seen press articles about the closure in a couple of years of the Northern Power Station and Playford Power Station. AGL has also announced that they intend to close Torrens Island A Station and half of Pelican Point is currently offline. So we have had some closures right across the nation and some adjustment of operating regimes as the companies respond to the fact that there is actually a surplus of generation at the moment.

MR JACOBI: The surplus of generation, I've read it's sometimes expressed in terms of the number of years out before it's expected that that surplus will be diminished.

MR SWIFT: Yes.

MR JACOBI: What's AEMO's current estimate of the extent to which surplus will remain in the market?

MR SWIFT: We publish an Electricity Statement of Opportunities or ESOO each year and that ESOO is undertaken using stochastic modelling to work out whether the plant that we have been advised will be available will meet what we forecast for demand in that year and deliver the reliability standard. That modelling is published annually with an update at the half year. The most recent ESOO shows that under some scenarios there could actually be a shortage in South Australia within a couple of years but overall it shows that there's not the need for generation investment in the NEM for pretty much a decade.

MR JACOBI: Is that within the NEM overall in Australia of is that specific to South Australia, the last one?

MR SWIFT: The last one is for the NEM overall. For South Australia it just depends on the timing of withdrawals and the actual investment in renewable energy as to whether there is or isn't a risk of a small shortfall at the end of this decade.

MR JACOBI: Perhaps we can move to the role of the generators and retailers within the market. I think we've got a slide that shows their relationship. I'm just interested if you can offer a basic explanation of the role of those particular entities within the market structure as it operates.

MR SWIFT: Yes. The National Electricity Market is called a mandatory gross pool. Now, that means every larger generator in Australia, certainly all generators over 30 megawatts, are bound to discharge their energy through the national electricity market and to comply with the rules of that market. So the generators bid into the pool, either singly or often as parts of portfolios owned by larger companies, and within the market mechanism they are dispatched. We'll maybe talk later about the security-constrained optimised dispatch process that's used in that pool. That then determines the generators which are dispatched and retailers draw electricity from that pool to supply their customers. It is also possible and from time to time we have large wholesale customers who connect directly to the pool.

MR JACOBI: We dealt with generators and retailers.

MR SWIFT: Mm.

MR JACOBI: And the separate role of transmission and distribution entities.

MR SWIFT: Well, obviously to enable those transactions to occur, you are relying on the underlying transmission and distribution network to transfer the energy from the generators through to the customers. The network is very important in the operation of the national electricity market. It can be constrained. Under many circumstances you may not be able to get the cheapest power from all states to all customers at a time. So constraints on the network will affect prices and we have schemes in Australia that incentivise the regulated businesses to provide the right transmission services that the market needs.

MR JACOBI: You have referred to the design principle of despatch and of constraint - - -

MR SWIFT: Mm'hm.

MR JACOBI: - - - based on bids. Are there other design principles that underpin how the NEM operates?

MR SWIFT: Yes, there are. The fundamental design of the national electricity market is the security constrained optimised despatch approach and by security constrained we mean that the despatch at all times will be such that the power system will be secure against the next most credible contingency. It sounds a rather morbid way to run but we actually run the market at all times, thinking about the next worst thing that could go wrong and ensuring that if that did go wrong, customers shouldn't notice through the loadings on the – keeping the loadings on the network within their secure operating bounds and maintaining frequency within standards; which is done by the loadings pre-fault or pre-contingent loadings and also the ancillary services that are purchased across the market. So that is a fundamental part of the market, that before you despatch, you are ensuring that the system is going to be set up so that it is secure.

I guess another sort of word that might be looking like that in common English would be resilient, so that customers are not going to notice if something trips or some occurrence occurs. That is only for credible contingencies though, not for any possible thing that could go wrong obviously. Within that, you are then trying to despatch the cheapest generation available to meet demand and that is a complex process that is done with a linear optimisation and that sets a clearing price for each of the regions in the market.

MR JACOBI: I will come back to the regions in a minute and the chart shows a – am I right in understanding you have no choice but to sell in to the pool?

MR SWIFT: That is correct. If you are a generator that is over 30 megawatts and

connected to the national electricity grid, under the national electricity law, you are bound by the rules and must be a scheduled generator.

MR JACOBI: Okay. Now you have referred to there being pricing regions and I am just interested in understanding to what extent that is a construct of the market or that is a construct of the physical infrastructure of the system?

MR SWIFT: Yes. There are choices in the design that have been made and there are other markets that break things down further but the transfer of electricity across the market is not entirely free. There are losses because of the distance between Victoria and South Australia, Victoria, New South Wales, New South Wales, Queensland they are not short distances. So there are losses required to push energy between those regions and those are those interconnectors we mentioned earlier. So under certain circumstances they may reach their safe operating limit, or secure operating limit. So that process of optimisation of despatch has to take those matters in to account and we create what are called regional reference prices. Or at each regional reference node, the node in South Australia happens to be down near the Torrens Island power station and that is the pricing point for South Australia.

MR JACOBI: Now I just want to step back and very much high level of generality and deal with the reason for there being five pricing regions.

MR SWIFT: The optimum outcome in terms of theoretical pricing is to have different prices where there are constraints occurred and that gets back to the mathematics of this linear optimisation. So if you had no constraints, the price across the whole national electricity market would be the same. As soon as you start taking in to account losses and constraints then you start to get different prices or different value points at different points across the national electricity market. This needs to be taken in to account in the despatch and pricing process otherwise you are not providing an accurate value of generation at a point, or cost of consumption at a point.

MR JACOBI: Do those reference prices drive the cost of, for example, the sale of South Australian electricity interstate? Is that the price at which electricity is acquired in that other jurisdiction?

MR SWIFT: Well therein lies a little complexity. The generators in South Australia and customers in South Australia pay the South Australian price. Customers and generators in Victoria pay the Victorian price and that does accrue a price difference across the interconnector caused if there is a constraint there and that price separation drives what is called inter-regional settlement residues and we have a process to auction those off.

MR JACOBI: Mm'hm. Now I think you referred to a linear optimisation model but in terms of the bidding process - - -

MR SWIFT: Yes.

MR JACOBI: - - - there is a – as I understand it there is a time interval for that but then there is also a settlement process. Could you explain that?

MR SWIFT: Yes. Every five minutes there is process of optimisation of despatch and the setting of prices is done. That is called a despatch interval. Those spot market prices are averaged up to provide the trading interval price, the half hour price. And then through measuring everybody's meters and a process of metering and settlement run by AEMO, you then settle up – we actually settle up weekly, four weeks in arrears and so all generators are paid for the generation they delivered to the market at the half hourly cleared trading interval prices and customers pay.

MR JACOBI: Now putting aside the payments for the cost of electricity – sorry, the payments for electricity generated, as I understand it, there is also a concept for payment for ancillary services. Could you explain that?

MR SWIFT: Yes. To deliver a secure operating system and to maintain power quality within the standards set out in the rules, so those particularly the frequency control standard and also to some extent voltage and power quality, you need more than just energy. So trading in an energy market requires some of these other factors to be priced and defined as a service and obtained. One of the most important services is the frequency control services and frequency control services can be raise or lower and so they are there to make sure that the system can maintain its frequency. So for example, one of the key ones would be a regulating raise service, that would generally be provided by a generator that is controlled directly by AEMO and what that would do is if the frequency drops a little which it could if the load rises or if some generator trips off, or there's a powerline drops, then that will be driven up very quickly to try to push the frequency back to the 50 hertz and within the zone. So we have eight frequency control ancillary services and they are all despatched through the market and they are co-optimised with the despatch of energy because it is the same generators often that are supplying many of those ancillary services. Although ancillary services can be provided, for example by fast tripped loads.

MR JACOBI: Now to perhaps take it back to a high level in terms of an example, could you give an example of – we have spoken of frequency control. I am just interested in the sorts of generators that might sit in the system that might provide those particular frequency services to the system?

MR SWIFT: Yes. Well, at the moment that is generally conventional, synchronous generators who are controlled under what's sometimes referred to as AGC or automatic generation control. So they are driven by the energy management system that AEMO runs.

That is an old governor. I often like to describe maintaining the frequency in terms of rotary lawnmowers but that's probably because I don't mow my lawn enough. If you get into the back corner of a lawn and it gets too thick, then obviously your lawnmower will slow down because it has got too high a load on it now. So you have to then increase the throttle on the lawnmower to get it to increase its power to keep its revs up or it will actually stall. Then again, when you get out of the thick mess in the corner the thing will accelerate up because you've now got too much petrol going into it. So you have to quickly throttle it back to what you want.

So that is a simple model of a frequency control and you can see how, as you load the lawnmower up and unload it, its frequency shifts away from the frequency you want. So that's exactly what we're doing. We've set bands in which we're happy for the frequency to lie and we have to have services that will push it back into that band should the frequency drop because of too high loads or increase because loads have fallen off.

MR JACOBI: Within the market system there's this logic in terms of retailers paying for energy generated but how are the ancillary services funded? Who pays for them?

MR SWIFT: Ancillary services are also settled through the market, although some ancillary services are paid for by generators and some by customers. In terms of the regulating services, we use a more sophisticated technique which is called user pays, and that tries to mathematically determine who caused the need for that service.

MR JACOBI: Perhaps if I can just unpack that a bit. As I understand it, everybody derives a benefit from the ancillary services being provided because it ensures stability within the network.

MR SWIFT: Yes.

MR JACOBI: How is there an attribution of the distribution of that benefit amongst generators?

MR SWIFT: Well, generators that stick very close to the targets that are provided for them through the marketplace and who don't trip off or diverge from those dispatch targets are not causing a need for an ancillary service, whereas those who

do fluctuate a bit and do operate away from their targets do. So that's, in a sense, the mathematical drivers as to say who should pay for these things. You can also think customers trip off and cause the need for some of the lower services and generators can trip off and cause a need for raised services. So there are allocation methods that are gone through for each of the different categories.

MR JACOBI: Do particular generators with particular characteristics cause that more than others?

MR SWIFT: Yes.

MR JACOBI: And they are?

MR SWIFT: Well, each individual generator is monitored in its behaviour. Larger generator and causer pays factors are calculated and published regularly. So that does vary and it depends on their performance.

MR JACOBI: Going into the future, we've talked about the market model operating in terms of the pricing structures and in terms of the supply of energy and also the market structure for ancillary services. Is there expected to be changes in either of those market structures as we move into the future with changes in generation, transmission and distribution?

MR SWIFT: Yes, there are. It hasn't been a issue to date but as we get down into a system which has a lot more generation from renewables, which is often low or no inertia generation, and as we get more intermittent generation we are looking at how do we actually maintain frequency control in a low inertia system. That may require additional or slightly different ancillary services and there's work underway at the moment looking at when or how that might be required.

MR JACOBI: I think we've addressed in terms of the financial structure of the market about who pays and how payments are organised. I'm interested in understanding whether there's a financial market overlay in terms of the way that the market operates and the way that retailers and generators interact with one another.

MR SWIFT: Yes. The spot market price can vary from minus $1000 per megawatt hour up to $13,800 per megawatt hour. That's a very wide range when you're thinking about a product that – on average wholesale electricity at the moment is probably in the $40 sort of nominal range. So it's an enormous range that it can go over and in an energy-only market we need the price to be able to move over a large range so that it can clear under most circumstances and so that it can fund generators that only need to be there for a few hours a year under peak load conditions.

So with that wide range of potential price outcomes, anybody exposed to that market has a financial risk. If you're a generator you have a financial risk in terms of the revenue that you're going to receive and you have regular price costs to pay. So you'll be looking to try to stabilise your revenue. If you're a retailer who has contracted with customers to supply them energy, you want to stabilise the price that you pay. So, therefore, both sides of the market have an incentive to try to manage costs and the outcomes of the market pricing.

There are two main techniques we've seen people do there, either to structurally deal with that by becoming, as we call them, gentailers, companies which actually contain a significant amount of retail and generation capacity in the one, or to use financial markets and contract instruments to manage their financial outcomes. There are actually traded derivatives through the Australian Stock Exchange and there are a range of organised bilateral and over-the-counter contracts often undertaken under similar standardised processes through arrangements set up with the Australia Financial Markets Association and ISDA agreements. So there is a need and all companies operating in our market do manage their risk and, to the best of our knowledge, the vast majority of energy going through the grid would be contracted by the time it is actually cleared through the market.

MR JACOBI: In terms of proportions… You talked about the two different methodologies. One is to vertically integrate, as I understand it, and the other is to enter into contractual arrangements between independent entities. Is there a preference or a tendency to do one over the other?

MR SWIFT: Well, we've certainly seen over the period that the market has been there – we have evolved three very large gentailers that operate in the market. So that has certainly been a model of interest to many players but we do actually have active financial markets and we do have a number of generators and retailers who are independent.

MR JACOBI: Perhaps if I can get you to come back to the answer that you gave. You expressed that most electricity going through the market was already contracted. I just wonder whether you could unpack that and explain.

MR SWIFT: Well, that doesn't necessarily affect AEMO. We settle the market at the cleared market prices but then if you have a derivative contract around that, the generators and retailers would settle up after the fact to bring it back to the agreed price that they contracted for. This is sometimes called contracts for differences or those types of techniques. So we clear the market at the market prices but the participants loop around the market through these contracts to ensure that the price that they effectively pay or are paid is fixed. It's probably of the order of more than 95 per cent of the energy that is cleared through the market that is actually

under some sort of contractual arrangement.

MR JACOBI: Given the need for these financial arrangements or integration, is there a particular implication in terms of a new generator that is minded to enter the system? Does AEMO have any observations about what new generators are seen to do?

MR SWIFT: Yes. Well, a new generator would generally need to think about how it actually got a contractual position that at least backed its position for a number of years and for the majority of its generation. And that, if you didn't have that, it would make it quite difficult I imagine to finance such a project and so on. We did actually, on this graph, perhaps I should draw attention to the graph, you can see in that, that is just a random day, where you can see the five-minute prices and how they move around on a day. And on that day they have gone negative in South Australia for a period; they have gone positive for a period. The period where they have gone negative is very early in the morning where there is low load, so there must be wind blowing in South Australia in that case, so you get a bit too much generation here. So that forces the price low and then even negative for short periods. And then as the load comes up on the day, the price rises as you have to move up the merit order stack to actually supply that load. You will also see that the prices in the different states diverge at times and when they are diverging, if it's a minor divergence that is just loss factors. If it's a significant diversion that is because that line would be added to transfer limit.

MR JACOBI: Now on the graph what we are seeing there are wholesale prices not – is that right?

MR SWIFT: Absolutely. Now this is only the wholesale electricity price. The price that customers see is the wholesale price bundled up with the network prices, retailing, billing costs, those sorts of things and the final offer that then comes from their retailer for that total supply and delivery of the energy to their door.

MR JACOBI: Now aside from the outer bounds that you have described, the minus $1,000 are the prices within the wholesale market regulated?

MR SWIFT: No. There are obviously rules and requirements and as I mentioned before the AER are responsible for compliance to those but no, we rely on competition and the market construction to deliver efficient prices to customers through the wholesale market. The network charges are obviously regulated. Retail prices are across the national electricity market for larger customers are all deregulated, so they are totally driven by competition and in South Australia and Victoria, for all customers it is driven by competition.

MR JACOBI: Now we have talked about - finally come to the retail end, we have

talked about generators, transmissions and distribution as being part of the NEM. What role do customers have as part of the NEM?

MR SWIFT: Well, customers traditionally have been a fairly passive part of the electricity supply chain and their task is to look for the best offer from competitive retailers that is available to them. Some of the moves that are afoot now are to increase the choice available to customers and that is where new products and services are coming for customers where they can, using advanced metering infrastructure might be able to choose when they take energy and how they take it, based on the price of that energy. You will hear lots of stories about smart systems and smart meters which is the way in which systems around the developed world are going, to actually allow customers to participate more effectively in these markets by making choices in the way in which they use energy. And of course, at a bigger scale, they are making choices anyway as to whether to install solar cells on their roof and perhaps in the future whether they install a battery in their garden.

MR JACOBI: Mm. We have spoken about system stability and I am just interested in the reliability standard that is fixed within the system. About what it is and what its affects are?

MR SWIFT: Yes. In terms of the wholesale electricity market we have a probabilistic standard which is that we target no more than .002 per cent unserved energy in a region, averaged over time. If I turn that around the other way, that means that customers should receive 99.998 per cent of all the energy that they want. You can never make it 100 per cent because there is always the possibility under high load conditions that generators trip off, that transmission lines fail. You have also got issues with of course bushfires and lightning and so on. So that is considered to be a reasonable target for a developed country, to provide a high level of reliability. In the national electricity market itself, the way that is delivered is by those price settings in the market. And those price settings are regularly reviewed by the reliability panel under the AEMC and are reset from time to time to ensure that they will supply sufficient incentive to achieve those standards. In terms of the networks, obviously you have to have a reliability standard to which they are built to deliver that power and that is set up slightly differently in each state. In South Australia the reliability standards for transmission in particular are well prescribed by ESCOSA, the regulator here and reviewed on the same regulatory cycle as the AER set revenue.

MR JACOBI: Just interested in the – you have described the reliability standard in terms of the range of prices that are available within the market. I am interested to know the relationship between then the reliability standard and signals for investment within the system? Is there a relationship?

MR SWIFT: Yes. Well, totally. And the high price set in the market, or the market price cap, the highest it's allowed to go, which is currently $13,800 per megawatt hour, that is devised based on modelling, to show that that will return sufficient revenue to fund the last generator required to deliver that sort of level of reliability. As you can imagine, to achieve such a high level of reliability, given the fact that the demand from customers is quite volatile, some of that demand is met by renewable generation like wind and solar. So you finish up – if you want to achieve a high reliability, some generators will need to run for only a few hours in a whole year. So they have to, in that few hours, recover their total cost of ownership and operation. So that is why you need a high figure and that figure is set through a detailed process with this panel which consists of a range of representatives from generation and retail and customers and AEMO is ex-officio member of that. So that is part of the process to make sure that the market is set up to provide the right pricing and incentives to delivery the reliability standard.

MR JACOBI: You spoke earlier of there being retirements of plants within the system, particularly in South Australia, including the Torrens Island - - -

MR SWIFT: Mm.

MR JACOBI: - - - Pelican Point facilities. Do we take – is it a reasonable interpretation to then conclude that the price signals as they are currently operating are pointing to exit?

MR SWIFT: Yes they are. And we talked a bit about the surplus generation. The surplus generation has been driven by the fact that we have had falling or flat demand since about 2009. That is unprecedented in the history of the electricity industry and was a surprise to the industry. In the past electricity industry consumption, or electricity consumption has been very closely linked to economic growth and this is the first time we have seen a decoupling of that where the economy since 2009 continued to grow but consumption fell. So that created a surplus of generation to some extent. And we also had an amount of generation pushed in to the market funded by feed in tariffs and the RET scheme. So that then means that many of the conventional generators reduced their output, the price is reduced, but also the mode of operation of those generators is forced into an unusual mode that they are not designed for in terms of the shape of their generation. Those two factors have meant that some of the conventional generators have actually failed to achieve financial viability and they've had to change or are now closing.

MR JACOBI: I just want to come now to deal with how AEMO manages a balancing within the system, particularly given the intermittency of some generators, and how AEMO is working to address that issue.

MR SWIFT: There are a couple of key factors in terms of how we manage intermittency. One is the design of the market itself and the other is the forecasting system. If I start with the forecasting system, a few years ago the government funded AEMO's predecessor, NEMMCO, to develop the Australian Wind Energy Forecasting System which is a state of the art forecasting system. I do have a slide of the accuracy that it provides here. We note there 40 hours ahead – so that's almost two days ahead – we're down to a 6 per cent error. So that actually means that, although it's intermittent, we're able to predict what it's doing fairly closely.

Those forecasts are actually built into the market systems and the forward information that's provided to all participants in the market and that allows other parties to plan what they intend to do in terms of their operation into the market. So the forecasting system is a critical part of that. We are extending the technology in AWEFS to solar and we have it now running for utility-scale solar and we are developing the system to rooftop solar. So forecasting is a key part of it.

The other key part of it is the design of the National Electricity Market itself. It is a five-minute dispatch cycle, as I was saying before, real-time dispatch. People are able to bid and rebid up to seconds before the market clears. That means that the market is quite responsive to those fluctuations and changes. The price in the market, as was shown on that five-minute graph, does then provide the incentives to other parties to generate. I might say, if you then think about our discussion about financial contracts, it can also be seen as a risk factor. If generation isn't available to meet demand in each five minutes then the price is going to go up. So people have an incentive there to be there to actually help manage that volatility of supply.

It's not only the supply that varies, of course. Since well before wind we had to deal with variability, loads variable. So that's just part of running a power system, managing that. I was doing some work just the other day. We were reviewing again and the indications are that the wind generation, although it has risen in the NEM, has not to date caused an increase in the requirement for regulating services. So we are still quite well managing that intermittency.

MR JACOBI: Has it led to an increased need for scheduling of generators within the system? Has it led to a new category of how that's addressed?

MR SWIFT: Yes. As part of bringing in the larger numbers of wind generators we created a special category of semi-scheduled. All the larger generators are scheduled which means that they are controlled through the dispatch process and managed – most of them are actually managed directly by AEMO's power system,

energy market system. To cope with the large amounts of wind we created a new category called semi-scheduled. They can't be controlled in the way that a conventional generator can but their output can be capped in a period. So semi-scheduled requires them to be part of the dispatch process, part of AWEFS, and they can be capped if it's necessary to maintain system security.

There are other features in the market that help. I mentioned the minus $1000, the fact that the price can go negative. That's another way in which the market provides incentives. If there's too much generation on the system, the price will go negative and that will provide an obvious incentive for people to reduce generation.

MR JACOBI: Perhaps if I can just take you back. You spoke of the ability to control scheduled generators. What does AEMO in fact do? Does that mean that AEMO in fact decouples that generator from the system or engages it?

MR SWIFT: No. The National Electricity Market has what's called self-commitment. So generators are provided with a lot of information about what's happening and expected to happen over the coming period and they have to make their own decision about when to synchronise with the system and start generating. However, once they are generating they have to bid for dispatch. Most of the large generators are electronically controlled from AEMO's systems, although that's not necessary under the market, but they do have to follow dispatch targets that are set once they are synchronised to the system.

MR JACOBI: The Commission has heard a lot about decentralisation of the system and that is a continuing trend. We're just interested in what AEMO's perspective is on what the future of decentralisation is likely to be like and what its effect will be on the way that the market operates.

MR SWIFT: To date, as is seen from our forecast and the way we currently treat it, we do think a lot of embedded generation is just part of negative load, effectively, just part of the load on the system. That's becoming less tenable in the future as that becomes a more significant proportion of the energy in the system. I know power operators around the world are working on how a system might be managed in the future. We do rely currently on the large generators that are controlled by our systems to manage the frequency and control the supply-demand balance across the whole grid. That still works fine today but one can see the day coming when customers are more responsive to price with Smart Meters and home automation where they maybe have batteries, where they have solar and their own generation, where you do have to now start thinking about how you manage a system which is far more diversified.

MR JACOBI: Do you see that that distributed generation model will ultimately

produce efficiencies within the system itself?

MR SWIFT: The work that AEMO has done in the past in planning, I guess our view would be that diversity is a good thing. So hydrogeneration is a marvellous form of generation but if you had all hydrogeneration you'd be in big trouble when there's a drought. If you have all base-load generation you have very high costs and you don't have the flexible generation of the gas turbines and those sorts of things. If you want to have low emissions you've obviously got to have a range of low emission generators into the mix.

So our view would be that the overall lowest cost solution to reliable and secure power is a diversity of sources. Embedded generation and generation on people's roofs obviously can be a good part of that because it also reduces the losses in getting power to people and it reduces the need for network costs. On the other hand, it's a particular type of generation that generates in a particular pattern and you wouldn't want all generation to be coming from that source by itself.

COMMISSIONER: David, thinking about the future and the potential for aggressive activity for climate change, is that something that AEMO models? Clearly, you're thinking about it.

MR SWIFT: Mm.

COMMISSIONER: The impact that it has on your network and the generators?

MR SWIFT: Yes. When we do our forward planning, we obviously use scenarios that try to capture some of the range of possibilities, but we're not there to invent new policies. As I showed on the original slide there, there is a COAG Energy Council that looks at those sorts of broader matters and governments drive policies, not AEMO. So we wouldn't move into that space in that sense. We have, on one occasion, done a 100% renewable plan that was funded by the Federal government a few years ago, looking at what the issues and implications would be of trying to achieve that, and that is definitely a challenging position. The plans that we will generally put out in our NTNDP, we do publish what carbon emissions you would get in those plans, but none of those plans would have the deep cuts in emissions that some parties might argue are necessary.

MR JACOBI: I understand that the plan you just referred to features the analysis of 100% renewables.

MR SWIFT: Yes.

MR JACOBI: Was that a study of technical feasibility?

MR SWIFT: Yes.

MR JACOBI: And what were its key conclusions?

MR SWIFT: Well, perhaps I'm off the cuff there, but, I mean, the work did show that it was possible to do, and that actually showed the value of diversity. I can recall they had quite a bit of biomass as well as sort of solar and wind. It did show that there would be quite high investment required to get there.

MR JACOBI: And can I just come back just to deal with one final thing that I think we passed across, and that is that if you're thinking about the South Australian regional network, are there constraints on the size of new generation facilities that could be integrated within that system, bearing in mind issues of reliability and security of supply?

MR SWIFT: Yes. We haven't spoken about this. I did mention in the start one of the key factors in the national electricity market overall arrangements is this third party or open access arrangement, which allows parties to come along. In the first instance, they would come to ElectraNet or SA Power Networks, whoever they are trying to connect to, and make an application to connect. The rules then specify a process that's gone through to give them a fair and reasonable offer to connect, and that process takes into account the technical standards that you'd need to impose on that generator to make sure that it operated satisfactorily in the power system and maintained the security and power quality in doing so. That process, of course, has been worked through quite a few times over recent years in South Australia as new generators have connected, a few gas-fire generators and all the windfarms, and I know ElectraNet are giving evidence later and they have a lot of expertise in how that's done. AEMO also has a role in that process and we sign off a number of the parameters related to security of supply.

We have never done work on what would be required to connect a very large power station to the system, but I did talk before about how the whole arrangement is set up to be security constrained and that security constrained means that the power system is able to withstand a credible contingency. I'm not sure what credible contingency a large nuclear power station would impose on the system, but I imagine it would be a lot higher than the largest credible contingency we have today, and that would have implications. I would think a large power station would have trouble connecting and discharging its power into even a 275,000 volt line. So there would be limitations on the size of machine that could be connected effectively to the system as it currently stands, but I've not done, and I've not seen specific work done, on what those implications might be.

COMMISSIONER: David, thank you very much again for your evidence today. We very much appreciate the time you've given us.

MR SWIFT: Thank you.

COMMISSIONER: We'll adjourn now until 11 o'clock when ElectraNet will appear.

ADJOURNED **[10.05 am]**