NATURAL RESOURCES COMMITTEE

FRACKING

Balcony Room, Parliament House, Adelaide

Friday, 4 December 2015 at 10:10am

(OFFICIAL HANSARD REPORT)

PARLIAMENT OF SOUTH AUSTRALIA

WITNESSES—*continuing*

MEMBERS:

Hon. S.W. Key MP (Presiding Member)
Hon. R.L. Brokenshire MLC
Hon. J.S.L. Dawkins MLC
Hon. G.A. Kandelaars MLC
Mr J.P. Gee MP
Mr C.J. Picton MP
Mr P.A. Treloar MP

WITNESS:

INGRAFFEA, ANTHONY, Dwight C. Baum Professor of Engineering and Weiss Presidential Teaching Fellow, Cornell University

[Via Skype videoconferencing]

956 The PRESIDING MEMBER: Thank you very much for your time today, Professor Ingraffea. We have a number of people here in the Balcony Room in Parliament House, and we also have the media here, so no pressure, but we are looking forward to hearing from you. As you know, our committee, the Natural Resources Committee, is looking at the issue of fracking in the South-East of South Australia, and we have our members here. Can you see us, or can you only hear us?

Prof. INGRAFFEA: Yes, I can see you all very fine, thank you.

957 The PRESIDING MEMBER: Good. I would like to introduce the committee to you. We have the Hon. Robert Brokenshire, the Hon. John Dawkins and the Hon. Gerry Kandelaars. Those three gentlemen are all part of our Legislative Council, our upper house. We have Mr Jon Gee, who is the member for Napier, and my name is Steph Key, and I am the member for Ashford. Jon and I are in the lower house, the House of Assembly. Next to me is our research officer, Barbara Coddington, and on my other side is our executive officer, Patrick Dupont.

Because this is a parliamentary hearing, I just need to read you your rights so that you know your status. We have some people here from Hansard who are taking down what you have to say, which you will get a copy of. As I said before, we also have media people here who are very interested in what you have to say, as well as a gallery of interested both members of parliament and people from the community who are here to hear you. I will just get on with the introduction and then hand it over to you.

Prof. INGRAFFEA: Okay.

958 The PRESIDING MEMBER: Perhaps you could just wave if you cannot hear at any stage—that might work—because we can see you.

Prof. INGRAFFEA: Sure.

959 The PRESIDING MEMBER: You have agreed to give evidence to the Natural Resources Committee in South Australia by electronic means from a location outside Australia. Accordingly, parliamentary privilege may not apply in the same way that it would have if you had given evidence in South Australia. Should you publish your evidence to a third party, that publication may be subject to defamation laws in the state in which you publish it.

We really appreciate your attendance today. The committee is a standing committee of the Parliament of South Australia. Its powers and functions are set out in the Parliamentary Committees Act 1991. Sections 28 and 31 of the Parliamentary Committees Act set out the privileges, immunities and powers of this committee and the protection afforded to witnesses. Section 26 of the Parliamentary Committees Act provides that members of the public may be present during the examination of witnesses; as I said, we have a number of members here.

A request to make a statement in private will be considered by the committee and, if agreed to, members of the public will leave the room for the duration of that statement. So, if you feel that you would like to say something just to the committee, that can be arranged.

Prof. INGRAFFEA: Okay, thank you.

960 The PRESIDING MEMBER: The audio of today's proceedings will be streamed electronically within the parliamentary precinct, and the transcript of these proceedings will be available to the public once you have had an opportunity to ensure they are factually correct. As you know, today's hearing is in relation to fracking, unconventional gas inquiry. Could you introduce yourself and then continue with your presentation. As I said, thank you very much. We appreciate your doing this, so over to you, professor.

Prof. INGRAFFEA: Before I start, I am going to try to share my computer screen and make sure that works. Can you see my screen now?

961 The PRESIDING MEMBER: Yes, thank you. I will ask one of the committee members to move and second that your presentation form part of our evidence.

Moved by Hon. R.L. Brokenshire.

Seconded by Hon. G.A. Kandelaars.

Carried.

Prof. INGRAFFEA: Let me begin by thanking you very much for giving me the honour to give testimony to your committee. I'm taking this very seriously, and I'm going to do my very best to report to you facts, data, information that I believe to be completely true, and I will deliver it in the most honest way I can.

While you were speaking to me, there were a couple of times when the sound dropped out. I think that's because of the long distance we are communicating over Skype, so if I say something, if you see my mouth moving but you don't hear anything, let me know and I'll go back and repeat.

962 The PRESIDING MEMBER: Thank you.

Prof. INGRAFFEA: For your benefit, you will also note that in the lower right-hand corner of each of my slides there is a number, so if you have any questions about any particular information on any of these slides you can make a note and tell me later during Q&A and we can return to that particular numbered slide.

963 The PRESIDING MEMBER: Thank you.

Prof. INGRAFFEA: Let me begin with some preliminary comments. Did the screen change? Are you now looking at slide No. 2?

964 The PRESIDING MEMBER: Yes.

Prof. INGRAFFEA: Good. First, bravo, my compliments. I've extracted two quotes here from your interim report of past November and I've underlined two particular lines in those quotes. The first one is:

> Fracking is only one part (though a complex one) of the overall process of gas extraction.

I can tell you that I have had interaction with many legislative and regulatory bodies in the US and around the world over the last six years and you are the first—the very first—legislative body to acknowledge that the issue about which we are speaking is not fracking: it's shale gas in its entirety—in its entirety. Fracking is a part, as you notice, but it's one of only many parts, and as you will hear during the rest of my testimony, in my opinion it is that part that brings with it the least risk.

So, I think it's perfectly appropriate, knowledgeable and wise of you to up-front acknowledge that we're really talking about in South Australia everything having to do with shale gas development, storage, transmission and end use. So, my compliments.

I would also note that you are only one of three legislative bodies that I am aware of on the entire planet that decided to do an inquiry into shale gas before any production occurred in

your territory. Again, my compliments. If you are curious to know who the others are, I'll let you know later, but you're in good company.

965 The PRESIDING MEMBER: Thank you.

Prof. INGRAFFEA: Having said wonderful, laudatory complimentary things, I want to go to my second opening comment which perhaps you won't find so delectable. When I was first contacted to give testimony to your committee and I started to investigate the geology, geochemistry and hydrocarbon history of your state, I was frankly astounded. I couldn't figure out why in South-East South Australia you are really seriously considering developing shale gas.

The reason I say that is because, in a way, similar to a couple of states in the United States like Illinois, North Carolina, Maryland, where there might be, but have not yet been confirmed, some shale gas resource, those states in the US have gone to great lengths to go through the entire process multiyear—all kinds of debate, all kinds of legislative gnawing and gnashing of teeth—and when they finally did some investigation they found out there was nothing there.

My second point is, as you know, the negotiations in Paris about climate change are underway right now and the fundamental basis for those negotiations is to decrease the development and use of fossil fuels. With only the possibility of a relatively small shale gas resource in one corner of South Australia, and with the science acknowledging that we need to keep roughly three-quarters of all the undeveloped fossil fuels underground if we are going to meet our climate-change objectives, I'm a little concerned that South Australia has already done its part to produce fossil fuels; you are producing oil and gas in the north-east.

At some point you as a state and you as a legislative body are going to have to decide which of your fossil fuels you are not going to develop. So, I think I have told you already, by implication, that I would hope you do not develop the shale gas fields in the south-east corner of your state for these reasons and other reasons I am about to describe.

The rest of my testimony will be built around your terms of reference, of which there are four, and I will explicitly address each of those. But before I do that I want to make sure we are on the same page about what we are talking about here when we say shale gas development because of all the legislative and regulatory bodies with which I have had interaction very few of them have appreciated the fundamental differences, and there are two of them, the two fundamental differences between developing shale gas and developing conventional gas. So, I want to take a few moments to make sure that you understand what I mean by those two fundamental differences.

One of them is spatial intensity and I will show what that means in a couple of pictures, but here I am using a graphic produced by one of our gas companies, Chesapeake, that tries to depict, in essence, the entire process of getting shale gas out of the ground. What you will notice is that there is a regular grid of pads, roughly three kilometres by 1½ kilometres, and some thousands of metres in south-east South Australia—I suspect 3,000 to 4,000 metres underground—there is a shale layer, and supposedly in that shale layer there is gas, methane.

That shale is effectively impermeable. That's the reason why the oil and gas industry has waited till the very end of its epic to try to get gas and oil out of the ground through shale, because it basically doesn't want to give it up. To give it up, as you can see here, they have to drill a lot of wells, and they have to drill the wells not only vertically but deviated and laterally. When they have done that, this whole process that is depicted in this picture is inherently inefficient.

By that, I mean current data from all the shale gas production in the United States, across all the plays in the United States, shows that a process that is being depicted here with this density of wells produces only 7 to 10 per cent of the gas in place. It's inherently inefficient, and that is why they have to drill so many wells and they have to drill the laterals so close together. So, that is underground spatial intensity and surface spacial intensity.

They also have to use what I call the second fundamental difference, and that's technologies of scale. To get gas out of shale, everything is bigger, longer, more powerful. So let me show you through a series of pictures what I mean by technologies of scale and spatially intense development. I am looking at slide No. 6. I hope you are too. This is a Google Earth image of an area just west of Dallas, Fort Worth, Texas, and this is in the Barnett shale play, the oldest and most mature shale play in the US, where they are currently over 15,000 wells drilled in the last 15 years.

Every one of the white dots that you see in this picture is a pad. I am going to go to the next slide and zoom in, and you will notice that the scale will change from a four-kilometre scale to a one-kilometre scale, and again (I hope you can see my cursor) every one of these white dots, either a small dot or a larger rectangular dot, is a pad.

So, I am sure you are all geographically unchallenged, and you will note that this is an area that is roughly five kilometres by four kilometres, and there are over 60 pads in this area. That is spatial intensity. Why spatial intensity? Because the shales are inherently impermeable; whether it is South Australian shale or Texas shale, it is impermeable, and to get 7 to 10 per cent of the gas out of it you have to beat it to death with many wells.

I am extracting another quote from your interim report, and I want to point out that this quote is inherently incorrect. It says that since multiple wells will be drilled with horizontal segments from one pad there will be reduced overall impact on the landscape compared to coal seam gas. Well, show me reduced impact here. Right now in South-East Australia you have no impact, so any impact is great impact. This is spatially intense impact and it's the only way that any operator can get reasonable production out of a shale play.

I'm going to ask you to use your imagination now and let's go to the South-East corner of South Australia. I suspect some of you have been to the Jolly 1 well. Here it is, here is Penola. You will note that this map I'm showing you right now is to the same scale as this one, so I'm going to ask you to use your imagination and map these 60-plus pads into that area, and ask whether that is spatially intense and whether there is significant area impact. I think the answer to both those questions is yes.

Technologies of scale: I mentioned that getting gas out of shale is difficult. Everything is longer, bigger, higher, deeper. I listed a bunch of aspects of shale gas development to emphasise what I mean by technologies of scale.

Larger drill rigs: you drill not only 2,000 or 3,000 metres down, but you're going to have to turn that well and drill another 2,000 or 3,000 metres laterally. That requires very large drill rigs that we call them triples. Those drill rigs require much more diesel horsepower on the drilling engines than traditional drill rigs. More diesel horsepower, more noise, and more NO_x emissions.

Fracking equipment: the fracking that has occurred in the north-east part of your state is traditional fracking. It uses perhaps a few hundred thousand litres of fracking fluid. To get gas out of shale you will need 20 million litres of fracking fluid per well. You will also need pressures three or four times higher than are currently being used for frack jobs in your state. I'm using English units here in Australia but typically 15,000 pounds per square inch of fluid pressure, so higher fluid volume, higher pressures—you will need 25,000 horsepower pumps.

Because you're pumping 20 million litres of flowback down the well, you're going to get five to 10 to 15 million litres back up the well as flowback. That's waste; it's contaminated fluid, no longer drinkable, no longer able to be put back into the water cycle. So you have to figure out what to do with large volumes of fluid waste from each well, and remember that each well is on a multi-well pad. There are going to be longer and larger flares and venting of methane; more truck traffic to bring water, fracking chemicals, pumps, proppant—10 to 20 times more truck traffic than for conventional wells.

Every one of these pads is connected by a pipeline, so you're going to see a lot of pipeline construction and that disturbs the surface, and more and large compressor stations and processing plants. Compressor stations to increase the pressure from the wells that rapidly deplete—that's another characteristic of shale gas wells that make them different from conventional gas wells. The depletion rate is extremely quick. The pressure drop is extremely quick. That means you need compressor stations to get the gas out of the gathering lines and into your transmission lines. If you develop the gas and it turns out to be wet, you will need processing plants. Throughout this whole process you will have much higher emissions than you would have on conventional well pads because everything is bigger, longer and more powerful.

With that as background—those two fundamental differences—let's address each of your terms of reference. The first one I choose to address is the risks of groundwater contamination. I'm going to take you to the state of Pennsylvania. The state of Pennsylvania overlies the Marcellus

gas play which is the largest shale play in the world. The state of Pennsylvania prides itself on having very tough regulations; regulations that have twice been revised in the last five years.

We published a study in a peer-reviewed journal last year where we attempted to determine how many of those shale gas wells were leaking. That's what we mean here by 'impairment rate'—what percentage of the shale gas wells drilled in Pennsylvania in the Marcellus were known to be leaking within the first five years of their having been drilled. We compared that leak rate in the shale gas wells to the leak rate in the non-shale gas wells and we used the statistics provided to us by the Pennsylvania Department of Environmental Protection—that's the regulatory body in Pennsylvania—and their records show that shale gas wells were showing a leak rate of about 6.2 per cent in the first five years as compared to an overall failure rate in conventional wells of 1 per cent—one in 100 conventional wells and six in 100 shale gas wells.

In some regions of the state where drilling occurred very, very quickly, where operators were totally inexperienced, the failure rate in the wells was almost 10 per cent—one in 10—within the first five years, leaking. If you have leaking gas wells, you have a risk to groundwater contamination.

I am going to show you another map. This is a map of the state of Pennsylvania, and I am going to draw a correlation between the leaking gas wells and the contaminated water wells. This is from an industry presentation to its shareholder group. You will note that the south-western region of Pennsylvania and the north-eastern region of Pennsylvania are the areas where the gas in place has the highest density and where the largest number of shale gas wells have been drilled. Keep that picture in mind.

This is the same state of Pennsylvania and this is a map which colour codes the density of complaints by private landowners of water well contamination. The counties that are coloured here (and that's not all of the counties but it comprises most of the north-eastern region and the south-western region), in those counties there have been over 2,300 complaints of water well contamination from shale gas wells. The colour gives you the density of complaints.

We will visit Bradford County again. There have been over 400 individual complaints from landowners in that county of their water wells being contaminated by shale gas development. In Greene County in the south-western corner there have been over 600 complaints.

A complaint isn't the truth, necessarily. If someone complains that their water well is contaminated doesn't mean it has been, so the Pennsylvania Department of Environmental Protection, as the regulatory body, is legally required to investigate each of these cases, so you can imagine the workload that that regulatory body has had in one state, having drilled 9,000 shale gas wells and received over 2,300 complaints.

Of those 2,300 complaints, 260 of them have been determined by the state to be positive, that is, yes: your water well was contaminated by methane or another hydrocarbon from nearby shale gas development. That's a 10 per cent hit rate, so far. Over 1,000 of those complaints have not yet been investigated. There is just too much of a workload to do it.

Let's go to the next term of reference: the effectiveness of existing legislation and regulation. You provided me with your Petroleum and Geothermal Energy Regulations version 2013. I think those are the most up-to-date: if they aren't, let me know now. I read them thoroughly and then I started doing word searches on them. The first word I searched for was 'shale', and the word 'shale' does not occur in your regulations, nor do the words 'green completions'. I could go on and on. There are many examples in which your regulations are, in my opinion, laissez-faire. They are not explicit with respect to important elements regarding wellbore integrity.

The reason I can say that is that I have read the regulations of virtually every shale gas producing state in the United States and all of the shale gas producing provinces in Canada. I have read those regulations and analysed those regulations, and I can tell you that your regulations are not yet up to snuff, compared to those of peer states and provinces.

I mentioned previously that our state of Pennsylvania, which saw commercial shale gas development in 2007 has twice made major revisions to its regulations to account for the fact that the regulations that were in existence in 2007 were not appropriate for shale gas development. As the regulatory body learns from the mistakes of industry, they revise their regulations.

I am strongly suggesting that, as additional homework for your committee, you do a thorough review of regulations from other regulatory bodies if you have not already done so, and I think you will see what I mean when I say that your current regulations are vague, laissez-faire, written such that the industry is given all the responsibility to interpret things the way they want and the state in this case is left, in my opinion, holding the bag.

I would suggest that you start with the regulations in Pennsylvania. It is the place where we have the largest shale gas development going on in the US and I also suggest that you look at the regulations that were written for New Brunswick, Canada. They do not yet have any shale gas development but they are one of the bodies that I mentioned before that did a very thorough investigation and actually wrote regulations before allowing it. I think you will find stark differences between those two sets of regulations and those for South Australia.

I want to show you some other pictures of what shale gas development looks like. I know some of you have visited other states in Australia to see where some shale gas development is going on, but I am not sure you have seen what it really looks like when it gets going. This is a seven-well pad in Pennsylvania. Here is the pad and there are seven wells here. You will notice that there are a number of retention ponds for both waste and fresh water. You will notice large vegetation removal. These are no longer the small pads that you are used to for conventional oil and gas development. They are large.

Flowback impoundments: I did not see anything at all in your regulations regarding surface containment or underground containment or tank containment or lake containment of flowback. This is a major issue in the United States. It was when it got started in Texas in 2000: it is still a major issue now. Where do you put the waste? Where do you store it temporarily? How do you protect the public from the noxious odours from the waste and from surface spills from transporting and storing the waste?

Flaring: the word 'flare' does occur in your regulations, but it does not say anything about when the flaring has to start, when the flaring has to stop. Flaring for a shale gas well can go on for weeks—not hours, weeks. That is a 200 metre tall flare 120 dB at its base.

I already mentioned compressor stations. Compressor stations have evolved. I didn't see anything at all in your regulations regarding the different types of compressor stations that can be installed. Noise pollution and gaseous emissions from compressor stations are common and are common complaints. If you have wet gas, you're going to need processing plants. Think of them as mini-refineries—again, lots of noise, lots of flares, lots of noxious emissions.

In sum, shale gas development, as it is practised, requires a large number of spatially intense, large, multi-well, clustered pads and significant ancillary infrastructure—pipelines, compressor stations, flowback storage, truck farms, processing units. All that has to be taken into account by regulation.

I want to conclude by pointing out that you've done tremendous homework. Again, I am lauding your committee for the research it has done, but there's more research available, so I'm pointing you here to the largest current database archive of peer reviewed science literature on shale gas. My organisation put this together starting about a year ago. I want to point it out to you. This is a bar graph that shows the publication history of peer reviewed science on shale gas development, actually shale and tight gas development. You will note that in 2009, a few years after things had started in the US, there was a total of six peer-reviewed publications in the entire world—six. What you're seeing now is exponential growth. We're now seeing about one new publication per day.

Fifty per cent of all the published peer-reviewed science on shale gas has been published in the last 1½ years. We didn't know much when we got started in the US. You're in a much better position; you haven't started. I'm a professor and I'm used to giving people assignments, but it would be way above me to give you the assignment of reading all 650 of these papers. But you are now aware of them; you can't duck the issue. The science is now there. You're in a much better position to make informed decisions about what you're going to do with shale gas development and what you're going to put into your regulations if you go ahead with it. You have no excuse for ignorance. Many states in the US went ahead without this knowledge—you can't.

We have taken that database and divided it into 12 categories to make it easier. This is a screenshot which shows all the categories listed on the left. You pick a category and it will show

you every one of the papers, and to the extent that we have the legal right to distribute the paper, you can download it from this website. If we do not have the legal right to distribute it, you can go to your library and get it.

If you do an analysis of some of these subtopics, you will find startlingly clear consensus. These are science papers. If we ask what the science says about health impacts, human health impacts, you can go into that database and you will find that there are 16 peer-reviewed papers, so far only 16 peer-reviewed papers, on health impacts. Of those 16 papers, 87 per cent of them—14—say the health impacts are bad. None of them say the health impacts are good. Thirteen per cent of them say we haven't measured any health impacts.

It is a similar situation on air quality: 92 per cent find negative impact, bad impact on air quality; 8 per cent say no measurable impact on air quality. Water quality impacts: three-quarters of the papers published so far find that there have been bad impacts on water; about one-quarter say no measurable impact. There's a growing consensus, the number of papers is growing, and the consensus is growing, and it's now your responsibility to learn about this and decide what to do about it.

To summarise: again, because of the two fundamental differences between shale gas development and conventional gas development—spatial intensity and technologies of scale—I am making the following four assertions with regard to your terms of reference. The risks of groundwater contamination in your state, if you go ahead with shale gas development, are very high. Why would they not be? What makes you think you're going to be different from Pennsylvania?

Fracking is not the issue with water contamination. Well bore integrity and surface spills are the issue so again, you are wise to make sure that your committee is investigating not just fracking but all aspects, including drilling, wellbore integrity, surface fills, transportation of chemicals, transportation of waste, and the impacts on the landscape. I showed you images and photographs; I showed you maps. They will be considerable. You will be changing the landscape of that part of your state.

The effectiveness of existing legislation and regulation: I think your regs are wholly insufficient in their current state. They do not address the problems and the issues that have occurred in other provinces and other states that have been addressed and revised in much tougher regulations.

I didn't say anything at all at this point about the potential net economic outcomes to the region and the rest of the state, partially because the economics in Australia are different from the economics in the US, but I would point out that in the US the shale gas boom has busted. It's done; it's over. Let me repeat that: the shale gas boom is over in the US. The US will never again produce as much shale gas as it did in 2014. All the major shale gas plays are in decline except for one.

Shale gas is an extension of the fossil fuel era. It is not a 100-year supply. It is not a 50-year supply. In the US, it will wind up being about 10 to 15 years' supply. That's my testimony. I want to thank you once again for allowing me to testify to you. I would be anxious to try to address any questions you have at this point.

966 The PRESIDING MEMBER: Thank you, professor. We appreciate your comprehensive presentation and also overview. We do have some questions from our members. Mr Brokenshire, do you want to start the ball rolling?

967 The Hon. R.L. BROKENSHIRE: Thank you, Chair, and thank you, professor. On one of your slides, professor, you had a photograph of Barnett, Texas, where there were 15,000 wells, and there was a lot of agricultural production still occurring with and around those wells. Are you seeing coexistence or are there problems in production declines, being able to operate the agriculture properly there, and any possible issues regarding livestock and contamination?

Prof. INGRAFFEA: Sometimes the sounds breaks up, and I'm not sure that I heard, but I think you're referring to this slide and impacts on livestock?

968 The Hon. R.L. BROKENSHIRE: Yes, livestock and cropping, cereal cropping, etc. You can clearly see a lot of arable country there and a hell of a lot of wells.

Prof. INGRAFFEA: I'm glad you asked that question. I can point you to a paper that was published just recently addressing exactly that issue, not only in the Barnett play but also in the Bakken play in North Dakota and the Marcellus play in Pennsylvania, that investigated animal health impacts, both direct, because animals need to drink water, and indirect, because of the air impacts, dust impacts and the surface spills. There is now a one-paper database in the open literature that discusses exactly the question you asked.

There are impacts. There is a lot of anecdotal information, certainly in an area like this which is known for not only its farm but its cattle grazing. There is a well-known incident in the Haynesville shale play, which is in Louisiana, in which a few dozen cattle died within a day because they unfortunately drank from a spill, a flowback spill. Flowback, as you know, is salty, and livestock frequently are attracted to salty water, and they drank it and they died. That's anecdotal. There are anecdotal cases in Pennsylvania and North Dakota which are similar—livestock dying.

But the big picture here is yet to be painted. When you see this image I am showing you, and you have all those wells and all the air emissions and all of the possibilities for water contamination—I don't know what to say. I am not an animal health expert. I am not a crop-growing expert. I defer to the veterinarians and the agronomists who are saying that there is a growing concern that this high density of development inside of what was an agricultural area, inside of what was a grazing area, is problematic.

That is another basic problem with shale gas in general: it envelops you. If you look over on the right here, this is a housing development. There are places in Dallas, Fort Worth, where you have multimillion dollar homes with shale gas wells in their backyard and compressor stations across the street. Because of the spatial intensity, the companies drill where they can.

In most jurisdictions in the US, zoning law does not trump oil and gas law. You can have a community that has zoned residential areas, but oil and gas law trumps that. If someone owns the mineral rights—I guess, in Australia, the state owns the mineral rights—if the state decides to put an oil or gas well in the middle of a residential area—I suspect that they wouldn't; in the US they would because the mineral rights are owned by private individuals. That's a long answer to your question, and probably an unsatisfactory one, but I did the best I could.

969 The Hon. J.S.L. DAWKINS: Thank you very much, professor, for your evidence to us this morning. As a bit of a follow-on from the Hon. Mr Brokenshire, I wonder whether you could tell me what the attitude of the farmer organisations in Pennsylvania, North Dakota and perhaps the other states you have described to the shale gas activity—

Prof. INGRAFFEA: I can't hear the question, I'm sorry.

970 The Hon. J.S.L. DAWKINS: Okay, I will repeat it. I wonder whether you could tell me what you know of the attitude of the farmer organisations that exist in Pennsylvania, North Dakota and the other relevant regions to the gas activity, particularly in relation to what the Hon. Mr Brokenshire just asked you. Also, has there been a focus from the agricultural sectors on being able to produce clean, green agricultural products, particularly in exports? If so—

Prof. INGRAFFEA: I'm sorry, I really apologise. I wish I could be there with you, but I only got every third or fourth word. If someone could repeat the question very close to the microphone and loud, I will do my best to answer, but I'm sorry—

971 The Hon. J.S.L. DAWKINS: I do not want to shock you, but I will come even closer. I have never been accused of having a quiet voice. Firstly, about the attitude of farmer organisations in Pennsylvania and North Dakota particularly.

Prof. INGRAFFEA: Sorry, the attitude of?

972 The PRESIDING MEMBER: Farmers and farming organisations.

973 The Hon. J.S.L. DAWKINS: Farming organisations. The groups of farmers who have bodies that represent them. We call them here the National Farmers' Federation or Primary Producers South Australia.

Prof. INGRAFFEA: I think what I am hearing you say is the 'attitude of farmers'?

974 The Hon. J.S.L. DAWKINS: And their peak bodies, the organisations that represent them to government and to politicians.

Prof. INGRAFFEA: I am going to try something. I am going to try to stop sharing my screen and maybe the sound will come through better. Just try it now.

975 The Hon. J.S.L. DAWKINS: Okay, I will try again; I apologise.

Prof. INGRAFFEA: No, you shouldn't apologise; it's my fault because I am not there.

976 The Hon. J.S.L. DAWKINS: Not at all. I suppose I am interested in the attitude of the peak bodies that represent farmers in North Dakota and Pennsylvania in relation to the activity you have described to us, and also if those bodies and individual farmers focus on a clean, green image when marketing their products. And, if so, has there been any impact?

Prof. INGRAFFEA: Okay, I think I'm finally getting it. Let's see if my answer comes close to your question. In the US, as I mentioned before, in general mineral rights are not owned by the state, they're owned by individuals and, in cases like Pennsylvania and Texas that I'm describing here, those individuals very often are farmers.

So, on the one hand you have farmers who might be struggling to make ends meet. Texas has had drought for five years. Pennsylvania farmers are getting very low prices for their dairy. They saw shale gas development as a godsend. It was magic. It was like winning the lottery.

At first, they welcomed shale gas development with open arms. They were all going to become 'shaleionaires'. They were going to get big cheques for free in their mailbox every month. Then, the water started going bad and then the cheques started getting smaller and then the bust happened and the cheques stopped altogether. Many farmers became millionaires overnight, or close to it. Many of them improved their farms, they bought new equipment, improved their stock herds. Many of them sold out and moved to Florida. They said, 'Why do I want to be a farmer anymore? I'm a millionaire.' So, you saw a whole range of responses.

The farming organisations, in general, had been pro shale gas development because they see it as additional income for farms which, in many cases, were struggling. On the other hand, we have a growing organic farming industry in the US and the organic farming industry is uniformly against shale gas development for obvious reasons. They can no longer sell their product. No-one will buy from an organic farm that is surrounded by shale gas wells.

So, we have a complex situation in the US. I suspect it's much different than the situation you have in South Australia. I don't know what you can derive from what I've just said that's helpful, but I'm imagining, since the state owns the resource, if a farmer in South Australia finds that his livestock or his livelihood on that farm is being impacted negatively, then I would think the state would reimburse him for that. That's part of the cost. This isn't pure profit for the state. There are negatives here.

977 The Hon. J.S.L. DAWKINS: Thank you very much for that answer.

Prof. INGRAFFEA: Was that close?

978 The Hon. J.S.L. DAWKINS: Thank you, yes.

979 The Hon. G.A. KANDELAARS: What has been the impact in terms of US energy markets in relation to shale gas? Hasn't it given the US independence in terms of energy sources?

Prof. INGRAFFEA: Again, I can't hear you. I think the clue here is you have to get that microphone right up next to your mouth and shout.

980 The Hon. G.A. KANDELAARS: What has been the impact in the US in terms of energy independence as a result of shale gas?

Prof. INGRAFFEA: What is the impact on energy independence from shale gas? Excellent question. Let me back up a step and say that the US currently consumes 20 million barrels of oil per day. Last year, the US produced nine million barrels of oil, mostly from its shale deposits. That's the new thing: shale oil, not shale gas. I will get to gas in a minute. The huge shale oil deposits in North Dakota and Texas allowed the US to go from roughly six million barrels of production per day to almost 10 million and then it peaked and dropped. It peaked in 2014 and it's on its way down. So,

the US will never be oil energy independent. It never was, it never will be. It can't be. We consume too much and we can't produce enough.

Let's turn to shale gas. Six years ago the US was producing and consuming 23 trillion cubic feet of gas per year. We're now producing and consuming almost 26 trillion cubic feet of gas. We are gas energy independent.

Before the shale gas we were on our way to becoming gas energy dependent. We were starting to import natural gas from the Middle East and from Canada. We no longer do that. So shale gas has made the US gas independent. The US is not energy independent. We are not fossil fuel independent because we will never produce enough oil, but we are gas independent. But, as I pointed out before, the shale gas boom has bust.

We produced 26 trillion cubic feet in 2014. Our Energy Information Administration is predicting that by 2016-17 total production of shale gas will start to decline. Most industry analysts are expecting that we will run out of shale gas at the current rate at which we are producing it, without exporting any of it, in about 10 to 12 years. If we start exporting it, we will be out of it in a much shorter period of time. It's a flash in the pan. I don't know if you use that phrase down there, but here today, gone tomorrow.

981 The PRESIDING MEMBER: We do, mainly to do with gold production. You're talking about the industry having gone bust. Where is shale gas being produced at the moment in the US?

Prof. INGRAFFEA: I mentioned that there is one shale gas play that is increasing, and I'm going to go back and show you where that is. You can see my screen again?

982 The PRESIDING MEMBER: Yes.

Prof. INGRAFFEA: Remember this is Pennsylvania, and this is a colour map which shows the density of gas in place per square mile. This is a billion cubic feet per section, that's a billion cubic feet per square mile surface. You will notice that here we're talking about the Marcellus gas in place, and here we're talking about Devonian and Marcellus and Utica gas in place. So, beneath the Marcellus shale in Pennsylvania, Ohio and West Virginia, there is a Utica shale; it is about another thousand metres down.

Production from the Utica shale is continuing to increase, but it is a small percentage of all the shale gas produced in the US. All of the major shale gas plays—the Marcellus, the Fayetteville, the Haynesville, the Barnett—they're all in decline as of this year. So most of the shale gas is now coming out of the Marcellus, but it's no longer growing: it's now decreasing.

983 The PRESIDING MEMBER: Thank you very much. I think we are going to have to leave it there.

Prof. INGRAFFEA: This picture says a lot more than I talked about. These colours mean everything. The industry talks about 'hot spots', not hot in terms of temperature but hot in terms of the gas in place. This is all the Marcellus, all this blue is Marcellus, but most of Marcellus is useless— 50 billion cubic feet per square mile is nothing, it's uneconomic. Yes, we have a huge play in terms of 20,000 square miles, but only a relatively small section of it is going to produce a lot of gas, and that's characteristic of shale gas.

If you go ahead and start doing exploration wells in the South-East, they will find the same thing. They will find an exploration well where there might be a lot of gas, and they will move one kilometre away and they won't find any or that it will not be economic to produce. Not all shale plays produced are born the same, and there is no such thing as uniform production across a play.

That's what we learned in the US and that's what you should be aware of. It could be that in the South-East you have a few wells that will be gushers, and you will have dozens that won't be economic, or it could be just the opposite; you don’t know. You don’t know until you drill a lot of wells, but if you drill a lot of wells you had better be prepared for the consequences.

984 The PRESIDING MEMBER: Can I thank you very much for your evidence today. We really appreciate your time. Despite the technical problems, we've really learnt a lot from you today. Thank you very much.

Prof. INGRAFFEA: We got over it. We're good, we got over it. Thank you very much for the opportunity.

[Skype videoconference concluded]