ESIG Webinar: AEMO's Connection Simulation Tool			
Question	**Answer**		
Does the simulation tool also helps users verify and correct their models? Are there any additional verification steps for the AEMO?	The intention is that users will be able to connect their plant to AEMO's wide-area PSCAD EMT model and directly tune their model to resolve issues, as well as verify their performance to an extent. AEMO takes no role in reviewing any of the results, and rather the tool is thought of as an optional sandbox.		
Does the simulation tool include "committed" and "anticipated" projects? not "proposed"?	A model setup for use in the tool will include the 'Existing' and 'Committed' projects at the time of an application to use the tool. Some 'Anticipated' stage generation can be included where it is deemed necessary, such as where contol interactions between generating plant, system strength or congestion issues are expected.		
how frequently is the system model updated ?	The system model is updated in bulk roughly every few months. Additionally, when setting up for studying a particular project, its local area will be ensured to be up-to-date within the model an updated as needed.		
PSCAD or PSS/e model for studies of the Generator interconnection ?	This tool focuses on allowing projects the ability to perform studies in PSCAD, however through our connection process a combination of both PSCAD and PSSE studies are needed. AEMO can directly provide PSSE models to proponents within our system to perform studies, unlike with the PSCAD model.		
"Confidentiality" issues aside, and given recent attacks on the grid in US and other places, how are you handling critical energy infrastructure information?	AEMO has many initiatives towards ensuring our systems are secure. With respect to this tool, tremendous effort was involved in creating secure, isolated virtual machines which themselves can only be accessed after a process of vetting and after contractual agreements around the use of the tool are signed. Physically, these systems sit disconnected from any access to AEMO's internal systems.		
How are you planning to balance the generation when inverter based generation not available?	While not directly related to the Connections Simulation Tool AEMO prepares an Integrated System Plan which is a whole-of-system plan that provides an integrated roadmap for the efficient development of our system over the next 20 years and beyond. That shows there will need to be a substantial amount of dispatchable sources - storage and potentially gas generation.	Link: Integrated System Plan 2022	Document Link: Integrated System Plan 2022
How do you decide how large the kept PSCAD system is?	AEMO's PSCAD model is the entire system up to around the 33-66kV level, with parts of the distribution network modelled where they are electrically significant to the performance of plant in that area. One jurisdiction is not included as it is isolated by a HVDC connection. In general, we act to represent all plant and network that is of material impact to new plant connections. In future we envisage the need to use equivalences as the number of connected plant continues to grow.		
how practical is it to study an interconnection-wide system using EMT analysis? Aren't the issues very location specific?	Simulation times range from around 1-3.5 hours. This could be improved with equivalencing of portions of the network, and is on occasion done within AEMO internally. This is a feature we're exploring for a future update to the tool.		
If connection studies by the network owners are an entirely separate process, by how much (if at all) will this tool reduce the connection process timelines?	The expectation is that use of the tool will allow a number of issues that would have otherwise been discovered by AEMO and the NSPs (network owners) to be found and resolved by the connecting plant before submission to us. These issues, when arising within the tool, can be immediately tested and the model tuned. If AEMO or the NSP was to identify the issue, only an approximation of the issue could be communicated to the project, and such a direct resolution as can be achieved within the tool would not be possible. The tool can also be optionally utilised in scenarios where AEMO finds an issue and the project needs direct access to that model showing the problem in order to find a solution.		

Can you give us hardware specifications and pice of the servers you are using? How fast are they for example for a 10 s fault simulation?	The Azure virtual machines themselves cost roughly a few hundred dollars per day depending on the size of the machine, ranging from a 32 core machine to a 104 core machine, noting each machine is paired with an additional 8 core machine (these are the master and client-side VM's as discussed in our presentation). This cost is part of what feeds into the overall fee that a user pays for use of the tool (on a cost-recovery basis). Simulation times range from around 1-3.5 hours for a 30 second simulation. Some additional information on pricing can be found in our fee structure available on our website.	Document Link: Simulator Tool Fee Structure	
Is there any Generator size limitation that can be connected ?	There is no upper limit on the size of the plant that could be connected to the models and used within the tool. There would be considerations around achieving a valid load flow for a very large plant which may mean a large connection would take additional engineering effort and setup time on the AEMO side. There is no lower limit on the size of plant that can apply to use the tool.		
Will it consider interconnection in the distribution network ?	Where a distribution network or distribution connected plant is electrically relevant to the study, we will endeavour to add these to the model. Plant within the distribution network can use the tool. We may seek additional advice from those applicants and their relevant NSPs (network owners) in integrating their plant to our models.		
How do you manage the computational burden on AEMO PSCAD server? do you allow developers access only during allotted timeframe?	The servers used within the tool are spun up only when an applicant has agreed to use the tool, and are destroyed when they are finished. The servers can be sized at many levels, with the primary factor being additional cost for additional size. The fee for using the tool paid by the applicant incorporates this cost. Additionally of note, applicants can choose from a low, medium and high spec machine which each incur different costs and which each are able to run the PSCAD wide-area model at different speeds.		
Do you model Distributed Energy Resources (DERs) in PSCAD? If yes, can you talk about how you do that ..	Currently DER is not fully modelled within the wide-area PSCAD models (outside of their output being represented through the equivalent load). There is work ongoing within AEMO to improve the DER representation within our power system models (see link)	Link: DER Power System Model Development	
Do network owners evaluate deep network upgrades in their connection studies and allocated such upgrade costs to the generator (like here in the US)?	This is not a characteristic of the NEM regulatory framework. The transmission networks operates on an open access basis. Typically network upgrades are done by the NSPs (network owners) and charges are applied to loads not generators. Generators have to consider congestion risks in their selection of connection location.		
how long does it take to run a typical simulation?	typically it takes roughly 1-3.5 hours for a 30 second simulation depending on the core count of the machine used (ranging from 32-104 cores). Other factors about the machine like clock speed can impact this as well.		
What assumptions are used in building a case for a particular project? Does the submitter have any input on that?	the major elements being considered are what additional 'committed' and/or 'anticipated' plant to integrate, their dispatch, and some minor considerations about balancing the load flow with those included plant (noting the case these adjustments are made to is initially build from a real system snapshot). What plant to include, their dispatch and moderate adjustments to the load flow conditions can be requested by the user when they apply to use the tool. The load flow used in the base PSCAD case if typically a 'low-load, high IBR, low synchronous generation' case taken as a snapshot from a the real system. We also make judgements about some additional faults and system measurements to provide to the project. These can be directly requested in a user application as well.		

Can multiple projects be included from a single request?	An applicant could submit multiple models for us to integrate, and it could be possible for us to allow them access to both within the tool for them to study (both simultaneously connected to the same network). In terms of the additional, relevant nearby generation, we will include all that are deemed necessary. An applicant can also submit requests for multiple sets of VM's to be setup for them (i.e. two models in two different sets of VM's connected to a different instance of the wide-area PSCAD model).		
Once a study is complete and satisfied, how does a developer proceed to get a grid connection?	We consider this tool as completely separate from the connections process which obtains a grid connection. A project may or may not seek to use the tool at any point before, during or after their connections process. The primary motives communicated to us for the tools use have been - to further tune the models prior to AEMO's and the NSPs (network owners) assessments to reduce risk that those assessment will find major issues. - for use when AEMO finds an issue and the project needs direct access to the issue (rather than an approximate replication of the issue) to find a resolution The use of the tool however is in no way limited to these two scenarios, and thought of rather as a sandbox that projects can choose to use for various reasons.		
Briefly, does the large share of projected coordinated DERs come from electric cars or some other source?	The level of coordinated DER we quoted is in an input assumption in one of the scenarios (step change scenario considered the most likely scenario) in the AEMO Integrated System Plan (ISP). The Integrated System Plan is a whole-of-system plan that provides an integrated roadmap for the efficient development of our system over the next 20 years and beyond. That report defines coordinated DER as including "behind-the-meter battery installations that are enabled and coordinated via VPP [virtual power plant] arrangements. This category also includes EVs with V2G [vehicle-to-grid] capabilities."	Link: Integrated System Plan 2022	Document Link: Integrated System Plan 2022
How the real time outages (planned and unplanned) affects the output of the Generator interconnection simulation?	As we currently don't directly consider planned or unplanned outages in our connections process (outages referring to temporary outages), we also don't consider them within the tool. We do have underlying requirements about the load flow and dispatch conditions we have set up in the PSCAD case that consider N-1 scenarios, and so in a sense they are partially captured by representing a valid operating condition. Planned outages are typically assessed in the operational space when planning for that outage.		
PSCAD V5 provides EMT answers but how does this relate to grid control when 80 plus percent of demand is met by IBR	AEMO has many initiatives to better understand the impact of an increasing share of IBR on the power system and the impact on the power system tools we use to study that system, such as PSCAD. Generally, where IBR penetration is increasing, the transient responses of plant and control interactions between plant become more impactful to the overall system performance, and so using appropriate tools that can effectively model those transients and the details of the plant controls becomes crucial to better understand the real system behaviour. The question of how or if EMT modelling in the real-time operation space is necessary is one example of a consideration that will be made as the transition continues.		

How relevant are EMT studies based on outer loop transfer functions as IBR folk do not provide detailed info	We require user-specific PSCAD models to be provided through the connection process, with many checks, balances and benchmarking initiatives to ensure the PSCAD model is representative of the real plant. For more detail on the requirements in the Australian context, both our Power System Model Guidelines and our Dynamic Model Acceptance Test (DMAT) Guideline may be helpful. Appendix C of the Power System Model Guidelines linked here may provide further information relating to your query.	Document Link: Power System Mo	Document Link: DMAT
As the levels of variable renewables increases do you have to run more cases with data across the Private Central to Client server interface?	Assuming by 'Private Central to Client server interface' it is meant an arrangement similar to the 'master and client server arrangement' as outlined in our presentation; there is not specific necessity to study a plants performance in this kind of arrangement in the Australian context. as mentioned in the question above, AEMO and the NSP's receive copies of the user-specific PSCAD models and have a requirement to complete studies to demonstrate the plant can connect to our system. We do see however that as IBR penetration increases, we are likely to have more complex issues to resolve which will need projects to have the ability to seek more direct access to the wide-area PSCAD models to assist in issue resolution; direct access like that which this tool provides.		
How to decide and build an equivalent for an external network to reduce the system size?	This will be a question we aim to answer if/when we move to implement a network equivalencing feature into the tool (as discussed in our presentation). We expect this will consider factors such as the electrical distance voltage disturbances of a certain size propagate within the network, with the general aim of assessing whether detailed modelling of a region to be equivalenced could impact the area of the network we are studying.		
Have you heard an expression of interest from any U.S. RTO/ISO or utility in developing a similar tool?	We have presented, and continue to be open to presenting, our experience on developing the tool with operators from around the world, including the U.S. We are not aware of any plans to develop similar tools but are happy to engage with anyone who would like to consider it.		
Why confidentiality is at risk if the models are compiled?	As discussed in more detail in other answers (see answers in cells B26 and B36), AEMO receives user-specific PSCAD models as part of the connection process. These contain sensitive data and comprise the bulk of the plant models in our wide-area PSCAD models. AEMO also has obligations under our National Electricity Rules to maintain confidentiality of the data we are provided.		
What general voltage levels / range are represented in your PSCAD model?	The model represents primarily the transmission level infrastructure, with some parts of the distribution network included were it is electrically impactful to the validity of our studies. This is roughly 33/66kV up to the 500kV level.		
What is the smallest and biggest generator can be interconnected via tool ?	see answer in cell B14 above		
How does the tool handle multiple projects that are planning to be connected into the system in the same year? How do they model the interaction?	In our connection process, for any connecting plant we require studies include all 'committed projects', which is a milestone that is passed in the connections process by all connecting plant. This committed milestone is typically reached some time before the plant begins construction. Our electricity rules require that plant not yet past this milestone consider all plant that have passed this milestone in their studies. We follow this method of including nearby plant for users of the tool (including all committed projects to date), with some exceptional circumstances where a plant close to that milestone may be included as well. also see answer in cell B5		
Does the connection simulation tool include proposed plant to allow an assessment of potential interactions with plant that is yet to be connected?	See answer above, and answer in cell B5		

Does AEMO have concerns about BPS security against bad actors who would be able to characterize the system and expose vulnerabilities using the tool?	Users of the tool are currently restricted to those we call 'Registered' or 'Intending' Participants as defined in our electricity rules. These parties have proven to be legitimate in their intentions to connect to our system through a detailed process of achieving the 'registered/intending' status. Legal contracts and agreements are signed prior to access to the tool as well. See also answer in cell B8 also around the security of the system itself.		
Majority of the Generator PSCAD model at the early stage of the project is from OEM (and could be different after commissioning) , how this is being dealt?	see answer in cell B22 on use of the tool throughout our connection process. Outside of the tool, our connection process generally requires assessment or the PSCAD model at the earlier stages of the project (what we call application stage), as well as at the more advanced stages of the project (what we call registration stage). We also require benchmarking of the PSCAD and PSSE models of a plant against actual plant behaviour during the commissioning stage. We expect that as a project progresses through the connection process minor changes may be required to the plant which we then require to be replicated in the PSCAD models, with additional assessments undertaken, if needed, to confirm the plant still complies with its requirements. Projects are free to utilise the tool at any and all stages of project development.		
3. Some projects might have different PSCAD models that only work with parallel simulations. Has the AEMO's connection tools been tested for those projects?	I assume this is referring to something like a plant with multiple PSCAD project spaces in a single workspace split across an ENI (two project spaces with different timesteps) (for example a wind + solar project behind a common connection point). This has not been specifically tested on the client-side server, however this is the process by which the wide-area PSCAD model runs its hundreds of project spaces, and so given there is little-to-no difference between the client and master-side servers we can say that we know it would be feasible (there are multiple projects in the large SPCAD case that operate like this). The client servers are 8 core machines to allow a reasonable processing power to accommodate this.		
4. What would be the procedures for a consultant/external entity to access the tool?	Users of the tool are currently restricted to those we call 'Registered' or 'Intending' Participants as defined in our electricity rules (these are typically the developer). This party would reach out to the Connection Tool team and go through a legal process and contract signing to get access. This developer will nominate an admin user for the web portal we demonstrated. They will have the freedom to add any additional users they require and give those individuals login access to the web portal (through which they can connect to the virtual machine to run studies). These users are likely to include the developers consultants and/or OEM.	Link: Connection Simulator Tool's AEMO Website Page	
What about thermal overloads on the transmission lines ?	We always try to keep lines from overload within the load flows we set up. The base cases we use are direct system snapshots with the additional of some local generation, and so we start from a known valid operating condition, taking precautions not to significantly deviate from this where it is not needed or not necessary.		
How do you coordinate projects that are close enough and are being interconnected at the same time?	See answer in cell B33		
Are the simulation outputs for a snapshot in time, or for a whole period of time? (e.g. a year of hourly power flows)	The case setup will be close to a direct system snapshot from a particular moment in time, with some changes made as appropriate or necessary. This acts as the operational case which the simulation is based on. Typically simulations run for around 30s, applying different disturbances to this 'base case' operating scenario we have setup in the case. We want to provide more 'snapshots' to choose from in future.		

Are you observing premature degradation of T&D equipements (i.e. transformer and switchgears) due to reverse power flow coming from DER?	AEMO does not own any assets in the Australian system. The various asset owners including the NSPs and TNSPs in our system would have more information on these kinds of questions.		
Could you comment on making many distribution networks independent. It might be more economic to situate voltage and frequency support at zone substations	Assuming this question is referring to isolated networks such as microgrids. There are initiatives to investigate these concepts in Australia that are largely led by our NSPs (network owners).		