DS3: RoCoF Alternative Solutions Project Phase 1 Report Comments

This template has been prepared to facilitate comments on the RoCoF Alternative Solutions Project Phase 1 Report. EirGrid and SONI commissioned DNV GL to produce the report titled "RoCoF Alternative Solutions Technology Assessment" as part of Phase 1 of the project. Respondents are not restricted to this template when commenting on the report and can provide supplementary material if desired.

These comments should provide information on the various sections of the report.

For information, please find linked the RoCoF Alternative Solutions Technology Assessment Report and the TSOs' Phase 1 Report Summary Document published on 25th June.

Please send responses in electronic format to DS3@eirgrid.com or DS3@soni.ltd.uk

Your Details:

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Company	*Tynagh Energy Limited*
Date of Submission	*17/07/2015*

Note: The TSOs may publish responses. If you wish your response to be treated as confidential, please indicate this by marking the following box with an "x".

Response confidential ☐

The closing date for responses is Friday, 10th July, 2015.

Synchronous & Synthetic Inertia	*Response / Comments*
Synchronous Inertia	
	Please provide any comments you may have on Chapters 3 and 4 of the Report
Synthetic Inertia	
Synthetic Inertia Response Time	
Frequency Measurement and RoCoF Detection	
Convertor Technology And Activation Speed	
Other Comments	

Technology Assessment	*Response / Comments*
Technology Assessment Criteria	
	** Please provide any comments you may have on Chapter 5 and Appendices of the Report **
Weighted Scoring Matrix Assessment	
Synchronous compensators	
HVDC Interconnectors	
Battery Technologies	
Flywheels	
Rotating Stabilisers	
Wind Turbines	
Pumped Hydro	
Compressed Air Energy Storage (CAES)	
AC Interconnection to GB	

Reduction in Min MW Thresholds	
	The interplay with DS3 system services needs to be considered. The reduction available, beyond that which will be required to provide the DS3 system services volume required to deliver the assumed 5% SNSP increase, does not appear to have been considered. Another criteria in the assessment should be a measure of the probability that it can be realised. It is a credible scenario that all available min gen reduction will be used up in the provision of DS3 system services and no additional volume will be available as a RoCoF alternative. A similar point could also be made for “Parking” and “Flexible Thermal Plant”.
“Parking” of machines	
Demand Side Management (DSM)	
Flexible Thermal Plant	
Other Comments	

TSOs' Summary Document	*Response / Comments*
Proposals for Phase 2 Analysis	
	The gap to be filled by any alternative may not be equivalent to the shortfall due to remaining at 0.5 Hz/s versus 1Hz/s. If we are considering an alternative it is due to the fact that 1Hz can not be achieved and therefore we need to consider what the new RoCoF standard could be. Surely it is reasonable to assume that an intermediate RoCoF level of 0.75Hz/s might be achievable or that a variable RoCoF depending on the mix of plant on the system is a possibility. I don't think it is correct to assume that it is a binary problem i.e. 0.5 Hz/s or 1Hz/s. Is it appropriate to base the phase 2 on a business as usual portfolio and that DS3 system services are outside the scope? It is reasonable to expect that DS3 system services will have a significant impact on the system and excluding this impact in phase 2 could result in incorrect conclusions.
Other Areas for Consideration	

Other	*Response / Comments*

	**Please provide any comments you may have on other issues **

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Your Details:

Name	*David Ryan*
Contact telephone number	*01 7029423*
Company	*ESB G&WM*
Date of Submission	*17/07/2015*

Note: The TSOs may publish responses. If you wish your response to be treated as confidential, please indicate this by marking the following box with an "x".

Response confidential ☐

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Synchronous & Synthetic Inertia	*Response / Comments*
Synchronous Inertia	
Synthetic Inertia	
	While the DNV paper indicates that synthetic inertia has possible potential, they have also identified the issues of detection, measurement and response times that require further analysis. Further, the question on how synthetic inertia responds to different types of frequency and RoCoF events has not been addressed. ESB G&WM supports the recommendation by your consultants, the necessity to undertake additional work on the measuring technology available. The impact of synthetic inertia on primary and secondary reserves on remaining units on the system also has to be addressed. Specifically, the amount of synthetic inertia required to respond to frequency events can have an inverse effect of generators. One effect can be potentially a pole slip. This has been highlighted in KEMA studies conducted in 2013/14 by EirGrid on the response of generators to RoCoF events. This must be part of the DS3 project (of which RoCoF is one strand) to focus and deliver a system that is sustainable and has integrity in relation to all of the users and their machines as well as the electrical quality.
Synthetic Inertia Response Time	
	Phase 1 study failed to indicate whether the mechanisms for measuring RoCoF events could be reliable when used for synthetic inertia response.
Frequency Measurement and RoCoF Detection	
	ROCOF measurement relays exist, the Distribution Network utilises RoCoF relays, called Loss of Mains Protection, to prevent islanding within the Distribution Network. There are no RoCoF relays utilised in the Transmission Network and their functionality will be significantly different to the Distribution Network. Therefore, it is essential that additional work be undertaken to further evaluate the technologies used for RoCoF detection and also how this can be developed for specific tasks within the transmission network. Before RoCoF relays can be incorporated into the transmission network, the detection of a RoCoF event needs to be reliably demonstrated. The type of response required to the RoCoF event and the predictability

	of the response also needs to be reliable. The issue of costs will also need to be addressed in case they are uneconomic.
Convertor Technology And Activation Speed	
	See frequency measurement and RoCoF detection
Other Comments	
	The initial Phase 1 study was to evaluate the range of theoretical options at a high level against a weighted scoring matrix and present a subset of viable options (2 to 3) for Phase 2 analysis. This has not been completed. The range of options being brought forward is excessive and should be reduced to ensure that a more detailed comprehensive review of the remaining viable options is undertaken. ESB recommend that the top ten are reviwed further , as per the currnet prioirity listing of your consultant. Also, the assessment criteria did not adequately address the total cost to the consumer as identified in the initial assessment criteria for this project stream.
	ESB welcome the commitment to publish the summary of responses.

Technology Assessment	*Response / Comments*
Technology Assessment Criteria	
	Cost should have been included in the Assessment Criteria as this is critical to the selection of potential solutions given that the cost of curtailment post 2018 will not be borne by the consumer but by the generator. Some of the additional system services considered are also considered as part of the DS3 programme and therefore should not be incorporated into both as it gives a false determination of allowing the SNSP to be increased. Also, this is a technical assessment of the technologies and not commercial.
Weighted Scoring Matrix Assessment	
	If all technologies, with the exeption of the AC interconnector, are to be considered in Phase 2, then the need for a scoring matrix should have been removed and a time to implement should only be considered as this was the logic to remove AC interconnection from the technologies to be assessed under Phase 2. However, assessing technologies under Phase 2 with time as a leading indicator would possibly remove the synthetic inertia products as the method of measuring and detecting ROCOF reliably has still to be proven. Therefore,the top ten (10) scoring technologies of the thirteen assessed in Phase 1 should only be considered for phase 2 of the project. As noted above the weighting of the additional system services should be lower as it is not a commercial assessment
Synchronous compensators	
	Synchronous condensers are primarily designed for reactive power support and using decommissioned power plants does not give the same inertia as the rating of the power plant given that the majority of the shaft inertia is contained in the turbine which is usually decoupled when nominal speed is reached.. Therefore the actual inertial response would be marginal and the effectiveness value would be insignificant. In relation to purpose built synchronous compensators, the size of the compensator is critical to the effect that synchronous compensators have on frequency events. If the compensator is over rated it could have the potential to compound the effect of a frequency event by tripping.

HVDC Interconnectors	
	This should not be considered as part of the phase 2 studies as the weighted score is too low. It also is a cost intensive technology.
Battery Technologies	
	Battery technologies are well understood and would have been used in various cases. The issue here is the very much in the the RoCoF detection and the way the battery based system responses to grid events.
Flywheels	
	Flywheels are providers of kinetic energy to the system. The costs indicated by the DNV report suggest the it would be uneconomical to persue the flywheel option given the MWs it could provide to the system. The technology could easily work if the flywheel inertia is up to H=3-5. If the flywheel is too heavy then it could result in inducing grid oscillation.
Rotating Stabilisers	
	While the rotating stabilisers are also providers of kinetic enery to the system, it can provide synchronous inertia as it is coupled directly to the grid system It can also provide other potential services which would be beneficial to the grid such as fast frequency response and operate as a synchronous condenser. It is a technology that will be developed further over the years and it is less expensive than the flywheel or synchronous compensator technologies. Again similarly to earlier mentioned technologies, the detection of events and the appropriate response would need assesments and tests.
Wind Turbines	
	Wind turbines could provide synthetic inertia but the energy released during a frequency event would need to be consumed to re-accelerate the turbine blades. As mentioned earlier, this could result in a higher demand of operating reserve for the conventional generation plant.
Pumped Hydro	
	The assessment on capital expenditure in the DNV report is too low.
Compressed Air Energy Storage (CAES)	
	Similar as before, the detection and response of a frequency disturbance is a critical factor

AC Interconnection to GB	
Reduction in Min MW Thresholds	
	This and 'Parking' would need to be investigated further. One particular concern is potential environlmental compliance from running at reduced minimum loads.
"Parking" of machines	
	As above
Demand Side Management (DSM)	
Flexible Thermal Plant	
Other Comments	

TSOs' Summary Document	*Response / Comments*
Proposals for Phase 2 Analysis	
	Unlike the process for phase 1, it would be important that interested parties are given adequate response times to the Phase 2 analysis that will be issued in Q4 2015. Revenue streams must be clearly defined as an outcome of Phase 2 is to enable business cases to be developed. To date this has not been the case At the first Alternative workshop, EirGrid gave a commitment to engage with service providers who believed they had potential solutions. This should be continued. One of the key points that the DNV report highlighted was that the measurement of RoCoF need further investigation. ESB GWM believes that this should be the case and the TSO should carry out additional work in this area.
Other Areas for Consideration	

Other	*Response / Comments*
	****Please provide any comments you may have on other issues ****

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Please send responses in electronic format to DS3@eirgrid.com or DS3@soni.ltd.uk

Your Details:

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Date of Submission	*21 July 2015*	

Note: The TSOs may publish responses. If you wish your response to be treated as confidential, please indicate this by marking the following box with an "x".

Response confidential ☐

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Synchronous & Synthetic Inertia	*Response / Comments*
Synchronous Inertia	
	Please provide any comments you may have on Chapters 3 and 4 of the Report
Synthetic Inertia	
Synthetic Inertia Response Time	
Frequency Measurement and RoCoF Detection	
Convertor Technology And Activation Speed	
Other Comments	

Technology Assessment	*Response / Comments*
Technology Assessment Criteria	
	** Please provide any comments you may have on Chapter 5 and Appendices of the Report **
Weighted Scoring Matrix Assessment	
Synchronous compensators	
HVDC Interconnectors	
Battery Technologies	
Flywheels	
Rotating Stabilisers	
Wind Turbines	
Pumped Hydro	
Compressed Air Energy Storage (CAES)	
AC Interconnection to GB	

Reduction in Min MW Thresholds	
“Parking” of machines	
Demand Side Management (DSM)	
Flexible Thermal Plant	
Other Comments	

TSOs’ Summary Document	*Response / Comments*
Proposals for Phase 2 Analysis	

	Rotating Stabilisers The initial report of phase I work on the complementary solutions for DS3/ROCOF made very clear reading, we would urge you to do a full techno-economic review during phase II, as we believe that this will clarify the commercial applicability of the solutions to the needs of the Irish Grid. At GE-PC, we have continued to develop the Rotating Stabiliser, and would now be happy to share with you budget figures for various ratings of this equipment. During the post review discussions in Dundalk, we discussed modelling, as this is your chosen route to compare the two fundamental technologies of Synchronous and non-Synchronous offerings. From my limited understanding of modelling this presents you with many complications with regards the specification and design of models. Further, the Rotating Stabiliser actually has two modes of operation – synchronous and non-synchronous which affect your modelling analysis. To this end, we would like to offer that GE-PC meet with to design the model required for the Rotating Stabiliser so that your team(s) can create a suitable model within your chosen modelling toolsuite. This may be mandatory for all providers as generic models are usually very limited in scope! **Synchronous Condensers** In the subsequent informal discussions after the workshop in Dundalk we made the point that in order to progress the studies to the next level it is essential for the reasons outlined above that there are more closely defined trials/modelling of the synchronous condenser technologies . You reflect this in your Summary Report but we felt that it was important to emphasise this point that in order for the evaluation to carry weight it would have to assess the range of synchronous condensers at various ratings. From our initial submission it will have been seen that the 2 solutions operate at different levels of rating, therefore for any techno-economic modelling to have value for the industry it needs to be able to be seen to be able to be compared at the micro and macro deployment levels. We welcome the fact that the next phase of the report will assess the cost factors across the lifetime of the deployments. We would also wish to confirm that we would be willing to supply budgetary indicative costing against these more closely defined stratified rating levels.
Other Areas for Consideration	

Other	***Response / Comments***
	****Please provide any comments you may have on other issues ****

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Please send responses in electronic format to DS3@eirgrid.com or DS3@soni.ltd.uk

Your Details:

Name	*Joe Duddy*
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Company	*RES*
Date of Submission	*7th August 2015*

Note: The TSOs may publish responses. If you wish your response to be treated as confidential, please indicate this by marking the following box with an "x".

Response confidential ☐

The closing date for responses is Friday, 10th July, 2015.

Synchronous & Synthetic Inertia	***Response / Comments***
Synchronous Inertia	
"The amount of power extracted or generated from the rotating mass of a synchronous machine is naturally controlled by the principles of inertia physics. The amount of energy delivered is proportional to the mass of the rotating shaft of the machine and its prime-mover and the change in frequency squared."	This is a simple statement of the principles. However the performance of of synchronous generators can be significantly modified by modern governor / power control systems which may suppress the amount of energy that is exchanged with the system during RoCoF events. The inertia constant alone may be an insufficient indicator of the performance of a synchronous machine to damp system RoCoF and limit the nmagnitude of frequency excursions. I attended a recent GB electricity industry meeting where a generator provided charts illustrating events of this inertia suppression at several CCGTs.
Synthetic Inertia	
"Machines that are connected by means of power electronics to the Grid are therefore non-synchronous in principle. As a result, machines connected non-synchronously through power electronics can only provide synthetic inertia in principle, but not synchronous inertia."	This is not consistent with descriptions of double-fed machines in the Annex *"1) Synchronous Compensators/condensers…* *…When primarily used for limiting RoCoF, only a fraction of the kinetic energy can be used when operating as a synchronous machine due to the limited allowed frequency upper and lower limits of the Grid. To increase the use of its kinetic energy requires implementing the compensator as a double-fed machine. In this case, the machine operates at a speed which is the sum or difference between the grid frequency and the control frequency. In addition to the intrinsic inertia present in the rotating machine,* ***the control frequency can be manipulated in order to provide synthetic inertia on top of the intrinsic inertia****…"* *"5) Rotating stabiliser…* *…When primarily used for limiting RoCoF, only a part of the kinetic energy can be used. To increase the use of its kinetic energy requires implementing the stabiliser as a double-fed machine. In this case, the machine operates at a speed which is the sum or difference between the grid frequency and the control frequency. In addition to the intrinsic inertia present in the rotating machine****, the control frequency can be manipulated in order to provide synthetic inertia on top of the intrinsic inertia****. In this way, the rotor can produce a rotating field that is synchronous to the grid frequency, while its actual speed of rotation is below synchronous speed.*

	Double-fed compensators are wound rotor machines, with either slip rings, double stator winding sets or rotating transformers providing the control power to the rotor. Double fed machines can also be equipped with a flywheel for providing additional mass and therefore inertia. As such, a compensator can provide larger equivalent inertia as opposed to a synchronous compensator. *The rotor is typically powered by a variable frequency drive in order to produce a rotating field at the right speed.* ***If the feed frequency to the rotor is held constant, a double fed synchronous machine produces inertia in the same way as a conventional generator does****."* *"6) Wind…* *…**In the case of a double-fed generator, the wind turbine provides synchronous inertia to the grid in a similar way to a conventional power plant**. With a double-fed generator the stator can be directly coupled to the grid. The rotational speed of the rotor is affected by frequency changes, provided the frequency of the power fed to the armature remains constant."* Is this double-fed wind turbine synchronous inertia performance confirmed by any references? This statement should be qualified in a similar manner to footnote 21.
"…The declining synchronous inertia makes the "synthetic" inertia FFR type devices likely to be a more financially viable option provided the technologies can provide adequate service…"	Financial viability of FFR devices also depends on the recognition of the value of FFR and suitable remuneration for FFR, particularly if investment in FFR facilities is required.
Synthetic Inertia Response Time	
"Ramping time, T_{ramp} for the ramping of active power from the FFR type device (see chapter 5). T_{ramp} is the time required to ramp up to the required active power response from the device once the activation signal has been received."	Ramping capabilities (for delivery of FFR) are not discussed or described in chapters 4 or 5. This is a significant omission.
Frequency Measurement and RoCoF Detection	

	Section 4.2 describes frequency and RoCoF methodology in the context of RoCoF relays which provide a trip signal (which could be used to open a circuit breaker or trigger a static response). Techniques to measure frequency and RoCoF for continuous dynamic provision of FFR / synthetic reponse are not described and may differ. This is a significant omission.
*"**Characteristic times for detecting frequency events**…* *…In Figure 3 an example is given of transients in sine waves as a result of a network volt* [sic] *in the power system…"*	Some missing words?
"…Several functions are used to reduce inappropriate operation of RoCoF devices:…" *"…The Cired Paper15 "Loss of Mains protection relay performance when subjected to network disturbances and events", describes high level performance of several Loss of Mains protection relays. Best performance was achieved by those relays incorporating a delay time. A 0.5 second time frame was indicated as appropriate to reliably calculate the RoCoF. The work that the University of Strathclyde has performed16, also provides the view that a time delay adds to the stability considering small scale system transients..."*	These extracts refer to RoCoF tripping or triggering devices. They may not apply to devices which respond continuously to RoCoF
	Did the authors review only RoCOF relay literature (references 6 & 7) or did they consider literature on synthetic inertia (none listed) e.g.

	• "The utilization of synthetic inertia from wind farms and its impact on existing speed governors and system Performance (Part 2 Report of Vindforsk Project V-369) Elforsk rapport 13:02 by Seyedi and Bollen • Wind turbine manufacturers product data • Peter Wibæk Christensen, Geman Caludio Tranowski, "Inertia for Wind Power Plants- State of the art review-Year 2011" • T. Knüppel, P. Thuring, S. Kumar, M.N. Kragelund, R. Nielsen, K. André, "Frequency Activated Fast Power Reserve for Wind Power Plant Delivered from Stored Kinetic Energy in the Wind Turbine Inertia"
Convertor Technology And Activation Speed	
Other Comments	

Technology Assessment	*Response / Comments*
Technology Assessment Criteria	
	The critical capability which all the considered technologies have in common is their ability to deliver energy in response to a RoCoF incident. The report does not facilitate direct comparison of the effectiveness of different technologies for delivering this energy.
	The criteria for awarding scores in each category are not clearly stated. This makes objective review difficult. E.g. how good would a non synchronous technology have to be to score 4 in effectiveness?
	It is not clear whether economic matters, which are mentioned in the annex, are included in the assessment.
Weighted Scoring Matrix Assessment	
	The effectiveness of parking and reduction in the minimum MW generation are both listed a 5 in the matrix but only 4 in the subsequent text.
Synchronous compensators	
	Technical application score of 5 seems high given that the faceplate annex states that the Inertia Constant H is only 3. How much energy will this device supply within the operational frequency range? Much less than 3 MWs/MVA Stated energy storage content of up to 0.4MWh is inconsistent with 250MVA, H = 3s and the restricted frequency range within which inertia is useful.
HVDC Interconnectors	
"HVDC interconnectors are mainly used to transport high amounts of energy from one power system network to another. Therefore electricity trading is the primary reason for such an installation. HVDC interconnectors can be designed for primary response and in that way help to prevent high RoCoF events…"	What is the reason for a reduced effectiveness score? Availability of interconnector for synthetic inertia or response time? In the same way that some technologies' effectiveness has been downgraded because they are not always available (synchronised) to deliver energy to mitigate RoCoF, HVDC interconnectors which are built to facilitate energy trade will probably be subject to many periods when their capacity is entirely dedicated to other services and no capacity remains to provide synthetic inertia or FFR. Has this been reflected in the effectiveness score?

Battery Technologies	
"Battery technologies are mainly applied for energy storage…"	Is there evidence to support this statement? RES has constructed two battery devices in North America for frequency regulation. A further four RES battery projects are under construction, of which three will also be used for frequency regulation and only one will be used for energy storage. http://www.res-group.com/portfolio/energy-storage
"…Battery power is instantly available from the terminals and therefore the power convertor is the main limitation for energy delivery. The rapid energy consumption capability however is much lower in capacity and therefore the technology is better suited to help prevent low RoCoF events as opposed to high RoCoF events…"	This has not been RES' experience with Li-ion batteries. Our two constructed systems provide equal up and down frequency regulation volumes and speeds. Did you mean "therefore the technology is better suited to help prevent negative RoCoF events as opposed to positive RoCoF events"?
Flywheels	
Rotating Stabilisers	
	I am not familiar with these devices and no obvious references are provided. How do they differ from synchronous compensators?
Wind Turbines	
	I am surprised that no study has been made of existing synthetic inertia options from some wind turbine manufacturers e.g. GE and Enercon. It is correct to say that wind turbine inertia constant depends on the design but it can be considerable and therefore some research was warranted. I have seen data for wind turbines with inertia constants in the range 2.5-6 s.

	It should also be noted that the energy which can be delivered by synthetic inertia from variable speed wind turbines will depend on additional factors e.g. wind speed (and therefore rotor speed), pre-dispatch down, operational parameters Ramp time for wind turbines (and some other technologies) is not be a useful indicator of capability to deliver inertia, synthetic inertia or fast frequency response
"…At present, several wind turbine manufacturers offer FFR response services for the full convertor type generators. However, the deployment of this function for RoCoF is not known. As a result, and since the older technology can already provide inertia in principle, DNV GL scored the maturity moderate."	Synthetic inertia is deployment of FFR for RoCoF mitigation. Was this not investigated? Several wind turbine manufacturers offer, or are actively developing, synthetic inertia.
Pumped Hydro	
	Why rate PHES effectiveness at 5 when they are not synchronised at all times and therefore may be unavailable to provide inertia during a RoCoF incident? Inconsistent with the score for Flexible thermal power plant.
Compressed Air Energy Storage (CAES)	
	Why rate CAES effectiveness at 5 when they are not synchronised at all times and therefore may be unavailable to provide inertia during a RoCoF incident? Inconsistent with the score for Flexible thermal power plant.
AC Interconnection to GB	
	Why is the effectiveness of this technology rated less than that of synchronous generators?
Reduction in Min MW Thresholds	
"Parking" of machines	
Demand Side Management (DSM)	

Flexible Thermal Plant	
	Lead time neglects the planning/construction consent process which can be extensive.
Other Comments	
	"Charging time (for storage)" is irrelevant to provision of (synthetic) inertia. Once charged / synchronised the capability persists.
	"Ramp-time" as described in the annex, is irrelevant to the provision of (synthetic) inertia from most of the listed technologies e.g. wind, PHES, CAES and GTs

TSOs' Summary Document	*Response / Comments*
Proposals for Phase 2 Analysis	
"…In particular, the TSOs view RoCoF detection methodology and response time as being an area that needs to be explored further..."	I agree. The report concentrates on RoCoF detection for relay tripping. Different techniques may be required for provision of synthetic inertia.
Other Areas for Consideration	

Other	***Response / Comments***
	None

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Date of Submission	*July 16, 2015*

Note: The TSOs may publish responses. If you wish your response to be treated as confidential, please indicate this by marking the following box with an "x".

Response confidential ☐

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Synchronous & Synthetic Inertia	*Response / Comments*
Synchronous Inertia	
Synthetic Inertia	
Synthetic Inertia Response Time	
Frequency Measurement and RoCoF Detection	
	We observe that there is a strong industry paradigm against the reliability and response time of RoCoF measurement. In fact this is one of the main conclusions of DNV GL report. There is a misconception probably resulting from the bad performance of the standard industry used for RoCoF relays for power in islanding schemes. Contrary to the DNV GL report, RoCoF measurement techniques and algorithms are already proven mature. As an example, Hydro-Québec under frequency load shedding currently uses RoCoF measurement. This UFLS [1],[2] installed in more than 150 25-kV substation and directly controlling more than 12 000 MW is using, for more than 12 years, RoCoF as a key features of its load shedding strategies (4 levels, -0.3 Hz/sec, -0.4 Hz/sec, -0.6 Hz/sec and -0.9 Hz/sec directly controlling 2800 MW of load). The RoCoF measurement algorithm, developed by Systemex's R&D partner IREQ (Hydro-Québec research center), has proven its reliability, robustness and rapidity (response time of about 200 ms). It is also important to remember that Hydro-Québec power system is one of the most complex in the world involving mostly all kind of electric transient and phenomena (sub synchronous resonance, intermodulation, harmonics, over synchronous parallel resonances and series resonances). Systemex Energies is currently adapting this measurement algorithm to the Irish power system particularity and deliver a robust, fast, secure and reliable RoCoF measurement system in a timely fashion to meet Eirgrid and Soni objectives. Since the algorithm is already operating on the HQ 60 Hz power grid, adaptation is easly perform and no major obstacles is envisaged. This can be demonstrated on our partner the University College Dublin UCD-ERC real time digital simulator, where Systemex Energies prototype is already installed.
Convertor Technology And Activation Speed	
Other Comments	

Technology Assessment	*Response / Comments*
Technology Assessment Criteria	
	The RoCoF Alternative Solutions Project objective is to identified the best technologies to mitigate high RoCoF (> -0.5 Hz/s) after the loss of a large power plant. High RoCoF on Irish power system comes from two sources, the power system MW imbalance caused by the generation loss and the fact that this event happens when the power system inertia is low. We strongly believe that the best and the most efficient way to mitigate a high RoCoF event is not to provide new inertia (synchronous or synthetic) to the power system but rather to compensate, as fast as possible, the MW imbalance that have created this high RoCoF. In fact, the two most proven technologies to mitigate frequency behavior (RoCoF and nadir) and loss of power plant are governor and under frequency load shedding which are direct actions on power system MW balance, not on inertia. Moreover, we do not know any power system who has specifically and successfully added inertia to its system to mitigate power system frequency behavior. We do not say that a reduced inertia response is not a reliability threat to power system frequency response, but that the inertial response that a synchronous (or non-synchronous) device can provide has a value only because the primary response is too slow. As a simple illustrative example, if all time delays associated with the governor's action could be eliminated, then the inertial response would have little value. From our point of view, the most efficient way to mitigate high RoCoF is then to provide sufficient MW in a fast and responsive manner. The Soft-R3 technology presented by Systemex Energies [3], [4] to Eirgrid and Soni is an innovative automated demand response device specifically designed to support power system reliability and provide frequency related system services including direct mitigation of high RoCoF by a fast, reliable, continuous, autonomous modulation of selected load. One of the key points behind Systemex's solution is that it is based on a robust RoCoF measurement algorithm[8]. This algorithm and the innovative continuous control strategies are completely user customizable. Moreover Soft-R3 can be set almost exclusively according to power system performance and is fully configurable unlike governor or wind turbine emulated inertial response. Soft-R3 can therefore be adapted to solve most of the problems related to frequency behavior in power systems**.** The other important feature in order to being fast enough to provide the required MW, is that the Soft-R3 is completlty autonomous and does not required any communication to react to the frequency change. As a last point, it has been demonstrated in [5] that 450 MW of Soft-R3 controllable load as the same effect on RoCoF that 44 000 GVAs of inertia. Translated to the Irish power system, it means that about 150 MW of load controlled by Soft-R3 is able to compensate the RoCoF increase caused by a SNSP variation from 50% to 75%. It

	will need about 5 000 MVA of synchronous compensator to have the same effect (so twenties 250 MVA synchronous compensators with an inertia of 3 second)
Weighted Scoring Matrix Assessment	
	• Cost has not been included in criteria to quantify suitability of technologies. We believe that is it unfair to compare between technologies ten times more expansive. We believe that this issue should be considered in Phase 2. • Technology complexity must be criteria as important of technology maturity. By example, synchronous compensator, which has the highest score of all technologies analysed, is a complex device involving hydrogen cooling and careful maintenances. This complexity is not reflected in the total score. • There are 13 technologies evaluated but only two that imply direct control of MW, which is, in our opinion, the more efficient way to mitigate high RoCoF on power system.
Synchronous compensators	
	These remarks also apply to all technologies except 2, 3 and 12. • Synchronous compensator is not a proven technology to mitigate high RoCoF, it is a proven technology to provide dynamic voltage support or to improve power factor. • We agree with effectiveness definition but we believe that this definition have not been strictly applied for all non-synchronous (or synthetic inertia) devices. As defined, effectiveness is a "combination of the energy delivery with regards to <u>the quantity of power</u> and the time required to correctly apply". These devices do not provide direct power, they increase the total magnetic field linked all machine together. It is this "tighter" link that restrains the power system frequency and mitigates the RoCoF. We believe that storing kinetic energy to mitigate high RoCoF is less efficient than directly reducing MW that has caused this high RoCoF. So the score of 5 in effectiveness criteria, comparatively to others solutions, is too high.
HVDC Interconnectors	
Battery Technologies	

Flywheels	
Rotating Stabilisers	
Wind Turbines	
Pumped Hydro	
Compressed Air Energy Storage (CAES)	
AC Interconnection to GB	
Reduction in Min MW Thresholds	
“Parking” of machines	
Demand Side Management (DSM)	
	• DSM is a large domain and is not restricted to peak shaving or solution to net congestion. Automated demand response (ADR) or grid friendly device is a subset of DSM which aims to provide power system reliability services like spinning reserve and regulation. We believe that a separate technology evaluation should have been done by GNV DL for ADR mainly because the entire design philosophy behind ADR is completely different that the one behind peak shaving and energy management DSM. • We completely disagree with GNV DL scoring of DSM maturity. First, the argument “However, the maturity for providing RoCoF is at the time of writing this report not proven” has not been applied to other categories. High RoCoF mitigation is a new problem for the industry and there is currently no proven technology to counter it at all (except under frequency load shedding used by Hydro-Québec). Synchronous compensators

	which score 5 for maturity is not a proven technology to mitigate high RoCoF; it is a proven technology to provide dynamic voltage support. Secondly, with more than 25 000 MW [6] of demand response deployed only in the US, we think that DSM is a mature technology and that all challenges mentioned by DNV GL (sufficient aggregated capacity, detection technology, novel communication etc.) has already been solved by the industries. As a last point, the demand side vision for 2020 published by the SEM [7] has already recognized the economic and environmental benefits of demand side response to the All-Island market and identified a large varity of load types with high value, amoung them industial, commercial, heat storage and Home & office automation load.
Flexible Thermal Plant	
Other Comments	
	• All lead time evaluations for technology 1, 2, 3,4,5,6 and 13 are too optimistic. For example, we do not believe that a complete solution involving about twenty 250 MVAR synchronous compensator (technology 1) could be installed from start to finish in 6 to 24 months on Irish power system. • On the contrary, we find the DSM or ADR lead time is exaggeratedly pessimistic (4 years). ADR technology is simple; it is comparable to installing a relay in a substation if the load selected is industrial, large commercial or a large battery installation.

TSOs' Summary Document	*Response / Comments*
Proposals for Phase 2 Analysis	
	We completely agree with TSO's that a combination of solutions or devices is the best and the more efficient way to resolved the RoCoF issues. Eirgrid and Soni propose to perform studies to determine inertia (MW.s) to reduce RoCoF from 1Hz/s to 0.5Hz/s requirements for 2 cases: – Case 1: Required volume of Synchronous inertia – Case 2: Required volume of Non-synchronous Inertia and to perform a sensitivity analysis of response time for Non-Synchronous devices. These 2 scenarios are based on the assumption that adding inertia is the only solution to mitigate high RoCoF. We disagree with this assumption mainly because it is more efficient to directly control the MW imbalance (for example by the modulation of a resistive load) than adding kinetic energy to add inertia to mitigate the RoCoF. So we suggest adding a third case being the study to determine the required volume of direct MW control solutions to reduce RoCoF from 1 Hz/s to 0.5 Hz/s.
Other Areas for Consideration	
	Soft-R3 is an autonomous, continuous and fast frequency and RoCoF regulator modulating industrial, institutional, commercial or residential load. Our solution is simple and efficient and use a mix of proven and "old" design concept used in all power system since many years. In fact, it could easily compare to an "ideal" governor's action (but acting on a load) because the only time delay in its continuous action is associated with the frequency and RoCoF measurement. It could also easily be compare with traditional under frequency load shedding but with its action being imperceptible by the consumers. As a last point Systemex want to highlight that, similarly to governor, our Soft-R3 solution is able not only to mitigate high RoCoF, but also to provide at the same time many others system service (FFR,POR,SOR,TOR,RRS and RRD).
	Even if generator and TSD-DSO project are successful, Systemex is recommending that, considering the significant risk to the safety and reliability of the Irish electricity system that high RoCoF is posing (risk of cascading and blackout), a solution using Soft-R3 RoCoF regulator be deployed as a supplement safety net. The concept of safety net has been successfully used on Hydro-Québec power system as described in [6] in avoiding almost 5 major power interruption or blackouts since its commissioning in 2002.

Other	*Response / Comments*
	Références [1] Nerc Standard PRC-006-NPCC-1 Automatic Underfrequency Load Shedding, page 28 [2] Programmable load shedding-systems-Hydro-Quebec's experience, Cote, P. ; Lacroix, M., Power Engineering Society Summer Meeting, 2001 , 15 Jul 2001 [3] Systemex Energies, Proposal for RoCoF alternative solutions, November 3 2014 [4] Systemex Energies, A novel technology: the RoCof regulator, G.Trudel, S. Jasmin [5] A Novel Technology to Improve Grid Frequency Response on Electrical Power System with High Level of Renewable Generation Penetration, Montreal, CCTC 2015 Paper Number 1570095489, G. Trudel, S. Jasmin [6] Designing a reliable power system.The Hydro-Québec's integrated approach, G.Trudel, J.P. Gingras, J.R. Pierre, Special Issue of the Proceedings of the IEEE on « Energy Infrastructure Defense Systems », may 20054 [7] Demand Side Vision for 2020, Decision Paper, Single Electricity Market, 27th May 2011 SEM/11/022 [8] Power control device, patent CA 2,778,345

This template has been prepared to facilitate comments on the RoCoF Alternative Solutions Project Phase 1 Report. EirGrid and SONI commissioned DNV GL to produce the report titled "RoCoF Alternative Solutions Technology Assessment" as part of Phase 1 of the project. Respondents are not restricted to this template when commenting on the report and can provide supplementary material if desired.

These comments should provide information on the various sections of the report.

For information, please find linked the RoCoF Alternative Solutions Technology Assessment Report and the TSOs' Phase 1 Report Summary Document published on 25th June.

Please send responses in electronic format to DS3@eirgrid.com or DS3@soni.ltd.uk

Your Details:

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Contact telephone number	*01 2015364*
Company	*Coillte*
Date of Submission	*17/07/2015*

Note: The TSOs may publish responses. If you wish your response to be treated as confidential, please indicate this by marking the following box with an "x".

Response confidential ☐

The closing date for responses is Friday, 17th July, 2015.

Synchronous & Synthetic Inertia	***Response / Comments***
Synchronous Inertia	
Synthetic Inertia	
Synthetic Inertia Response Time	
Frequency Measurement and RoCoF Detection	
	As highlighted in the report and discussed during the workshop the detection of the RoCoF event is quite challenging. As the overcoming of this challenge would allow non synchronous technologies to provide solutions Coillte would strongly support the further investigation of RoCoF detection techniques. In particular the possibility of using a trip signal to initiate the synthetic inertia response rather than measuring the frequency should be investigated in detail.
Convertor Technology And Activation Speed	
Other Comments	

Technology Assessment	*Response / Comments*
Technology Assessment Criteria	
	Coillte would agree with the assessment criteria used in the phase 1 analysis. We do have some comments in relation to how they have been applied in the relation to some of the specific technologies as outlined below.
Weighted Scoring Matrix Assessment	
Synchronous compensators	
	Coillte would question the scoring of the synchronous compensator. Without a flywheel the volume of inertia provided by such a device is very limited. In a traditional generator and turbine set approximaitely 80-85% of the inertia is provided by the turbine so the inertial contributuion from the generator alone is limited. If flywheels are to be included to increase the inertia there is major civil works involved and Coillte would question the high score for lead time. While it synchronous compensation may be a mature technology for voltage control it is not commonly used for provision of inertia so again the scoring here seems generous.
HVDC Interconnectors	
Battery Technologies	
Flywheels	
Rotating Stabilisers	
Wind Turbines	
Pumped Hydro	

Compressed Air Energy Storage (CAES)	
AC Interconnection to GB	
Reduction in Min MW Thresholds	
	This option scored second highest behind Synchronous Compensators, which as described above, have a number of flaws. In most cases the actual time required to implement this solution is relatively small (2-3 months) but the opportunity to implement this solution is only available at large overhaul periods (every 2-3 years). Given the clear technical benefits and the possibility for timely deployment (if planned) urgent engagement with potential proviers needs to happen immediately as part of Phase 2 so that this solution could come on line by 2018 and hence maintain predicted increases in SNSP.
"Parking" of machines	
Demand Side Management (DSM)	
Flexible Thermal Plant	
Other Comments	

TSOs' Summary Document	Response / Comments
Proposals for Phase 2 Analysis	
	Coillte support Eirgrid's decision not to focus on a small number of technologies in phase 2 as this may prematurely eliminate some tehcnologies. Coille also believe the proposed approach will identify the required volumes of inertia (synchronous or non synchronous) which is a vital factor in determining the correct solutions. However, Coillte have some concerns regarding the proposed approach. Phase 2, as currently proposed, will not identify, develop and facilitate technical solutions coming on line in 2017 as per the latest Eirgrid Operational Capability Outlook. This means that if the RoCoF Generator Project is unsuccessful or only partially successful there will be further delays in increasing the SNSP and hence prolonged periods of higher curtailment. To minimise the effect of this solutions which are technically proven and can be implemented in a timely fashion need to be progressed in parallel with the proposed phase 2 exercise. Phase 2 should identify the technolgies with proven technical merit and short lead times e.g. reduction in minimum load etc. An assessment should then be carried out to see if the procurement of such solutions have an overall positive impact on overall system costs (SMP, Uplift Costs, Dispatch Balancing Costs, Ancillary Services Costs etc.) regardless of the outcome the RoCoF Generator studies i.e. "no regrets". If proven cost effective the procurement exercise for these solutions could begin upon completion of Phase 2.
Other Areas for Consideration	

Other	Response / Comments

DS3: RoCoF Alternative Solutions Project Phase 1 Report Comments

This template has been prepared to facilitate comments on the RoCoF Alternative Solutions Project Phase 1 Report. EirGrid and SONI commissioned DNV GL to produce the report titled "RoCoF Alternative Solutions Technology Assessment" as part of Phase 1 of the project. Respondents are not restricted to this template when commenting on the report and can provide supplementary material if desired.

These comments should provide information on the various sections of the report.

For information, please find linked the RoCoF Alternative Solutions Technology Assessment Report and the TSOs' Phase 1 Report Summary Document published on 25th June.

Please send responses in electronic format to DS3@eirgrid.com or DS3@soni.ltd.uk

Your Details:

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Contact telephone number	*045 899341*
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Date of Submission	*17 July 2015*

Note: The TSOs may publish responses. If you wish your response to be treated as confidential, please indicate this by marking the following box with an "x".

Response confidential ☐

The closing date for responses is Friday, 17th July, 2015.

Synchronous & Synthetic Inertia	*Response / Comments*
Synchronous Inertia	
	****Please provide any comments you may have on Chapters 3 and 4 of the Report****
Synthetic Inertia	
Synthetic Inertia Response Time	
Frequency Measurement and RoCoF Detection	
	As discussed at the workshop the possibility of using a trip signal to initiate the synthetic inertia response rather than measuring the frequency should be investigated in detail, along with any other measures that may arise.
Convertor Technology And Activation Speed	
Other Comments	

Technology Assessment	*Response / Comments*
Technology Assessment Criteria	
	IWEA believes that the assessment criteria are appropriate, however we do have some comments in relation to how they have been applied in the relation to some of the specific technologies as outlined below.
Weighted Scoring Matrix Assessment	
	IWEA questions that weighting of some projects under some of the assessment criteria. There is no indication that any consideration is given to projects which are already at an advanced stage, and the implication that this might have on lead times. For example there is a CAES project under development which is lilely to have a shorter lead time than HVDC Interconnectors, however it has been given a lower ranking in terms of lead time. If a range of technologies is to be considered then it would also be useful to look at the associated delivery timeframes and assess accordingly.
Synchronous compensators	
	The scoring of the synchronous compensator is very disputable. Without a flywheel its effectiveness is very limited. While it may be a mature technology for voltage control it is not commonly used at all for provision of inertia. If flywheels are to be included there is major civil works involved and IWEA would question the high score for lead time.
HVDC Interconnectors	
Battery Technologies	
Flywheels	
Rotating Stabilisers	
Wind Turbines	

Pumped Hydro	
Compressed Air Energy Storage (CAES)	
	CAES was scored low on location however the relevance of locational considerations should be carefully considered, based on the number of units that may be required, and projects which are already underway.
AC Interconnection to GB	
Reduction in Min MW Thresholds	
	Given the issues concerning the effectiveness of Synchronous Compensators it would appear that this option is currently one of the most viable. As the opportunity to implement this solution is only available at large overhaul periods (every 3-4 years) urgent engagement with potential proviers need to happen immediately as part of Phase 2 to help meet 2020 targets.
"Parking" of machines	
Demand Side Management (DSM)	
Flexible Thermal Plant	
Other Comments	

TSOs' Summary Document	*Response / Comments*
Proposals for Phase 2 Analysis	
	IWEA welcomes that all technologies excluding AC interconnection are being brought forward to Phase 2 of the project. It seems reasonable that the technologies will be assessed in groupings of synchronous and non-synchronous technologies as there are issues specific to each of these that need to be resolved. In particular the detection methodologies for a RoCoF event require detailed consideration. While the proposed approach has merit it will not, however, identify, develop and facilitate technical solutions coming on line in 2017 as per the latest Eirgrid Operational Capability Outlook. This means that if the RoCoF Generator Project is unsuccessful or only partially successful there will be further delays in increasing the SNSP and hence prolonged periods of higher curtailment. To minimise the effect of this solutions which are technically proven and can be implemented in a timely fashion, such as the reduction of minimum loads, need to be progressed in parallel with the proposed phase 2 exercise. If it can be proven that the procurement of such solutions have an overall positive impact on system costs regardless of the outcome the RoCoF Generator studies i.e. "no regrets" the procurement exercise for these solutions should begin immediately.

	•
Other Areas for Consideration	
	As stated in the introduction the aim of all this is to meet the 2020 targets – this must be kept in mind when looking at capital works and waiting for DS3 before anything starts.
	While it has been noted that this is not a procurement exercise consideration should be given to how the results of Phase 2 will be used. This should be carried out in parallel with Phase 2 of the assessment to ensure that any results and suggestions can be implemented in a reasonable timeframe. We question whether an economic assessment is appropriate at this time. If an economic assessment is carried out we believe there needs to be a far more detailed review rather than using public information which varies considerably and may therefore significantly over estimate the capex of a new technology.
	IWEA has particular concerns in relation to the potential curtailment levels in the coming years with a significant increase in the connection of wind energy projects, possible outages of the interconnectors and DS3 not being resolved in the initial timeframe that was indicated. Delays to the increase of SNSP will have a significant impact to the levels of curtailment of wind generation. In light of this consideration should be given to some system requirements that could be procured in the short term e.g. the reduction of min gen of plant.

Other	***Response / Comments***
	IWEA welcomes the opportunity to respond to this consultation and looks forward to engaging further as the process develops.