WEBINAR

# Introduction to ABB Synchronous Condensers - Q&A session

Answered by Christian Payerl, Area Sales Manager of Synchronous Condenser

## 1. Technical questions regarding the Synchronous Condenser

### 1-1. How do ABB increase the negative VARs for a short-term rating (Canada example) given this is normally a stability issue?

The negative VAR limitation is determined by the zero-field current limit in the capability diagram. This point is determined by the reactance in the machine (-1/Xd). At rated voltage and frequency, nothing can be done to move this point. The reason for the difference (continuous and short-time) must therefore be other than stability, such as planned overrating.

### 1-2. Are synchronous condensers immune to transient stability issues as they do not have a prime mover, so will not increase in speed during a fault?

No, they are not immune although more likely to stay stable than a generator or motor at the same MVA rating due to no external torque acting on the rotor.

### 1-3. Thank for your exposition. As explained the working mode implies to work with active power near to zero, but in anyway, you also are taking active power from grid, which is the contribution of this active power consumption?

The active power consumption for a machine is depending on the operation of the machine, this means how much MVAr´s are absorbed or generated. The losses are normally between 0.7% (no-load losses at 0MVAr) up to 1.1% at max. overexcited operation (max. MVAr generated). Additional to the machine losses are losses for the consumption of the aux. equipment which is very much depending on the cooling system selection. As per our experiences from installed machines, synchronous condensers are often running near to no-load losses as only a few MVAr's are used for voltage regulation (MVAr support). Fault current and inertia contribution are not influencing the loss figures.

### 1-4. In the same way, with the flywheel SC is able to provide active power during a limited period of time. This depends on the flywheel and complete SC inertia but which is the active power capability for this type of 'generators'?

Synchronous condensers are not providing active power, despite that fact the inertia provided by the machine or by the fly wheel /machine combination is providing is measured in MWs. The MWs values provided by the machine is depending on the frame size and with that linked to the rotor inertia. A typical 4-pol AMS1400 synchronous condensers would be able to provide 100MWs inertia without flywheel. The AMS1400 with flywheel can provide up to 470MWs inertia.

### 1-5. Is it possible to redesign the syncon to have the rotor outside, like a hub motor. With the rotor outside, the moment of inertia is increased and thus provides more inertia.

It is possible in theory but would require a significant effort to implement in practice.

**1-6. How about the harmonic contents of the inverters of renewable sources? Can the Synchronous condenser handle with this issue?**

In most of the applications with Synchronous Condensers in or nearby renewable plants, the Synchronous Condenser is connected via a step-up transformer to a medium voltage bus (collector bus) or the medium voltage bus connected to the grid connection transformer or directly to the transmission bus. This means that the harmonics from the inverters is damped via the transformer. In any case harmonic content as well as negative sequence components (known values or IEC/NEMA recommended values) are added as design criteria for the SynCon.

**1-7. If one were to operate a generator or motor as a synchronous condenser, would the max amount of reactive power be limited by the MVA capacity of the generator/ motor or the MVAr capacity of the generator/ motor? i.e., would the field winding become the limiting factor instead of armature windings?**

The amount of MVAr possible to produce from a motor/generator operating as a synchronous condenser depends on the pf rating of the original motor/generator. For a pf=1 machine, the limitation will be defined by the rotor heating limit in the capability diagram (or the MVAr rating as mentioned). As the rated power factor drops, more and more reactive power can be produced along the positive Q-axis in the capability diagram. At some rated power factor, the limitation turns from being MVAr to MVA (rotor limit to stator limit).

**1-8. When you disconnect the pony motors, then I assume that some minor amount of active energy is required to keep the synchronous generator spinning. How much in % of reactive power is this active power requirement?**

The active power consumption for a machine is depending on the operation of the machine, this means how much MVAr´s are absorbed or generated. The losses are normally between 0.7% (no-load losses at 0MVAr) up to 1.1% at max. overexcited operation (max. MVAr generated). Additional to the machine losses are losses for the consumption of the aux. equipment which is very much depending on the cooling system selection. As per our experiences from installed machines, synchronous condensers are often running near to no-load losses as only a few MVAr's are used for voltage regulation (MVAr support). Fault current and inertia contribution are not influencing the loss figures.

**1-9. What is usual overload period? Is it something like 2 hours or 15 min?**

The thermal heating time constants for the stator is in the range of 30 minutes.

## 2. Technical question regarding the Synchronous Condenser installation

**2-1. Are AVR and protection models for available for OPAL-RT Hypersim, as well as PSCAD, PSS/E, and power factory?**

AVR and Synchronous Condenser limiter models are available as block box models for simulations and as open source models for the TSO or/and regulators in PSCAD, PSS/E as well as in Power factory. OPAL-RT Hypersim models are at moment not available.

**2-2. Can you tell something about advantage of using Pony motor as start-up instead of frequency converter?**

Starting of a synchronous condenser with a LV pony motor controlled by a LV drive is very simple, economic and space saving starting method.

**2-3. For the hybrid solution (STATCOM + Synchronous condenser), there is single control & protection system for both system or have to use individual C&P, then with integration control system.**

In the installed SynCon - Phoenix Project - the control & protection system for the SynCon was separated from the STACOM control & protection system. The SynCon control & protection panel included as well monitoring for the SynCon system as well as start & stor functionalities for the pony motor. But The overall SCADA system was defining the MVAr set-point for the SynCon as well as the STATCOM. As the SynCon control system was communicating with the overall SCADA system, all necessary functions could be read out and controlled via HMI (Human Machine Interface) of the SCADA system.

**2-4. Is speed control is implemented for Synchronous condenser? If yes, how it is achieved.**

The synchronous compensator is equivalent with a synchronous motor without any shaft, running at no-load. Since the speed of a synchronous machine is fixed by the frequency of the supply voltage and the number of pole pairs in the machine it always runs in constant speed. In any case we use magnetic pick-up and slots in the shaft for additional measuring of the speed for stopping and monitoring.

**2-5. I am thinking in two control modes for the SC system and AVR: reactive power and voltage control. In the case of voltage control, is it combined the voltage regulation of AVR with step-up tap changer? Which are the typical control strategies? Thank you.**

The tap-changer control and voltage control of the machine is not combined. But it must be ensured that the tap-changer control, if automatic, is slower than in the AVR in order to avoid interaction between the regulators. This is normally handled in the overall SCADA system.

**2-6. I can see on one of the slides that adding a flywheel can take the inertia to 450MWs from a 70MVAr sync condenser. Can you provide me more information on this combination of flywheel and synchronous condenser?**

The MWs values provided by a synchronous condenser is depending on the frame size and with that linked to the rotor inertia. A typical 4-pol AMS1400 synchronous condensers would be able to provide 100MWs inertia without flywheel. The AMS1400 with flywheel can provide up to 470MWs inertia. The MVA rating of the SynCon is more linked to the MVAr requirements needed for voltage support. So the SynCon could be rated for +/-15MVAr or up to +70MVAr/-30MVAr and still provide the full amount of 100MWs inertia (without fly wheel) and up to 470MWs (with fly wheel). In the fly wheel set-up, the whole string is consisting of the pony motor, the fly wheel and the synchronous condenser, which are mechanically linked via couplings.

**2-7. Do you recommend using generator circuit breakers as well or can you just rely on the HV circuit breaker for machine protection?**

It is possible for us to use the HVCB to synchronize the SynCon. However, depending on the size of the step-up transformer, which then will be energized via the SynCon, this will may require longer time and a bigger pony motor to ramp up the SynCon accordingly. Also, the connection point of auxiliary power needs to be checked.

**2-8. What is the response time for capacitive reactive power to the grid? Also, how fast synchronous condensers change from capacitive reactive power to inductive reactive power?**

First, response time must be defined. Typically, it is defined as the time to change from initial state to 90% of final value. With that definition the response time is typically 200ms -600ms depending on machine design at no-load in a positive step change in the terminal voltage and 600ms - 1500ms for a negative step. With the synchronous compensator synchronized to grid the machine can generate reactive power and the resulting response time in reactive power will then depend on the load conditions of the grid.

**2-9. For Syncon with large inertia, how do you provide secure aux power to protect run down (e.g. bearing cooling) in the event of a supply failure?**

A SynCon with Flywheel need to have secure LV-Power supply for the forced lube oil pumps and for the cooling circuits either with air/water coolers or air/air cooling. This can be done with different combinations of emergency GenSet, UPS and/or DC system for the total run-down time of about 7 hours. It is therefore important to have special discussions for that for synchronous condenser projects with fly wheel. This shall be combined with the discussion regarding the overall safety for this application, when flywheels are used.

**2-10. 3 machines on the same shaft? Syncon, pony motor and aux generator?**

In reality already today ABB is integrating a permanent magnet generator on the synchronous condenser, which is linked to the pony motor and occasionally as well as flywheel. But this permanent magnet generator is today only used for the excitation system.

**2-11. Does small Pony motor mean it is ?? kW/ and is it like 1-ph or 3-ph motor with Direct online start (DOL) of do we need soft start for the pony motor**

We use only 3-phase PM & VSD for starting, in combination with jacking oil system for the SynCon and Flywheel if included. By definition SynCon requires low reactances (to provide a high fault current) and therefore the starting current would be very large.

We don't use DOL as it is expected that the grid POC is already weak.

**2-12. Could you give us more information about protection, control and excitation systems for ABB synchronous condensers solutions?**

ABB´s solution for synchronous condensers is a combined control & protection panel. This panel includes as a standard redundant ABB´s Unitrol 1020 excitation system, two ABB protection relays (main and back-up protection) and a PLC AC500 responsible for control, monitoring and communication to the overall SCADA system. Different protection relays can be selected as well as additional functionalities such as redundant CPU´s or ABB´s Synchrotact relay, if the synchronization via the ABB Unitrol 1020 is not sufficient enough (synchronization with different CB´s).

**2-13. Can you explain, the reason for syncon directly connected with pony motor, and why it is not used "clutch" between pony motor and SC?**

ABB don't want to use additional equipment that may get faulty. The magnetic clutch needs additional control and DC supply. We try to keep our engineered SynCon packages as simple as possible. In some applications where you want to disconnect the generator/synchronous condenser from a turbine, the clutch solution is feasible and used.

**2-14. Do you have a comprehensive control system for the whole SynCon, including the pony motor and the excitation system?**

Yes, our control system (CCP) includes AVR, protection relay, synchronization, measuring and control via an ABB PLC typ AC500. This is configured to monitor and control all the different equipment in our scope and can communicate to an overall SCADA system, which may be in ABB or customers scope.

**2-15. What are the most common failure modes of the syncons and any MTBF data?**

In general synchronous machines such as generators, motors or condensers are very reliable equipment, which are design for specific requirements. Typical failure modes are often related to not proper installation procedures, such as flushing of the cooling system and particles in the lube oil system just after installation. Therefore a set of additional filters for the lube oil system is recommended. Typical MTBF figures, as this is typical used for transmission system equipment such as CB, CT´s, surge arrestors,... are not common, as each machine may have different operating behaviour and MTBF figures from syn. generators and syn. motor are not representative as the operation of synchronous condensers is much more carm than for generators and motors, were the mechanical stresses from the turbine or the loads are influencing.

**2-16. Please share the PSCAD model of the synchronous condenser**

Before shareing PSCAD, PSS/E or power factory models for the Syncon, None disclosure agreements (NDA´s) are signed between the parties. After signing this NDA´s the models are made available for the user for a defined project. Parameter list are provided when the SynCon is offered for the project.

**2-17. What is the role of the pony motor?**

The pony motor & VSD will ramp up the speed of the SynCon to synchronous speed and after that the SynCon will be synchronized to the grid and the MV CB is closed. After that the pony motor will run de-energized. So the pony motor is only used during the short starting procedure of the SynCon.

**2-18. In your hybrid example, why do you need both Statcom and synchronous condenser? When both are delivering same solution?**

The Statcom is generally faster in the response of MVAr required, but it cannot provide inertia or short circuit power (the SynCon can). But during a fault situation in the grid, the SynCon will provide instantaneous support, quicker than a STATCOM can react on a voltage dip. So the combination of both is offering the advantage of both systems. Beside that STATCOM´s can help with active filtering and SSR damping. But frankly, these type of system services are today also available in HVDC´s and energy storage systems. So a SynCon may work together with different power electronic solutions. BUT for fault current contribution and inertia the synchronous condenser is a top of the choice solution.

**2-19. Does Sync Cond provide some level of inertia support or do we need to add flywheel for any level of inertia support?**

Yes, the SynCon provide inertia up to about 100MWs. When added a Flywheel the system inertia goes up to about 470MWs.

**2-20. Does the pony motor required for any size Sync con OR pony motor can be avoided for smaller Sync condensers?**

All our AMS type of SynCon's use pony motor for starting.

**2-21. What's the smallest size SC available today? have you ever used SCs in a Micro Grid Application?**

The smallest frame size is AMS710 which provides about 2MVAr. Just now we are working with a project for an island with a max. load of 8MW. The SynCon is in this case used to provide fault current contribution as well as inertia to limit the rate of change of frequency. Most likely this can be understood as a microgrid, even so microgrids can even be much smaller.

## 3. Technical questions related to the grid

**3-1. Is it a good idea to interconnect the grid of different states of a country considering the rise in RoCoF for a network with distributed generation? On the other hand, it will provide a huge power exchange capability.**

Interconnections between regions is a good way to support a secure power system but be aware that these interconnectors in case of high-power exchange also may be seen as the big power source, which may cause big RoCoF rates if they get tripped. It's also important that each region has their own synchronous machines providing inertia, fault current support and phase angle stability as splitting of the power system need to be considered as a risk.

**3-2. Do synchronous condensers correct PF backwards, towards supply side and not load as PF capacitor do?**

The synchronous compensator will either generate or consume reactive power and the sum of reactive power in a node will determine the reactive load flow and by that the direction of the corrected PF.

**3-3. Would it help if the renewable power sources simulated a synchronous machine with a certain inertia?**

Yes, it would help as in most/all cases the renewable power source is located far away from the consumers. These renewables using converters, do normally not contribute to the grid with inertia or short circuit capacity, instead making the grid weaker. And as more and more traditional power plants with coal/nuclear are faced out the grid stability will be weaker. But, yes, it would help if the renewable resources can participate to provide inertia, and there are also efforts taken to support that. Examples are working groups with VSM (virtual synchronous machine), implementing of providing inertia from wind turbines or integration of battery storage in renewable power plants. What is commented by some transmission system operators is the aspect that synchronous machines provide the inertia response purely by the electromechanical coupling between the machine and the grid/frequency, that means without ANY control interaction. More inertia needed => more inertia provided by the machine - pure and simple. All other possible solution require control interactions - additional risk.

**3-4. Are the utilities generally owning the syncons, or are third parties building them and selling the services to utilities and generators?**

There are different set ups in different countries, related to market rules. In Australia, in some regions the renewable plants are required to provide the SynCon´s in their solution. In UK, National Grid is "Buying" ancillary services such as inertia and fault current contribution from the market, were market players offer these ancillary services to NG and install SynCon´s. In Germany the big TSO´s are installing centralized SynCon´s. So, this question is very political. From my personal objective and knowledge, I have learned that "Decentralized power generation require decentralized system support" related to voltage support (MVAR), inertia support (MWs) and fault level support (MVA). This decentralized support will create a more secure and stronger grid, than the centralized solutions.

**3-5. Our grid is at 66 kv, we face a lot of voltage dip issue. whether you will advise to go for synchronous condenser to overcome this problem**

Tricky question. It would need more information about the grid condition and reasons for the dips to evaluate which would be the best and economical type of equipment to use to solve the problem. Continuous Power quality measurements can provide here good input.

**3-6. While a power system is still fairly large the short circuit current at a given point of the grid wont lower much, even if the power sources are mostly based on power electronics. The fault current is like a "stolen" current from the loads, that had been fed in the instant before. Only if a part of the big power system becomes isolated, then fault current will also drop.**

I do not share this opinion. As the power market is a competition between different power plants the OPEX of the plant at a given point in time will define which power generation will be used and which fault level is available in the grid. Let's take a simplified example. We have a power system where power supplied is 100% from synchronous machines of 1000MW, which would provide a fault current which is roughly 5 times the power supplied about 5000MVA. If we now add renewables. Wind turbines can provide a fault current which is 1,1 - 1,2 times the power supplied. If during a windy day 80% of the power transmitted is from wind turbines 800MW, which is perfect to reduce CO2 emissions, the possible fault current during this time is reduced from all wind power plant to totally 960MVA and for the rest of the power generation it is 200MW with a fault level of 1000MVA. So, for this grid the fault level reduces from 5000MVA to 1960MVA. This means at this given point of time the fault level is drastically reduced.

**3-7. What is the typical reaction time for the voltage control as grid voltage dips are typically 50-150 ms?**

The reaction time of the AVR is in the order of 20ms but then there are the time constants of the exciter and main machine before the response can be observed in the output voltage.

**3-8. Single-phase are more frequent - any support with negative sequence?**

The synchronous compensator has a symmetric output and by that support the positive sequence. At a single phase fault or a line to line fault the SynCon will contribute with negative sequence current.

**3-9. Can you compare the speeds of response for a brushless excitation system versus slip rings in meeting utility response rate requirements?**

The difference between a brushless and static excitation system is the time constant of the exciter machine which slow down the response. Also the supply voltage to the excitation system will influence response rate. A high supply voltage will allow a faster change of the excitation current and thereby change of the terminal voltage of the machine.

## 4. Technical questions related to alternative solutions

**4-1. Thanks for a very impressive presentation. Can utility scale battery be a solution for both active and reactive power contribution as an alternative to sync. condenser?**

Yes, it could provide active and reactive power, but it cannot provide any significant short circuit power or inertia to the grid.

**4-2. Could you highlight the STATCOM and VSC major differences? where VSC has obvious advantage and disadvantage?**

STATCOM means STATic COMpensator and VSC means Voltage Source Converter. In reality many STATCOM´s are built by using the VSC technology to provide a "voltage source". Different topologies can be used to build up a VSC, such as 2-level converter, 3-lever converter or multi-level converters. The goal of all of them is to provide dynamic reactive power, which is used for voltage regulation, active filtering, sub synchronous resonance damping, flicker damping or damping of unbalances.

**4-3. Can you refer to Biblis NPP in SW Germany, - where the generator runs as phase shifter since plant decommissioning?**

Unfortunately, this refurbishment of an existing generator of the nuclear power plant Biblis into a synchronous condenser was not successful. During the project execution the investment costs became so high that the project got a lot of critic in the newspapers. After 7 years of operation this synchronous condenser was closed done. I do not know the details about this project, but as I mentioned in my presentation it is very important to check in detail if a refurbishment of an existing generator to a synchronous condenser is economically feasible. LEAP analysis and check of the existing generator in detail is critical to access the remaining lifetime of the generators insulation system. You can also imagine, that running a big generator, just to provide fault current or inertia during short periods is very costly as the losses are too high.

**4-4. How new is synchronous condenser in the world? Has this innovation existed for a long time?**

About 70 years ago Synchronous Condenser's were used for voltage regulation in the power system. Until today some of this old units are still in operation. After the introduction of power electronics in the 70-ties, SVC´s and later STATCOM´s took over from the SynCon´s. During that time big synchronous generators provided the stability in the grid. Sometimes together with additional flywheel. With the increase of nonsynchronous generation, the SynCon's have come back with the first units installed about 10 years ago. However, as the big generators are faced out more and more due to coal/nuclear shut down and replaced with renewables with inverters, the need of more inertia and short circuit capacity is in focus. This is where SynCon are coming in again. So it’s a re-born technology.

**4-5. Theoretically, if all the renewable power plants will be connected in DC to the grid, the problem won't be solved?**

Please keep in mind that the majority of energy transmitted, distributed and consumed today is still done in AC. The loads are often rotating machines, from big industrial processes, to pumps and air-condition (fans) in our homes and in our computers and the big majority works on AC. By just connecting all the renewables to DC will not help in solving the fault current problematic. As fault currents will still be needed in the transmission, distribution and consuming network of the AC power.

**4-6. Difference between VSC & synchronous condenser? advantage & disadvantage**

The big difference between the two solution is that VSC´s voltage source converters can NOT provide fault current contribution and inertia. The SynCon can provide BOTH fault contribution as well as inertia. Common for both technologies is that they can provide dynamically controllable reactive power (capacitive & inductive). The advantage for the SynCon is, that it already in the beginning of a voltage dip can support, which influence the depth of a voltage dip. The advantage for the VSC is that it quickly can support reactive power after clearing of the fault and regulate back to steady state conditions. VSC´s have also other features which can help in the power grid, such as active filtering of harmonics up to a certain harm. frequencies (but VSC´s are also creating harmonics, but on higher frequencies), damping of SSR (sub synchronous resonances) and flicker damping of electric arc furnaces (industrial application). Features of the SynCon´s are they are supporting phase angle stability in-between other SynCon´s, act as a sink for negative sequence currents.

**4-7. Has there been any situations where a "Power former" type machine could be used?**

No, not yet. This technology is useful where there is limited space for a step-up transformer which rarely is the case where synchronous condensers are placed.

**4-8. What are advantages adding a separate pony motor + synchronous condenser when any machine-driven generator can instead be “synchronous condenser ready” when a simple clutch is added to any generator driven by another machine? Several hundred operating already; Indian Queens, Pinjar, Malmo etc.**

Generators are normally designed for a special turbine or engine application, which require from the generator to provide a defined active power output and allow for a requested power factor as per the grid code. This operating point of the generator is shown in the capability diagram. As the normal goal of a generator is to provide active power this is impacting on the reactive power capability of the machine. Beside that are generators designed for to keep the fault current contribution as low as possible as this would otherwise increase the costs for the connecting MV switchgear or the generator CB. Of course theoretically a NEW power plant could be designed in a way to allow both for an generator operation as well as for synchronous condenser operation, but as per now very few of these special designs are realized as they increase on one side the costs /MW and on the other side limit the possible synchronous condenser functions.

**4-9. For refurbishment I suppose the exciter might be replaced for overexcited operation. Examples for refurbished normal generators into Condenser in Europe?**

Generators are normally designed with field forcing capability and therefor the exciter is not required to be refurbished. Depending on required output data exciter machine or even the main rotor may need to be replaced to fulfill customer requirements. An important factor is also the remaining lifetime of the generator. We recommend performing LEAP analysis before making any refurbishment decisions.

## 5. Commercial question regarding SynCon installation

### 5-1. which is the CAPEX per MVAR, whole installation including civil Works, auxiliary systems, etc.?

The CAPEX of a SynCon is depending on the requirements of the power system, the size, the voltage and where and how it is connected, environmental and local conditions, requirements such as cooling, noise, redundancy requirements.

### 5-2. My company carries out master planning studies for island grids. We do not presently model sync condensers combined with flywheels. It looks very attractive. Can you provide budgetary prices for this?

Yes, we can provide budgetary prices, which are depending on the requirements of the power system, the size, the voltage and where and how it is connected, environmental and local conditions, requirements such as cooling, noise, redundancy requirements.

### 5-3. Thanks for your presentation, can you provide an estimation of the price of SynCons per capacity? $/Mvar?

Yes, we can provide budgetary prices, which are depending on the requirements of the power system, the size, the voltage and where and how it is connected, environmental and local conditions, requirements such as cooling, noise, redundancy requirements.

### 5-4. How is with maintenance? If you can explain a little bit about recommended maintenance time periods and costs that it brings?

The maintenance requirements for a synchronous condenser is very similar to that for a synchronous motor or generator, but the maintenance interval is longer, as a synchronous condenser can be seen as a synchronous motor running without load (no mechanical stress, limited ON/OFF switching). The typical maintenance intervals are defined as per ABB´s L1 to L4 maintenance schedules were L1 is a general inspection taking about one working day (8 hours) / year and L4 correspond to a rotor inspection (40 working hours). The first L4 maintenance with rotor inspection is normally planned after 12 years of operation. Detailed maintenance schedules are normally provided with each offer.

### 5-5. How often is required and how complex is the maintenance for the SynCons?

Maintenance for synchronous condensers shall be done yearly to secure a long lifetime of the asset. ABB recommends working with ABB or ABB certified partners for the maintenance, even so the normal L1-L3 maintenance can easily be done by service engineers. For a L4 rotor inspection we recommended ABB specialists. For a SynCon the L4 service is recommended every 12 year.

### 5-6. What is cost of a typical brand-new turnkey package for 2MVA SCO? This for a hypothetical application on 11kV, 22 MVA mining operation, in South Africa.

My recommendation would be to contact me or our local ABB organization for a budgetary price, as costing is very much depending on the technical requirements, environmental conditions, scope of supply and redundancy requirements for the aux. Power system.

### 5-7. What is the price?

It depends on the machine size and how much MVAr it is loaded with at normal operating conditions

### 5-8. How much is the electricity consumption for a typical synchronous condenser?

The active power consumption for a machine is depending on the operation of the machine, this means how much MVAr´s are absorbed or generated. The losses are normally between 0.7% (no-load losses at

0MVAr) up to 1.1% at max. over exited operation (max. MVAr generated). Additional to the machine losses are losses for the consumption of the aux. equipment which is very much depending on the cooling system selection.

**5-9. What is the cost comparison between SVC, STATCOM and SynCon?**

This is very much depending on the requirements as well as on the voltage the solution will be connected to. But if we have to connect a dynamic solution providing 70MVAr to a 132kV network, my cost comparison would be as following: SynCon 100%, SVC 150%, STATCOM 300%. BUT please keep in mind these 3 different solutions do NOT provide the same functionality. Some functions cannot be provided by the SynCon, some functions cannot be provided by the SVC or the STATCOM.

**5-10. Commercially, what is the lowest power capacity of the proposed condensers?**

The smallest units are in the range of 2MVAr, but this must be for microgrid applications. For distribution system support the range is from 10MVAr upwards and for transmission system support the machines around 40-70MVAr are selected and sometimes even used as multiple redundant units.

**5-11. Which could be the CAPEX and OPEX for a package?**

Yes, we can provide budgetary prices, which are depending on the requirements of the power system, the size, the voltage and where and how it is connected, environmental and local conditions, requirements such as cooling, noise, redundancy requirements.

**5-12. How many Syncon Will be necessary per year in the following 5-10 years?**

This is very much depending on the implementation of the CO2 emission reduction programs globally and the development of other solutions, which may compete or be a complementary to SynCon´s.

**5-13. What is the typical time delivery for SynCon standard solution?**

Typical delivery time is 10-13 months depending on the size and number of units and the rest of the scope of supply.

**5-14. Would it be any future webinar like that? for instance in more advanced level? would you have some networking events for ABB? for people who are open to opportunities in Canada.**

The next webinar is planned on the 19th of January together with ENTSO-E and some European transmission system operators. Additionally, seminars /webinars to that are not planned yet. ABB may offer customer specific events, please contact your local ABB contact person or myself for further discussion.

**5-15. A follow up presentation that addresses the specification of SCs from a manufacturer's point of view. Especially touching on cost sensitive issues.**

Customer specific discussions can always be arranged, please contact your local ABB contact person or myself.

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For more information please visit:
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