Study Committee SC-C5 | PS3

WORKING WITH INNOVATION AND DISRUPTION—
PREPARING FOR THE FUTURE

10495_2022

International Practices for Reactive Power, SC Power, Inertia Compensation And Tariff Model Proposal for Pilot Synchronous Condenser Implementation

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Motivation

- To address the issues of lack of compensation mechanism for ancillary services
- Grid Stability/Reliability issues with Integration of Renewables
- Need for well planned regulation and cost recovery mechanism
- Comparing International Practices
- Tariff Model

Approach

- Study of various grid codes and regulations
- Identifying the available technologies for grid stability/reliability
- Cost comparison of solutions available in the market
- Identify strongest techno economic solution
- Cost Overview of the proposed solution
- Cost Recovery/Tariff Mechanism based on the above

Objects of Investigation

- Power System Network
- Investigation of available ancillary service technologies such as SVCs, STATCOM and Synchronous Condenser
- International Practices for Ancillary Services

Technology	Ancillary Services		
	Dyn Reactive Power Support	Short Circuit Power	Inertia
STATCOM	√ (Fast)	X	X
SVC	√ (Fast)	X	X
SynCon	√ (Medium)	√	√

Discussion

- Synchronous condensers emerge as the strongest techno-commercial solution
- Presently, no concrete cost recovery/tariff mechanisms and regulations exist for compensating inertia and short circuit power (SCP)
- Proposed Cost Recovery Mechanism:
  - **Model-I**: **Fixed Tariff:** All ancillary services (Short circuit power, inertia and reactive power) shall be provided at a fixed cost
  - **Model-II: Variable Tariff:** Capacity charges for inertia and short circuit power. Actual usage charge for reactive power (based on the reactive power actually delivered or absorbed)

Study Results

Technology	Cost in USD Million			
	SVC	STATCOM	SynCon (NEW)	SynCon (RE-PURPOSED)
Cost/MVAR (USD Million)	0.058	0.088	0.06	0.035

Model-I: Fixed Tariff	**Fixed Charges** for Inertia, SCP and Reactive Power	**$ 0.0018/ KVARh (AFC/MUs)**
Model-II: Variable Tariff	**Capacity charge** (Inertia and SCP) + **Actual usage charge (**for reactive Power)	$ 0.0028/ KVARh#

90% PLF for Inertia and SCP, 30% PLF for reactive power

Conclusion

- Various mechanisms are being tried across the world to compensate dynamic reactive power/ancillary services
- Presently, only the EIR grid regulations have initiated payments for new age ancillary services
- Urgent requirement of policy and pricing mechanism to promote investment in the area
- Synchronous condensers can be the most preferred techno-economic solution
- Variable tariff model can benefit the owner, the regulator as well as the consumer

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Renewable Integration Challenges

- Sudden drop in generation (Intermittency)
- RE generators do not provide inertia and have limitation of providing SC power and dynamic reactive power
- These Ancillary services are essential for grid stability and reliability
- Therefore, additional equipment such as SynCon, battery storage etc needs to be installed at strategic locations considering huge RE integration planned

Regulatory Support Required

- Assessment/mapping of short circuit power, inertia and reactive power
- Provision of incentive/benefit/payment to all service providers of such ancillary services on non-discriminatory basis
- Incentive for providing fast response ancillary services (Short circuit power/inertial support/reactive power support/ fast frequency response)
- Beneficiary of these ancillary services shall be charged for the services.

Cost of Installating New SynCon (Approx.)

S. No.	Description	Price for 400 KV USD Million
1.	Synchronous Condenser (250 MVAR)	4.02
2.	Generator Transformer Bank	1.21
3.	Generator Circuit Breaker	0.67
4.	SEE and GRP	1.34
5.	Drive Motor with VFD	0.67
6.	Generator Busduct	0.40
7.	Generator Auxiliary System	0.13
8.	HV, LV System, AC and Misc. System	0.40
9.	EHV Bay	0.67
10.	Land Cost	0.40
11.	Civil Foundations and Building Cost	0.40
12.	Erection, Testing and Commissioning	1.34
13.	Technical Support	2.68
14.	Miscellaneous Expenses	0.67
	Total	**15**

Comparison of Available Solutions

Support	SynCon	STATCOM	SVC
Inertia (Frequency Stability)	Yes	No	No
Dynamic Reactive Power	Yes	Yes	Yes
Short Circuit Power	Very High	Very Limited	Very Limited
Overload Capacity	Very High	No/ Expensive Equipment Required	No

Cost of Repurposing (Approx.)

S. No.	Description	Price USD Million
1.	Generator Rewinding (250 MVAR)	2.01
2.	Modification in Excitation System & GRP (if required)	1.34
3.	Drive Motor with VFD	0.67
4.	Generator Auxiliary System	0.134
5.	Misc. including civil cost	0.67
6.	Erection, Testing, Commissioning	1.34
7.	Technical Support	2.01
8.	Miscellaneous Expenses	0.67
	Total	**8.84**

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Suggested Cost Recovery Mechanims

- **Model-I: Fixed Tariff:** All ancillary Services (short circuit power, inertia and reactive power) as per requirement (subject to machine capacity) can be provided at a fixed cost.

Tariff based on sample calculation is as follows:

Case-I	During Loan Period (Ist Year)	(AFC/MUs) = **$ 0.0020 /KVARh**
Case-II	After Loan Period	(AFC/MUs) = **$ 0.0017 /KVARh**
	Levelised Cost (For plant Life of 30 years)	**$ 0.0018 /KVARh**

- **Model-II: Variable Tariff Model:** Following two components of tariff in this model:
  - **Capacity Charges:** For system inertia, SC power
  - **Actual usage charge:** For reactive power (based on reactive power actually delivered or absorbed)

Tariff based on sample calculation is as follows:

Case-I	Capacity Charge (For SC and Inertia)	(AFC/MUs) = **$ 0.00125 /KVARh**
Case-II	Capacity Charge (Inertia +SCP) + Actual charges (for reactive power)	(AFC/MUs)** = **$ 0.0028 /KVARh**

90% PLF for inertia and SCP, 30% PLF for reactive power

Annual Fixed Costs

S. No.	Description	(Providing inertia & SCP only)* USD Million	(Providing Inertia, SCP & Reactive power)** USD Million
1.	Return on Equity	0.87	0.87
2.	Interest on Loan	0	0
3.	Depreciation	0.2	0.2
4.	Interest on Working Capital	0.05	0.05
5.	O&M Expenses	0.45	0.45
6.	Active Power Cost from Grid	0.91	1.22
	Total AFC	**2.48**	**2.79**

International Practices

- Presently, no concrete cost recovery mechanisms/ regulations exists for compensating inertia and short circuit power.
- A tariff for compensating inertia has recently been introduced by EIR Grid.
- For reactive power compensation, different mechanisms have been adopted by the system operators.
- **Inertia compensation—EIR Grid (Ireland)**

The basis of payment for **Synchronous Inertial Response (SIR)** is the calculation of the SIR available volume of the providing unit over a trading period

SIR Trading Period Payment = SIR Available Volume × SIR Payment Rate × Trading Period Duration

SIR Payment Rate is the Payment Rate for SIR (expressed in €/MWs2h) applicable to SIR

Conclusion

- Various approaches are being tried across the world to compensate dynamic reactive power/ancillary services
- Presently, only the EIR grid regulations have initiated payments for new age ancillary services
- Urgent requirement of policy and pricing mechanism to promote investment in the area
- Synchronous condensers can be the most preferred techno-economic solution
- Variable tariff model (for inertia, SCP and Reactive Power) can benefit the owner, the regulator as well as the consumer