

DOCKETED

Docket Number:	18-IEPR-03
Project Title:	Southern California Energy Reliability
TN #:	223319
Document Title:	Tim Buttke Comments - Presentation Using Generators as Synchronous Condensers for Reactive Power, etc.
Description:	Presentation by Morgan L. Hendry - SSS Clutch Company, Inc. previously submitted to Docket No. 12-AFC-02C - Using Generators as Synchronous Condensers for Reactive Power & Aero-Derivative Gas Turbine Generators for Spinning Reserve
Filer:	System
Organization:	Tim Buttke
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Using Generators as Synchronous Condensers for Reactive Power & Aero-Derivative Gas Turbine Generators for Spinning Reserve

Additional submitted attachment is included below.

Using Generators as Synchronous Condensers for Reactive Power & Aero-Derivative Gas Turbine Generators for Spinning Reserve

Presented to: California Energy Commission, Sacramento, California

Morgan L. Hendry – SSS Clutch Company, Inc.
November 9, 2016



Clutch Company, Inc.

Purpose WebEx Meeting – #12-AFC-02C - Synchronous Condensing in De-Regulated areas of California

- 1) Generators produce MW's, Dynamic MVAR's, Spinning Reserve, & Grid Inertia
- 2) When not generating, generator can be disconnected by SSS Clutch & left connected to grid for Dynamic MVAR's, Spinning Reserve & Dynamic Inertia
- 3) SSS Clutches are supplied worldwide for Steam Turbine, Gas Turbine, and Reciprocating Engine driven generators for this purpose
- 4) Renewables do not produce MVAR's or Inertia – CAISO - 50% by 2030
- 5) At CAISO direction, Legacy Huntington Beach Generating Station Units 3 & 4 were converted to synchronous condensers by disconnecting steam turbines and installing pony motor acceleration systems to connect generators to grid
- 6) Huntington Beach Expansion Project (12-AFC-02C) – CAISO - 2 X 1 combined cycle generating plant to include SSS Clutches for synchronous condensing
- 7) Installation of SSS Clutches in ST & GT technically feasible and proven
- 8) Owner bidding job objected - no payment for clutch capital cost and operation
- 9) California Energy Commission Final Staff Assessment (520 pages), issued Oct 2016, Docket #12-AFC-02C, Project Compliance, TN # 214127 – SSS Clutches
- 10) CEC hearings November 14 & November 30, 2016

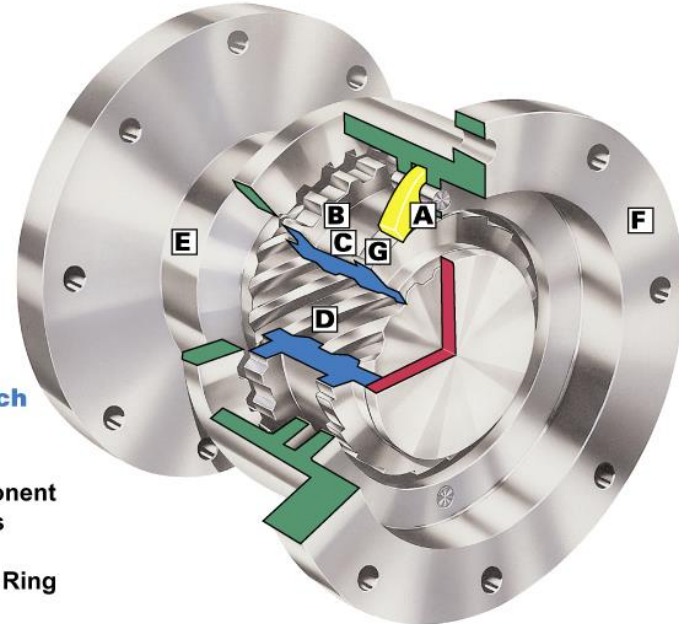


SSS Clutches in Power Plant Applications

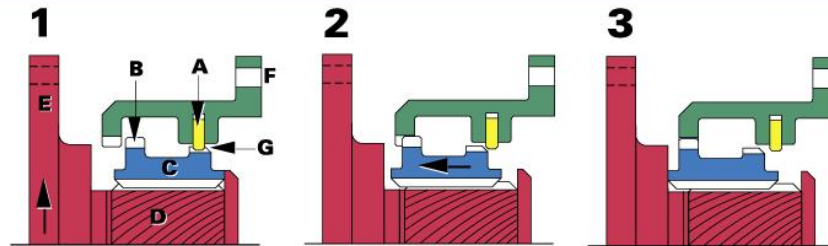
- Single-Shaft, Combined-Cycle Plant
- Cogeneration Plant
- Synchronous Condensing using the Generator of Peak Load Turbines
- Combined Heat and Power Plant
- Compressed Air Energy Storage (CAES) Plant
- Pumped Water Storage Plant
- Rotating Uninterruptible Power System (UPS)
- Auxiliaries
 - Gas and Steam Turbine Turning Gears
 - Gas Turbine Starting

Elements of Basic SSS Clutch

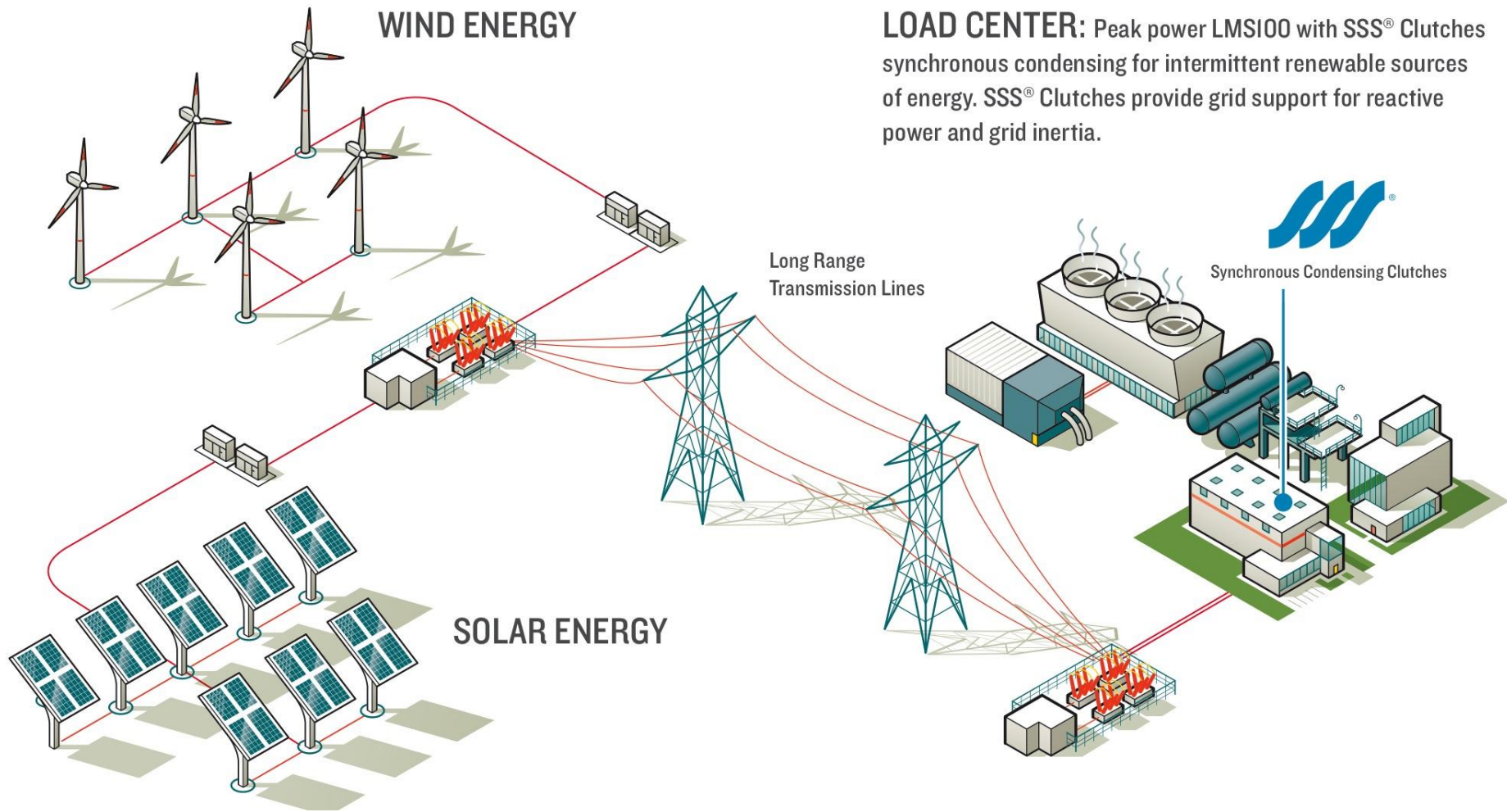
- A Pawl
- B Clutch Teeth
- C Sliding Component
- D Helical Splines
- E Input Shaft
- F Output Clutch Ring
- G Ratchet Teeth



SSS Clutch Principle Of Operation



Synchronous Condensing - Provide Reactive Power, Provide Spinning Reserve & can help Maximize Renewable Energy



Regional Installations of SSS Clutches - 4 Size 272T SSS® Encased Clutches - GE LMS100 Synchronous Condensing/Spinning Reserve

One Installed in 2008 — GE LMS100 at Calpine's Cumberland Energy Center, Millville, NJ
Two Installed in 2010 — GE LMS100 at LADWP's Haynes Power Station, Long Beach, CA
Two Installed in 2014—GE LMS100 at LADWP's Scattergood Power Sta., Playa Del Rey, CA



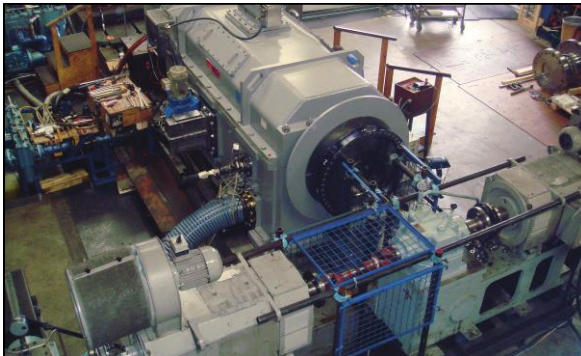
Two LMS100 Gas Turbine Generators with size 272T SSS® Encased Clutches at LADWP's Haynes Power Station, Long Beach, CA



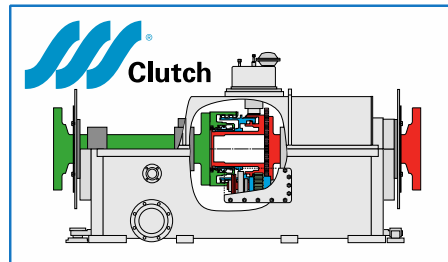
LMS100 Gas Turbine Generator with size 272T SSS® Encased Clutch at Calpine (formerly Conectiv) Cumberland Energy Center, Millville, NJ.



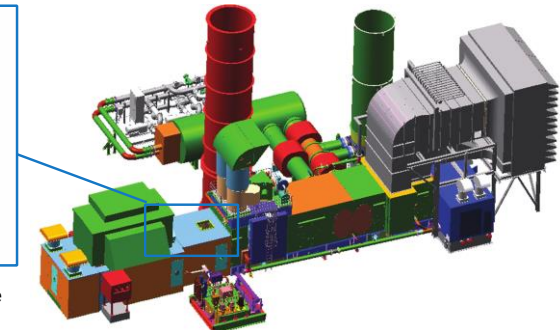
130 MW rated Size 272T SSS® Encased Clutch installed in LMS100.



SSS® Encased Clutch on test prior to delivery



SSS® Encased Clutch (with turbine gear) to enable synchronous condensing for reactive power or spinning reserve duty



Thirty-six SSS Clutches Installed-LM6000's: USA, Canada, New Zealand & The Netherlands

Installation

Summary

In Operation

33 - 60 Hz

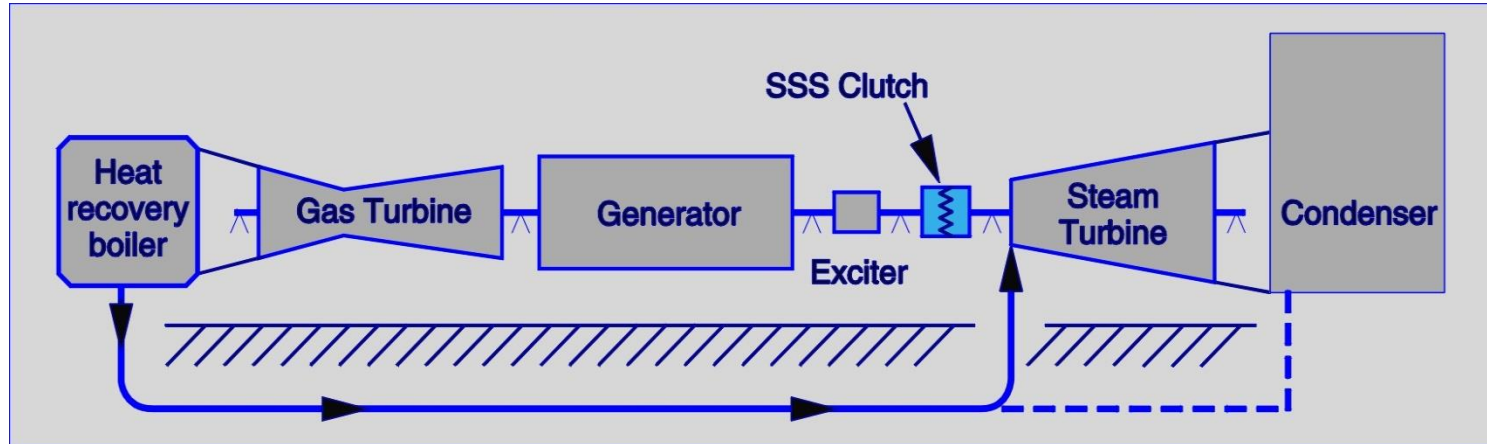
3- 50 Hz

About 400,000 Total
Fleet Hours
Operation To Date

**Two units
in Lemoore,
CA**



Regional Installations of SSS Clutches in Power Plants



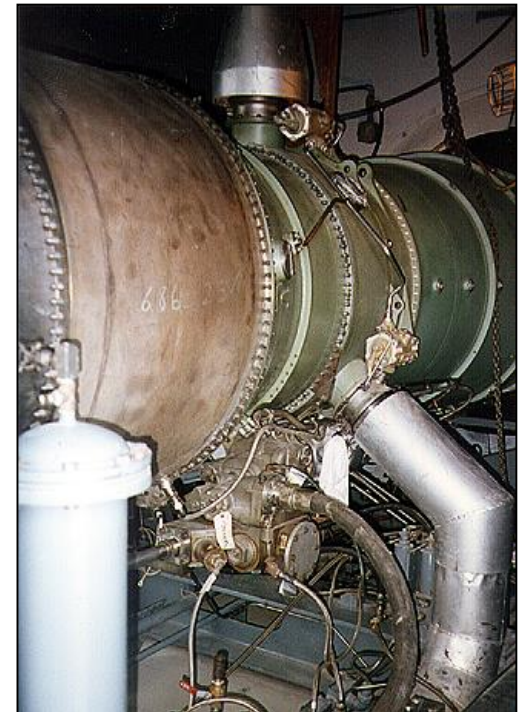
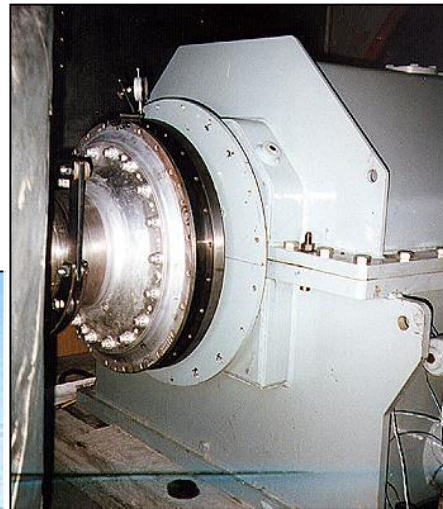
Single Shaft Combined Cycle Installations in Southwest Transmission Plan Area

- Four 105 MW SSS Clutches @ La Paloma, CA in 2000
- One 105 MW SSS Clutch @ Hermosillo, Mexico in 2000
- Two 105 MW SSS Clutches @ Rosarito, Mexico in 2000
- Two 1.9 MW SSS Clutches @ Phoenix, Az in 2001
- One 2 MW SSS Clutch @ Phoenix, Az in 2005



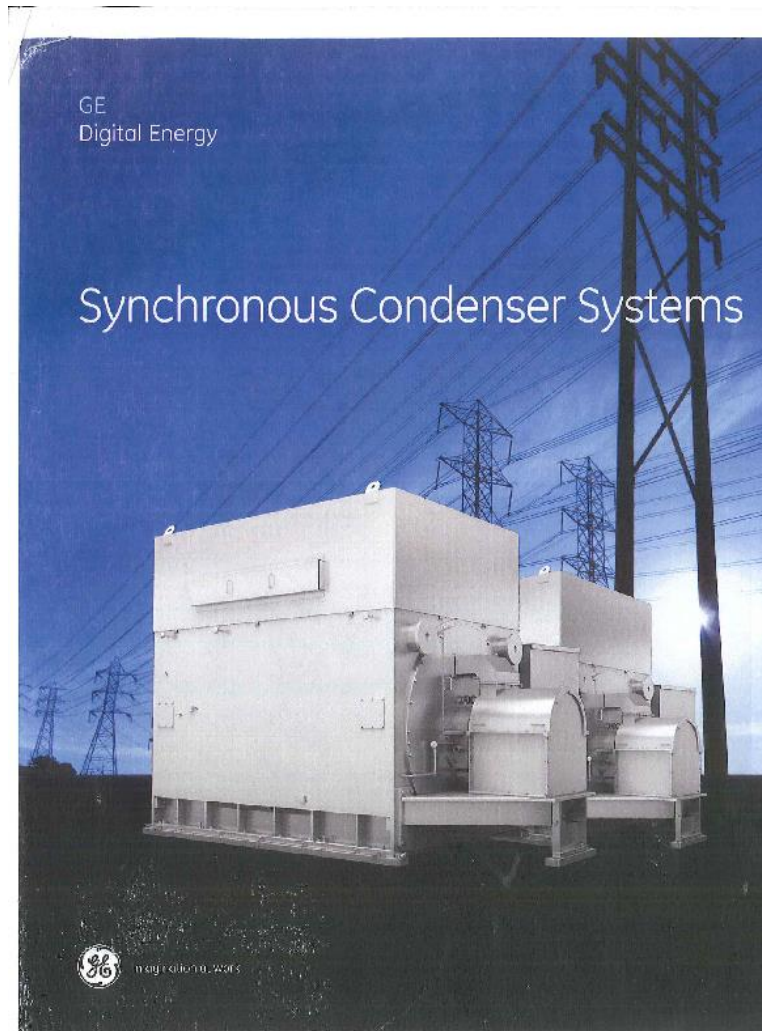
Synchronous Clutch Retrofit of FT-4 Twin Pac: San Jose, CA for Reactive Power – Voltage Stability

Greenwich Air Systems, Inc. relocated a TP&M Twin Pac with two 34 MW FT4-CI gas turbines from Public Service of New Jersey, Linden Plant, to PG&E, San Jose Plant (one block west of airport). A size 214T SSS Clutch was installed between only one gas turbine and the generator at the non-exciter end to permit synchronous condensing. In service for more than 10 years for voltage stability in lower San Francisco Bay area grid.



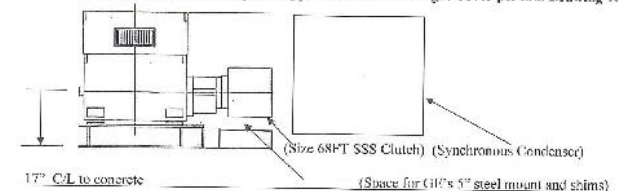
3 GE Synchronous Condenser Systems with SSS Clutches in start motor to be installed at SCE Santiago Station, Irvine in December

Addition of SSS Clutch reduced losses of spinning start motor with savings of \$13,000 per KW. Also savings in wear & maintenance associated with spinning start motor 24/7.



SSS GEARS APPLICATION DATA SHEET – Revision #4 – November 4, 2015
Reference # 15-160 & A-8852
E-20736

CUSTOMER: GE, Peterborough, Canada
PROJECT: Synchronous Condenser Acceleration VFD Induction Motor Disconnect
LOCATION: Southern California Edison, Santiago Substation, Irvine, California
PROPOSED: 68PT SSS Spacer Type Clutch with Oil Tight Cover per SSS Drawing 16213



DUTY:
Max Continuous Power: 1,000 HP at 1,200 rpm
Overrunning Speed: 1,200 rpm
Normal Full Load Torque: 4,420 FT LB
Breakaway Torque: 6,630 FT LB
Max Torque: 150% FLT Drive Limit Cause: Accelerate Torque
Max Engaging Speed: Zero rpm normally
Input acceleration: Output deceleration: Requirement to Catch on Fly - YES
Direction of Rotation: CCW Clutch when viewed from i/p to o/p

MISALIGNMENT:
Axial movement of- Installed length = 15.060", Max is 15.06" - 0.55" +0.01" = 15.62" and Min length is 14.5"
Output relative to input (includes install tolerance) negligible
none
0.010 inch with present design

EXTERNAL LOADS:
Axial thrust disengaged: Negligible
Axial thrust engaged: Small - Generator Mag Centering
Axial force required to slide teeth axially: 188 LB @ 100% Power

SERVICES:
Pressure Oil Available YES
Oil type ISO VG 46
Specified flow 16 Litres per minute
Available pressure (Max / Norm / min) 15 PSIG
Temperature range (Max / Norm / min) 20-50 Degrees C
Power Loss to customer oil system 2 kW disengaged/1 kW engaged
Drag Transmitted to SSS I/P Flange 15 lb. ft. estimated
Filtration 10 µm
Oil inlet and drain connection side of SSS casing RWS looking i/p to o/p

Ref #15-160 / E10736- Size 68PT SSS Spacer Type Clutch for Synchronous Condenser



What is a Synchronous Condenser ?

Definition

- Synchronous Machine Connected to Electrical System
- Driven from Electric System (Motoring)
- Absorbing or Supplying Dynamic VARs (with rotational inertia for the transmission system)

Automatic Voltage Regulator (AVR) on Low Voltage

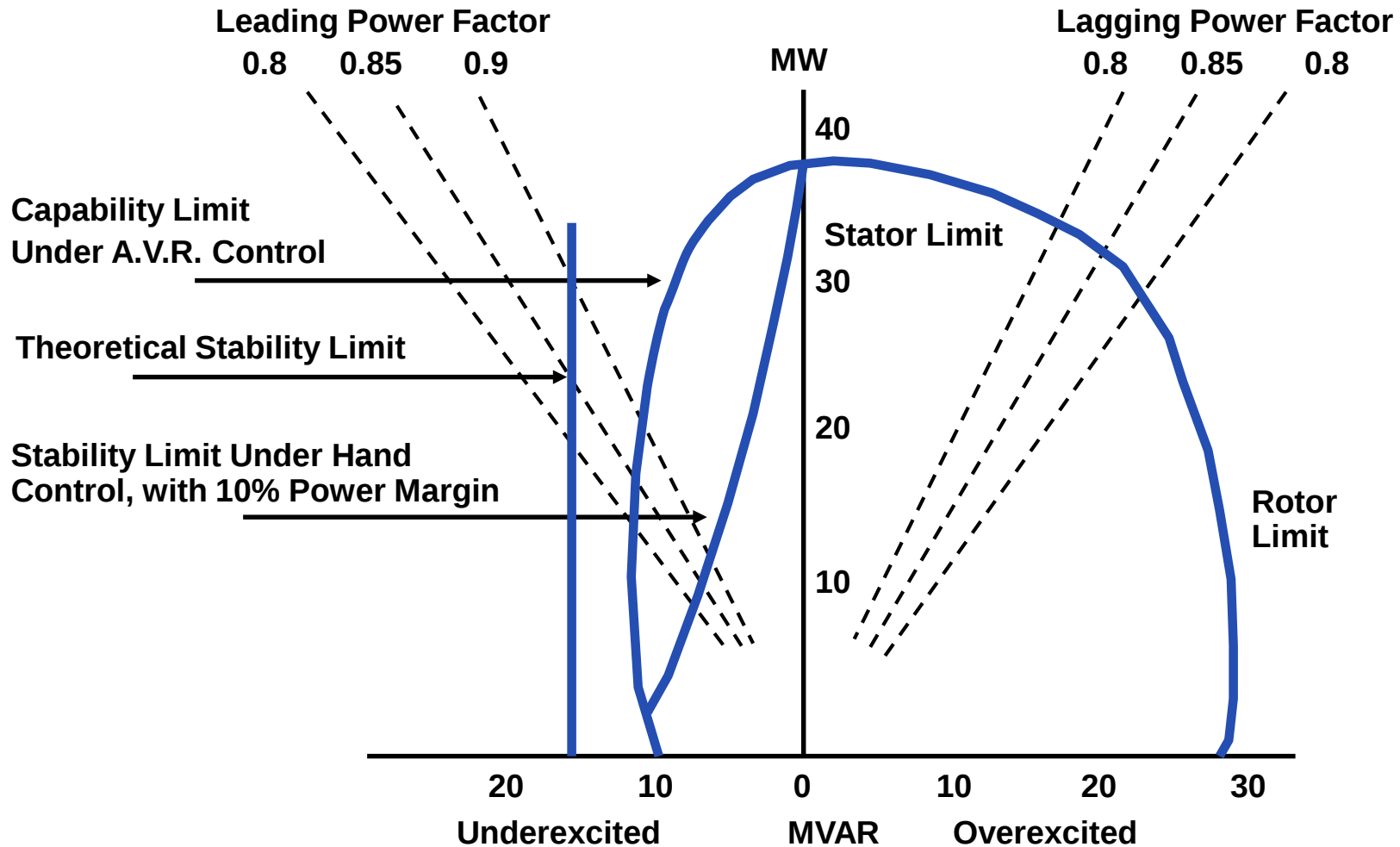
- Adjusts Excitation
- VARs Supplied Increased
- Power Factor Restored
- Voltage Restored

Automatic Voltage Regulator (AVR) on High Voltage

- Adjusts Excitation
- VARs Supplied Reduced
- Normal Voltage Restored



Typical Generator Reactive Capability Diagram



Benefits of Synchronous Condensing

- 1. Provide/absorb VARs in small increments to correct lagging/leading power factor**
- 2. Meet peak VAR requirements without reducing watts of generators in operation**
- 3. Power factor/voltage support at end of long transmission lines provides stability and enables more watts to be transmitted**
- 4. Power Factor/Voltage Support in Urban Centers and Industrial areas provides stability and enables more watts to be transmitted.**
- 5. Synchronous Condenser is unique - can provide rotating inertia and “Dynamic VARs” to stabilize grid system, particularly when loads vary quickly**
- 6. Generator operating as synchronous condenser could possibly qualify for spinning reserve requirements or credit**
- 7. Complements Static Capacitors by providing finite adjustment of VARs reducing need to switch capacitors off and on, extending their service life.**
- 8. Synchronous Condensers provide Reactive Power for both high and low voltage.**
- 9. Can absorb VARs at the end of underground cables to correct high voltage problems.**
- 10. Synchronous Condenser can be an additional source of revenue in a deregulated market.**



Summary of Synchronous Condensing Clutch Installations

Total number of clutches installed	533
Total number of countries	55
Total aircraft-type gas turbines	203
Total industrial gas turbines	330
Total clutches over 100 MW	36

Note: Largest clutch in service is 300 MW at 3,000 rpm installed in 1976 on compressed air energy storage (CAES) plant, Huntorf, Germany, now owned by RWE.

First SSS Clutch supplied for Synchronous Condensing about 40 years ago



Options for Synchronous Condensing

Candidates for MW's & MVAR's

Generators of Aero-derivative of Frame Type Gas Turbines: Peak demand, located near load centers or end of long transmission lines.

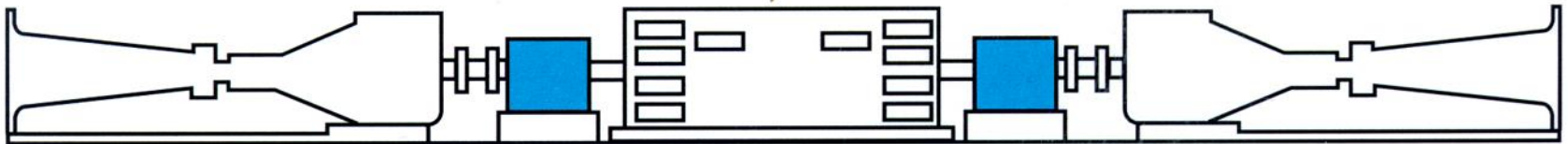
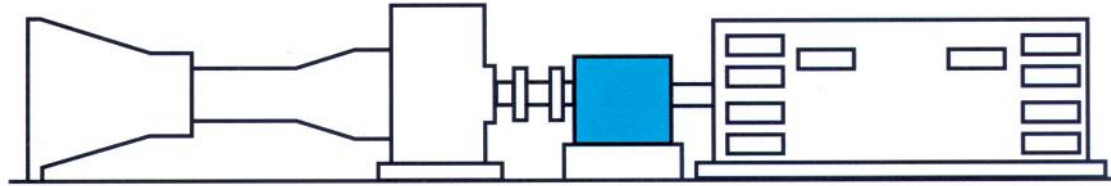
Large Steam Turbine Generators: Operated seasonally or decommissioned

Requirements:

- a) Means to accelerate generator to synchronous speed
- b) Means to detach Prime Mover from generator after synchronization (SSS Clutch)



One is by placement of the synchronous clutch between the Generator and its corresponding Steam or Gas Turbine.



LMS100 with SSS Encased Clutch Installed at LADWP, Haynes Power Station, Long Beach, California

**Six GE LMS100
Packages are
Installed At
LADWP, Haynes
Generating Station;
Two have SSS
Encased Clutches
(Units 12 & 14)**



GE LMS100 Package Layout Showing Generator, Lubrication System and Size 272T SSS Encased Clutch

Size 272T Encased SSS Clutch

Lubrication System for Generator and SSS Encased Clutch

Concrete Foundation for SSS Clutch

TOP WORK



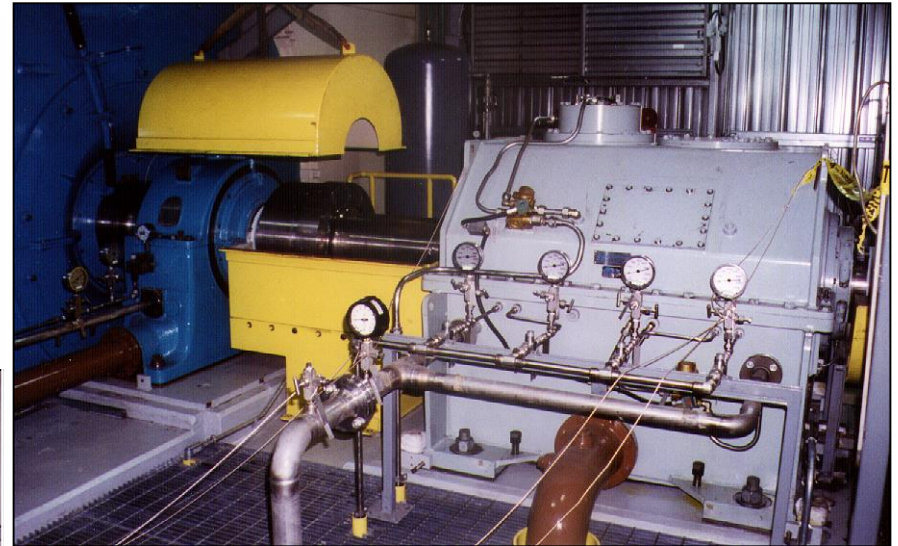
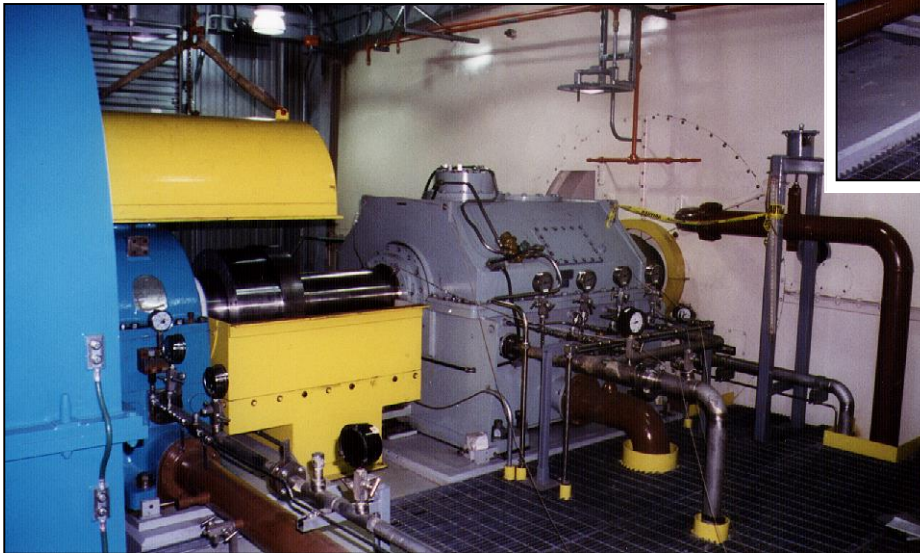
LMS100 with SSS Encased Clutch Installed at LADWP, Haynes Power Station, Long Beach, California

**Size 272T SSS
Encased Clutch
Installed in Unit
#14 at LADWP,
Haynes Generating
Station. Generator
is to the Left and
Turbine to the
Right. In the
Foreground is the
Generator Flexible
Coupling Guard**



Synchronous Condensing Project for Kansas City Power & Light

SSS Clutch model 280T between gas turbine and generator in Siemens model V84.3A, at Hawthorne Station, Kansas City Power & Light, Kansas City, Missouri. Generator has variable frequency and can be connected to the grid for synchronous condensing without starting the turbine.



Since plant startup in 1997, its capacity has been **170 MW of power** and, with turbine stopped and generator functioning as a synchronous motor, a **MVAR range of +150 and -87**.



Conversion of Generator to Synchronous Condenser, Keys Electric System, Key West, Florida, USA

Florida Municipal Power Authority, Orlando, Florida, installed two Frame 5 gas turbine generators in 1998 to guarantee 60% of normal power would always be available in Key West. One is equipped with an SSS Clutch as back up to their GE 44 MVA synchronous condenser.

Through 2003, the Frame 5 with SSS Clutch has generated power for 2285 hours and operated as a synchronous condenser for 4660 hours.



Ancillary Markets in the United States. Example - PJM & MISO

Tier II Synchronous (Spinning) Reserve Markets

- Induce response by on-line, marginal resources through compensation
- Introduce competition for spinning capacity
- Compensate providers of spinning capacity on the basis of a clearing price rather than cost



Synchronous Reserve - To support System Frequency

Operating Reserve

- **Primary Reserve** (full power in ten minutes)

Spinning Reserve (generator must be connected to grid)

- Tier I—supports system frequency
- Tier II—responsive to system frequency (PJM and MISO)

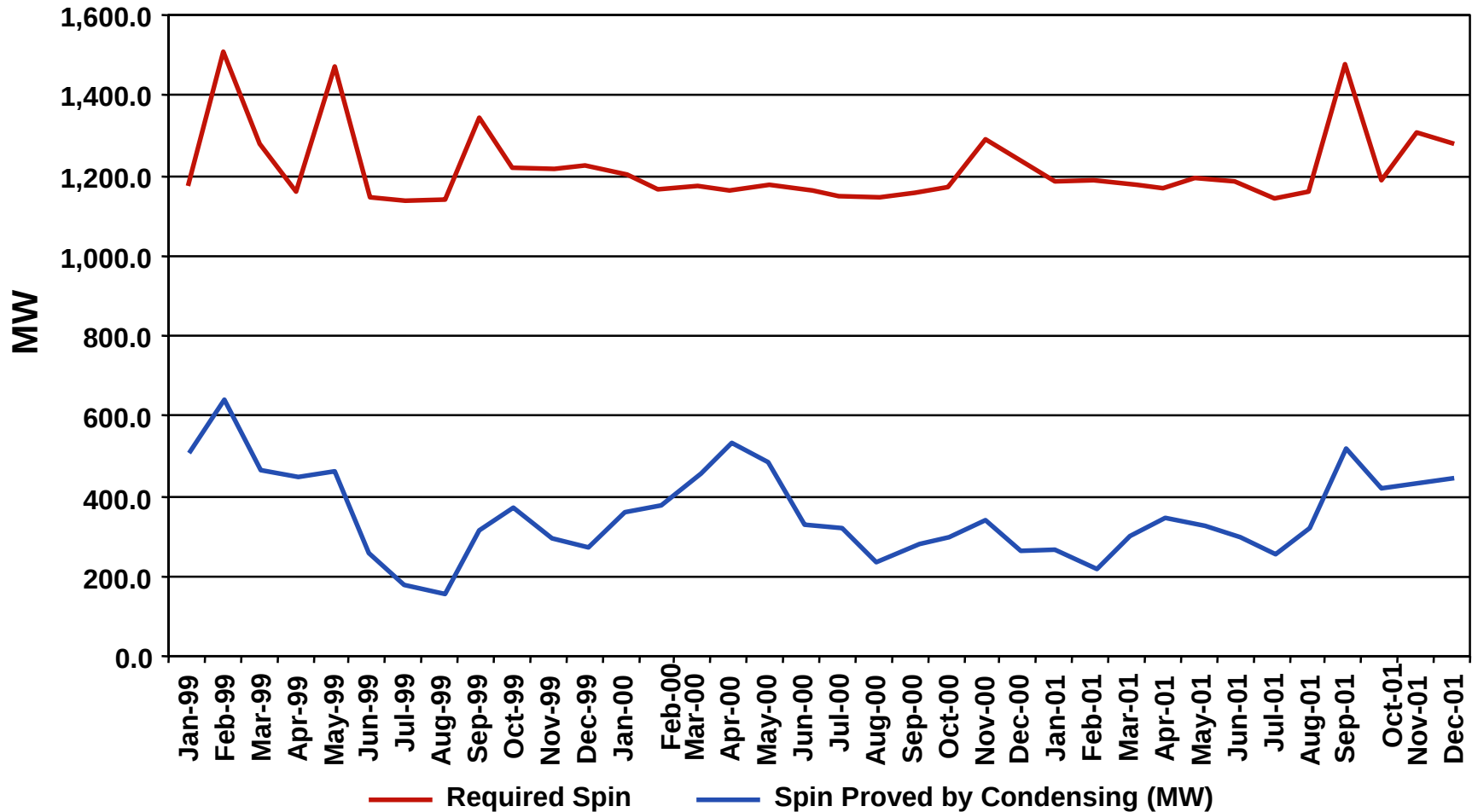
Quick Start Reserve (generator not connected to grid, but full power in ten minutes)

- **Secondary Reserve** (Quick start—full power in thirty minutes)
- **Black Start Capability**
- **Reactive Power**
 - Active sources
 - Passive sources

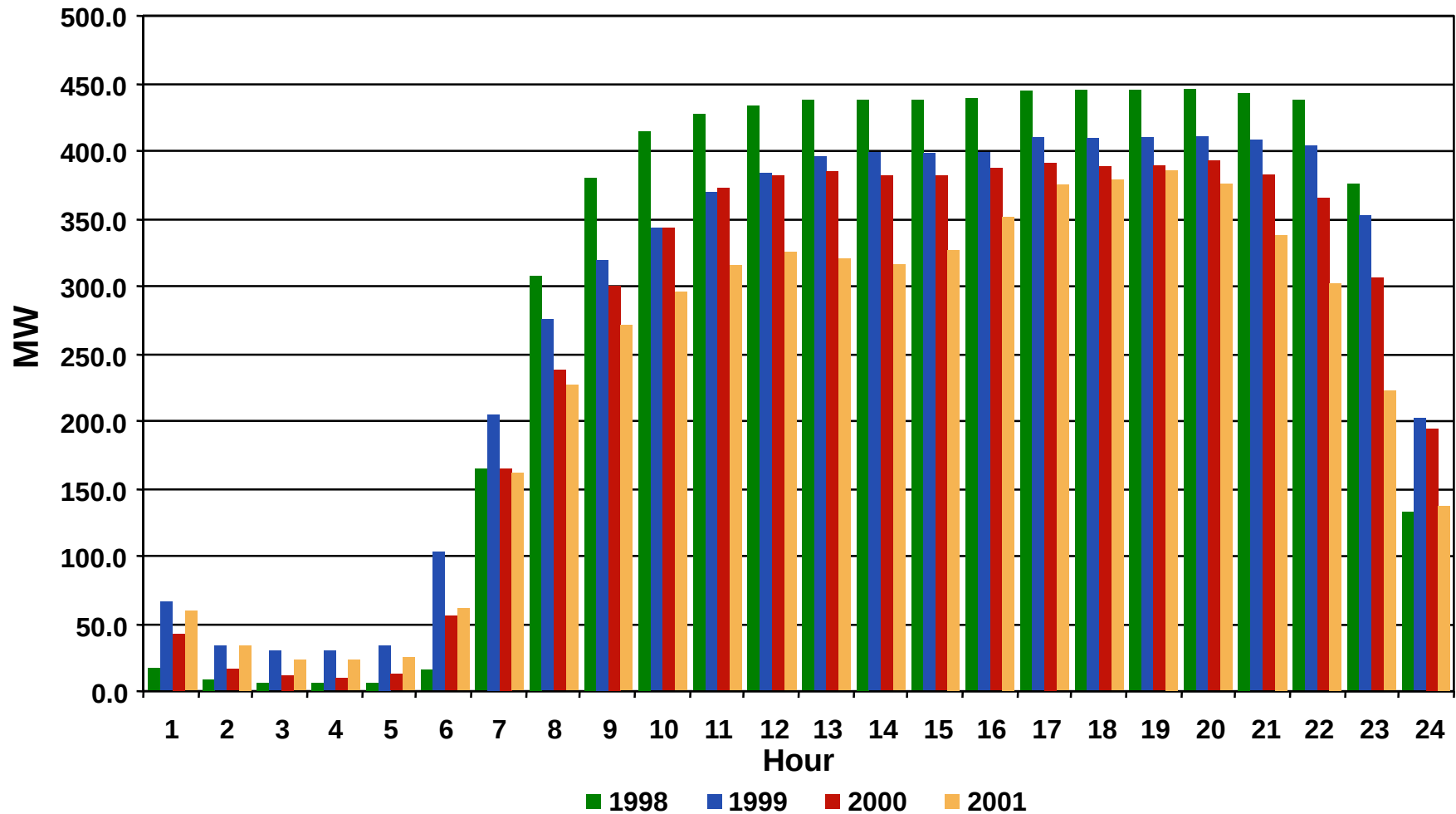


PJM–East: Total Required Spinning & Spinning Provided by Generators Operating in Synchronous Condensing Mode Only

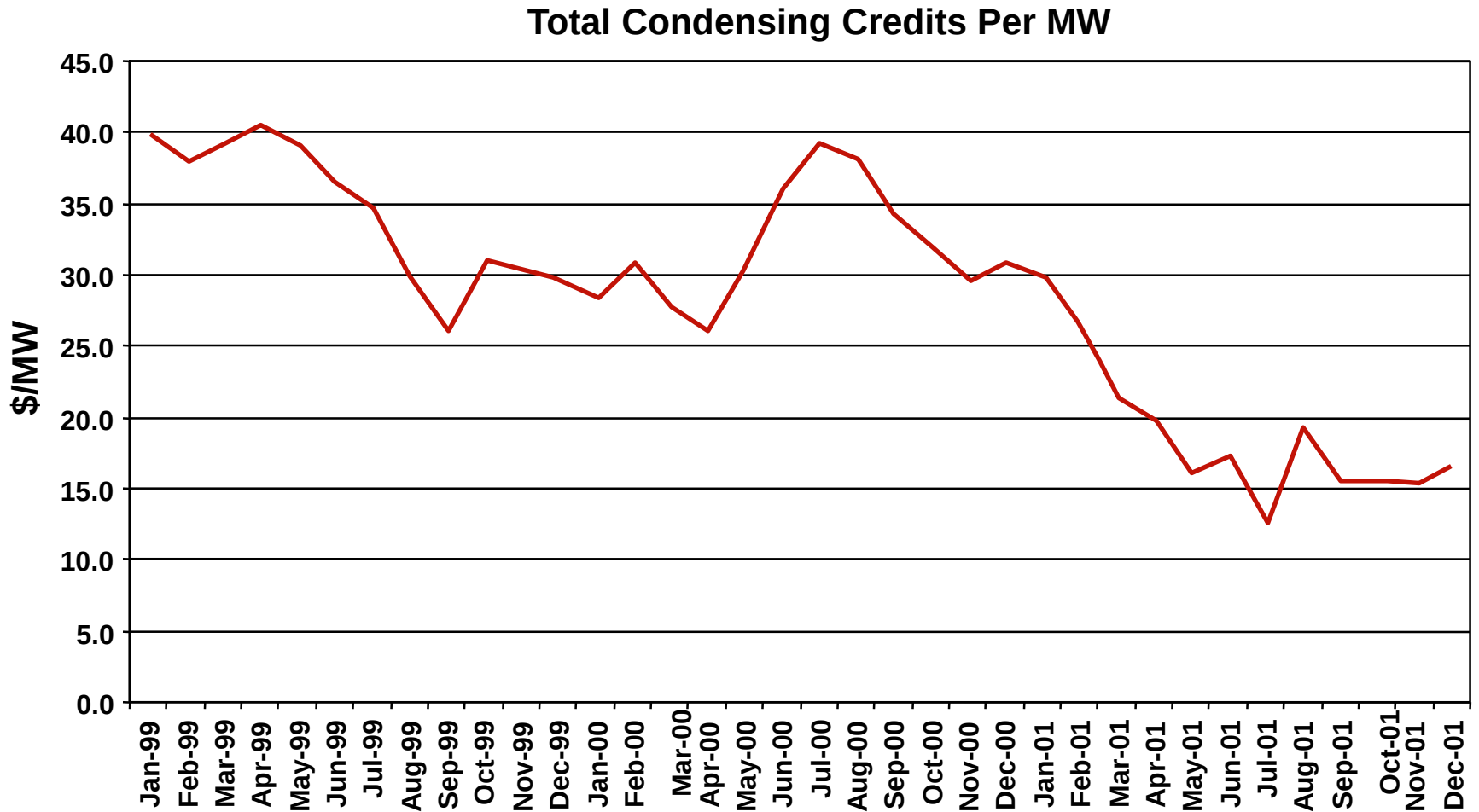
Required Spin Provided by Condensing



PJM East—Average Total Synchronous Condensing by Hour



PJM –Total Condensing Payments per MW per hour



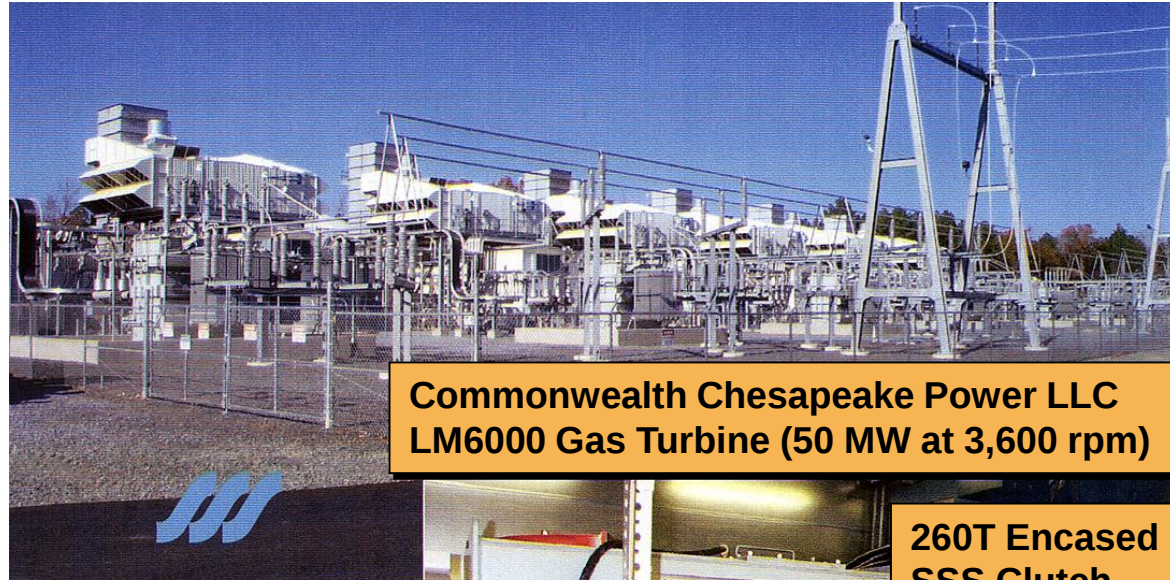
Economic Justification for PJM Spinning Market

Economic Justification to Retrofit LM6000 with SSS Clutch to Enable Participation in PJM Tier II Compensated Spinning Reserve Market

- Losses to spin LM6000 with SSS Clutch are less than 500 kW
- **Assume** \$.06/kW hr to purchase power to spin generator
- **Therefore**, cost in spinning reserve mode ($$.06 \times 500 \text{ kW}$) = \$30 per hr
- **2002 spinning reserve payment was:** $\$12.00/\text{MW} \times 40 \text{ MW}$ (rating of LM6000) = \$480 per hr revenue
- **Assume** 15 hours per day potential spinning reserve duty
- **Therefore** \$7200 ($\$480 \times 15 \text{ hr}$) per day gross revenue produced and \$450 ($\$30 \times 15 \text{ hr}$) per day cost
- **POTENTIAL NET REVENUE:** $\$7,200 - \$450 = \$6,750$ per day
- **Assume:** cost to retrofit SSS Clutch = **\$1,000,000**
- **Return on Investment (ROI):** **About 148 DAYS**
- **Conclusion:** Pay for investment - **Less than one-half year**



Tenaska Power – Commonwealth Chesapeake Power, New Church, Virginia



**Commonwealth Chesapeake Power LLC
LM6000 Gas Turbine (50 MW at 3,600 rpm)**

**260T Encased
SSS Clutch**

An SSS Clutch installed between the turbine and the generator enables four machines to qualify for Tier II Spinning Reserve.

Units could be used for Schedule 2 Reactive Power by maintaining the generator synchronized with the grid while the turbine is stationary and on standby.



Size 260T SSS Clutches Installed in 60 Hz LM6000 Gas Turbine Generator Sets

Utility	Location	GT Number	Drawing No.	Serial No.	SSS Ref.	Installation Date
ATCO Power	Grand Prairie, Alberta, Canada	Unit 1	SL18492	R.10883	C7600/A4027	September 1999
PSE&G	Burlington, New Jersey	Unit 121	SL18671	R.12361	C8063/A4305	January 2001
PSE&G	Burlington, New Jersey	Unit 122	SL18672	R.11502	C7816/A4169	May 2000
PSE&G	Burlington, New Jersey	Unit 123	SL18671	R.11501	C7816/A4169	May 2000
PSE&G	Burlington, New Jersey	Unit 124	SL18672	R.11504	C7816/A4169	May 2000
TECO Energy	New Church, Virginia	Unit 4	SL18811	R.13783	C8153/A4423	April 2001
TECO Energy	New Church, Virginia	Unit 5	SL18672	R.12363	C8153/A4423	April 2001
TECO Energy	New Church, Virginia	Unit 6	SL18672	R.12367	C8153/A4423	April 2001
TECO Energy	New Church, Virginia	Unit 7	SL18811	R.13785	C8153/A4423	April 2001
PSE&G	Kearny, New Jersey	Unit 121	SL18671	R.12360	C8063/A4305	May 2001
PSE&G	Kearny, New Jersey	Unit 122	SL18672	R.12365	C8063/A4305	May 2001
PSE&G	Kearny, New Jersey	Unit 123	SL18671	R.11503	C7816/A4169	May 2001
PSE&G	Kearny, New Jersey	Unit 124	SL18672	R.13785	C8063/A4205	May 2001
GWF Energy	Lemoore, California	Unit 22A	SL18672A	R.12381	C8063/A4305	April 2002
GWF Energy	Lemoore, California	Unit 22B	SL18671A	R.12368	C8063/A4305	April 2002
ATCO Power	Valley View, Alberta, Canada	Unit 1	SL18671	R.13784	C8700/A4651	June 2002
Otter Tail Power	Solway, Minnesota	Unit 1	SL18671	R.12369	C8063/A4305	March 2003



Size 260T SSS Clutches Installed in 60 Hz LM6000 Gas Turbine Generator Sets

Utility	Location	GT Number	Drawing No.	Serial No.	SSS Ref.	Installation Date
Lafayette Utilities	Lafayette, Louisiana	Unit 1	SL18671	R.13786	C10042/A5338	March 2006
Lafayette Utilities	Lafayette, Louisiana	Unit 2	SL18672	R.12380	C8063/A4305/A5313	March 2006
Sask Power	Ermine, Saskatchewan , Canada	Unit 1	SL18811	R.16621	C10489/A6407	April 2009
Sask Power	Ermine, Saskatchewan, Canada	Unit 2	SL18811	R.18510	C10771/A6474	April 2009
Sask Power	North Battleford, Saskatchewan, Canada	Unit 1	SL18811	R.24270	C10771/A6557	April 2010
Sask Power	North Battleford, Saskatchewan, Canada	Unit 2	SL18811	R.24271	C10771/A6558	April 2010
Sask Power	North Battleford, Saskatchewan, Canada	Unit 3	SL18811	R.18511	C10771/A6558	April 2010
Northland Power	Tantaloon, Saskatchewan, Canada	Unit 1	SL18811	R.19267	C12500/A6806	April 2011
Northland Power	Tantaloon, Saskatchewan, Canada	Unit 2	SL18811	R.19268	C12500/A6815	April 2011
PSE&G	Kearny, New Jersey	Unit 131	SL18811	R.19269	C12500/A6994,	May 2011
PSE&G	Kearny, New Jersey	Unit 132	SL18811	R.23685	C12500/A7007	May 2011
PSE&G	Kearny, New Jersey	Unit 133	SL18811	R.23686	C12500/A7010	May 2011
PSE&G	Kearny, New Jersey	Unit 134	SL18811	R.23687	C12500/A7011	May 2011
DEMEC	Smyrna, Delaware	Unit 2	SL18811	R.24269	C13040/A7113	December 2011
Basin Electric	Williston, North Dakota	Unit 1	SL18811	R.24272	C13040/A7429	August 2012
Basin Electric	Watford, North Dakota	Unit 1	SL18811	R.24273	C13040/A7500	September, 2012

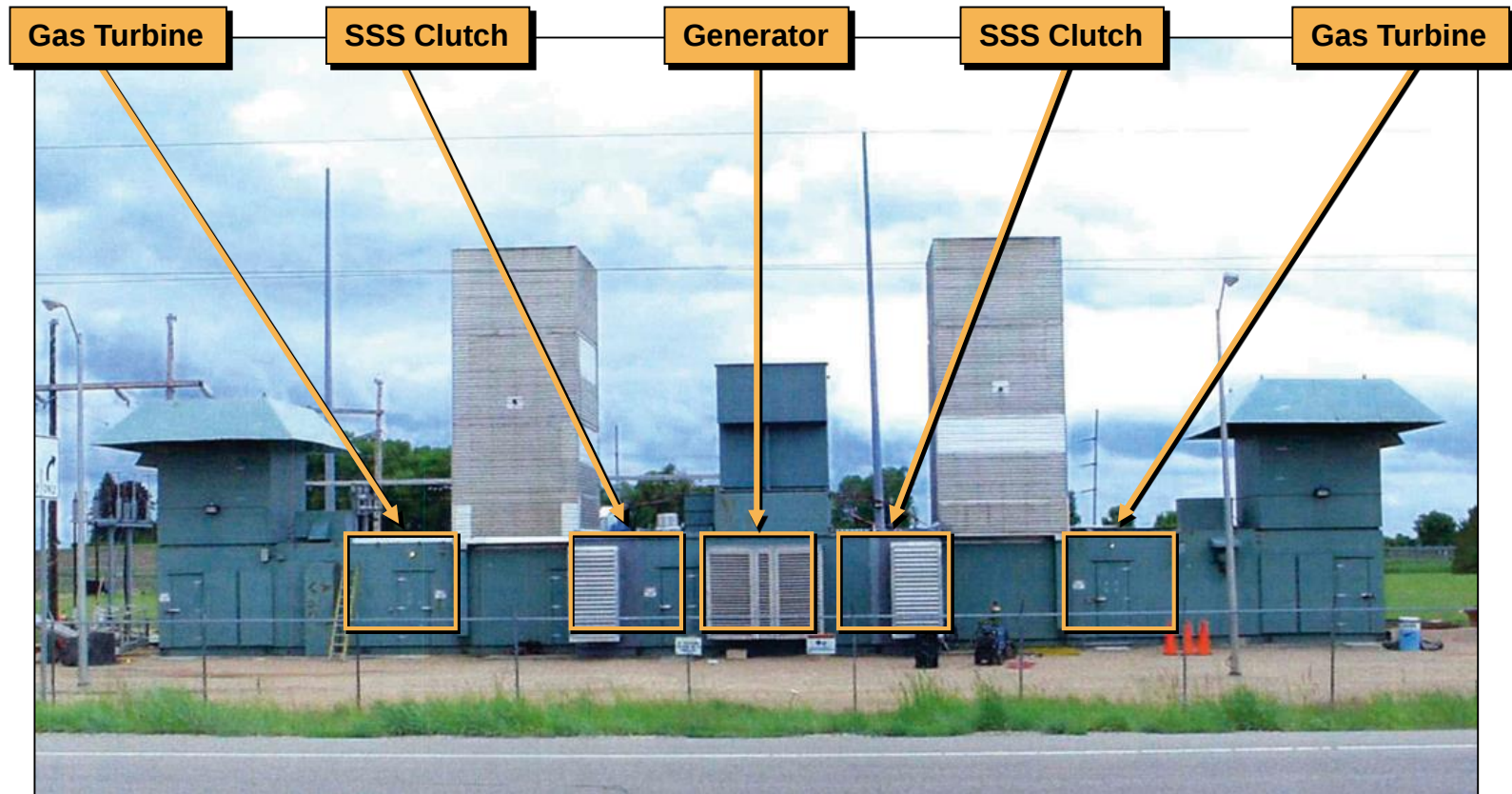
Notes Reference NR2130 August 29, 2013

Total Number Size 260T SSS Clutches in 60 Hz LM6000 Gas Turbine Generators, 1999-2013: 33 SSS Clutches



sssclutch.com

MISO - Dual Service: MW — Spinning Reserve



Completed Retrofit of FT-4 Twin Pac at Great River Energy, St. Bonifacous, Minnesota, now equipped with SSS Clutches between the Generator and the Gas Turbines on either side.



And the other one is inclusion of the SSS Clutch in an “acceleration system”, placed at exciter end of either:

Stand-alone generator

Generators with the coupling between the generator and turbine removed

- 1) To accelerate the generator to synchronous speed and**
- 2) Disconnect the acceleration system to enable the generator to be used for synchronous condensing**



Case Histories

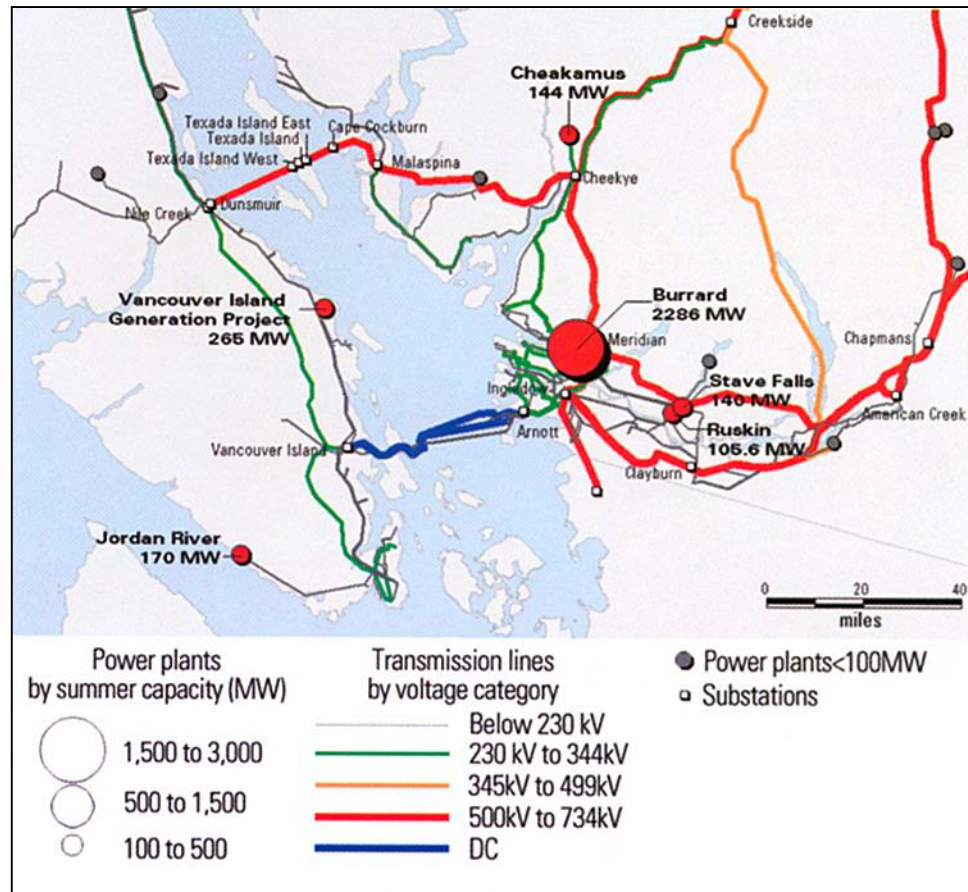
Synchronous Condensing Conversion Achieved by Use of “Acceleration Packages”:

- B.C. Hydro, Vancouver, British Columbia, Canada
- Zion Nuclear Plant, Zion, Illinois, USA
- City Electric System, Key West, Florida, USA



B.C. Hydro, Vancouver, British Columbia, Canada

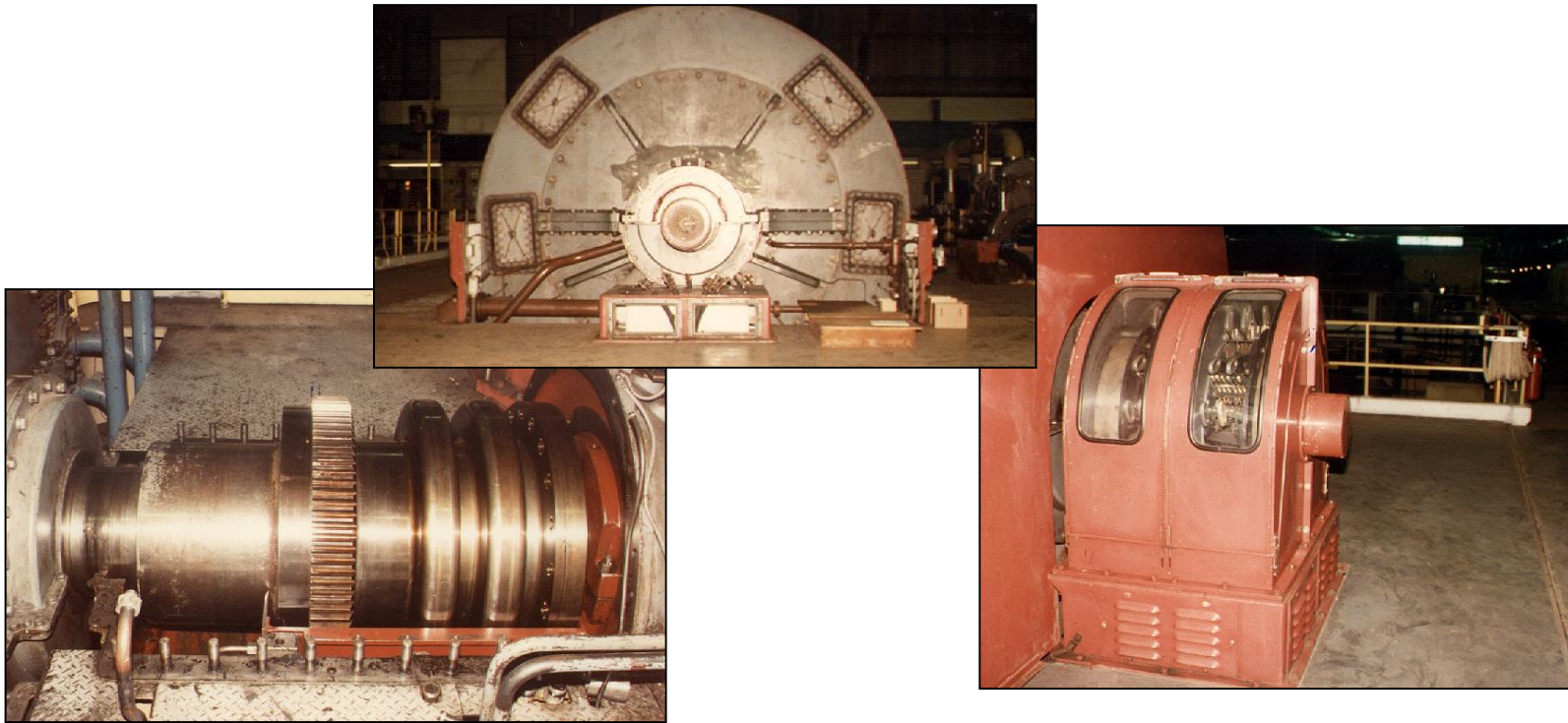
10,800 MW total
9,700 MW hydro—base
900 MW thermal—peak
140 MW gas turbine
60 MW other generation



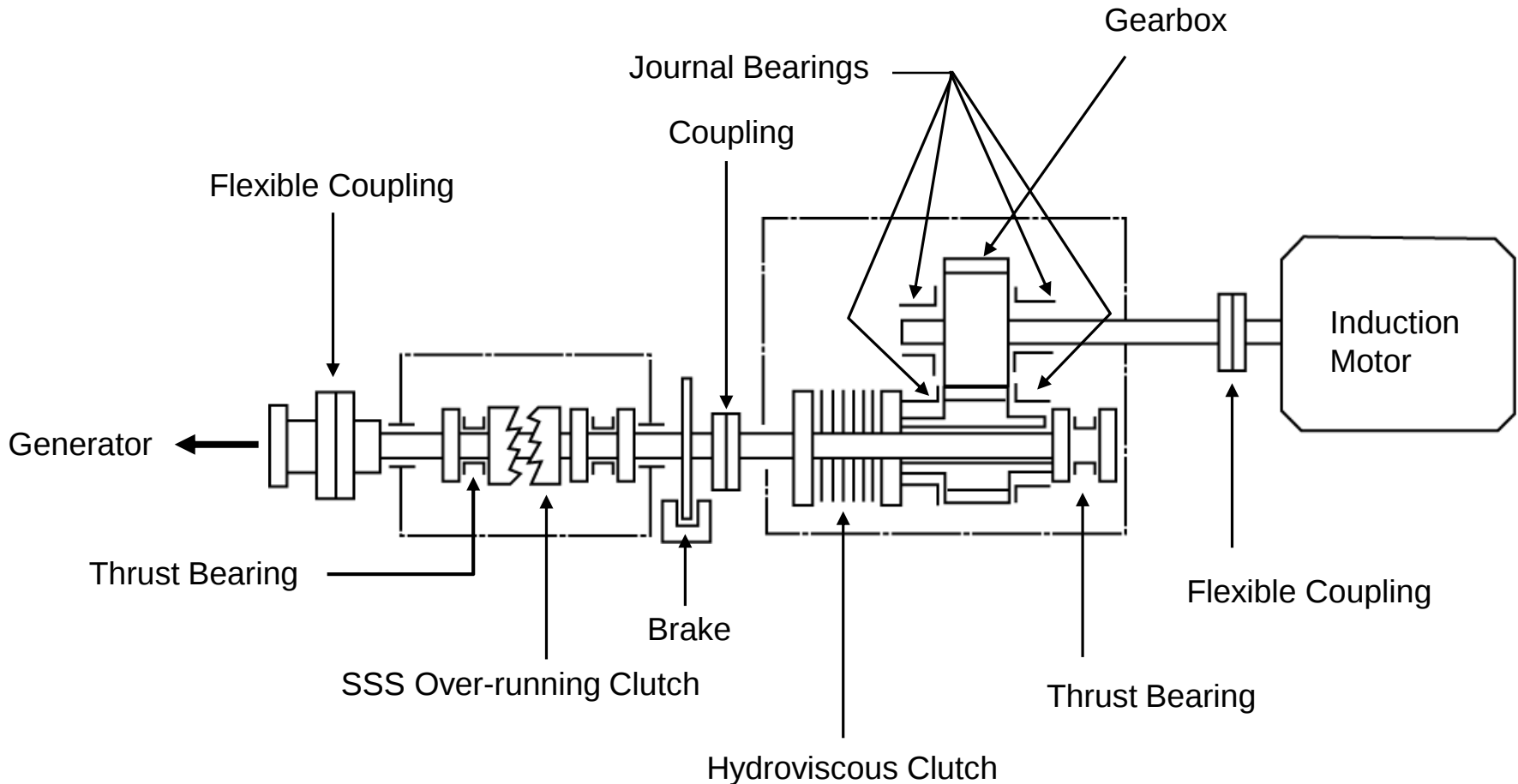
B.C. Hydro Burrard Thermal Plant

Four 150 MW English Electric steam turbines and generators prior to installation of synchronous condensing acceleration packages.

Generators used in winter for power generation and summer for synchronous condensing.



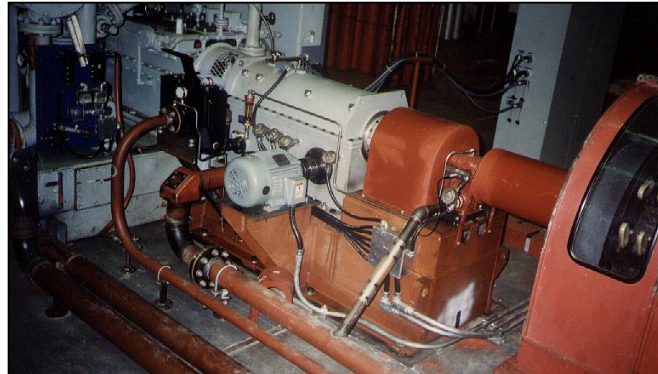
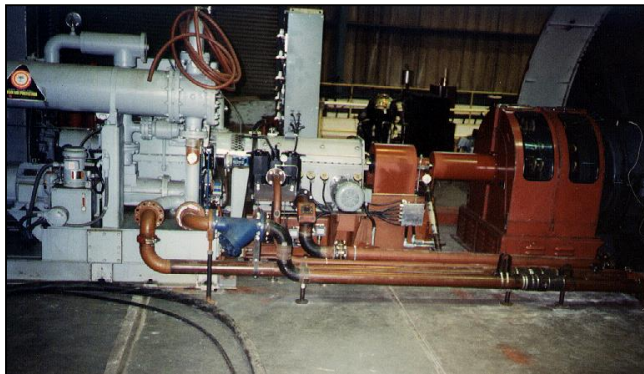
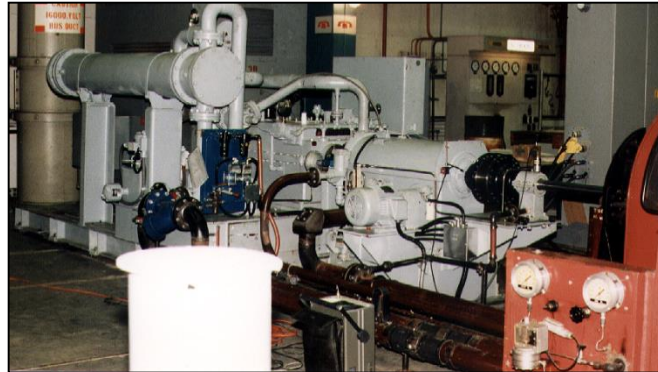
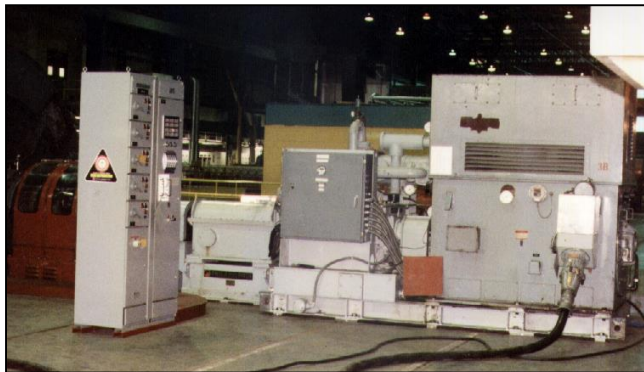
B. C. Hydro Burrard Thermal Plant Acceleration System



B.C. Hydro Burrard Thermal Plant

Synchronous condensing starting package.

SSS Encased Clutch - SSS Starting System Clutch, SSS Turning Gear Clutch, and new generator thrust bearing.



B.C. Hydro Burrard Thermal Plant

4 of 6 x 150 MW Units	Operating Hours (Periods as Indicated)			
	Unit 1	Unit 2	Unit 3	Unit 4
	Nov/88 to Dec/02	Dec/86 to Dec/02	Oct/86 to Dec/02	Nov/89 to Dec/02
Generating	61,469	66,645	77,096	82,324
Synchronous condensing	43,767	81,870	87,873	36,998

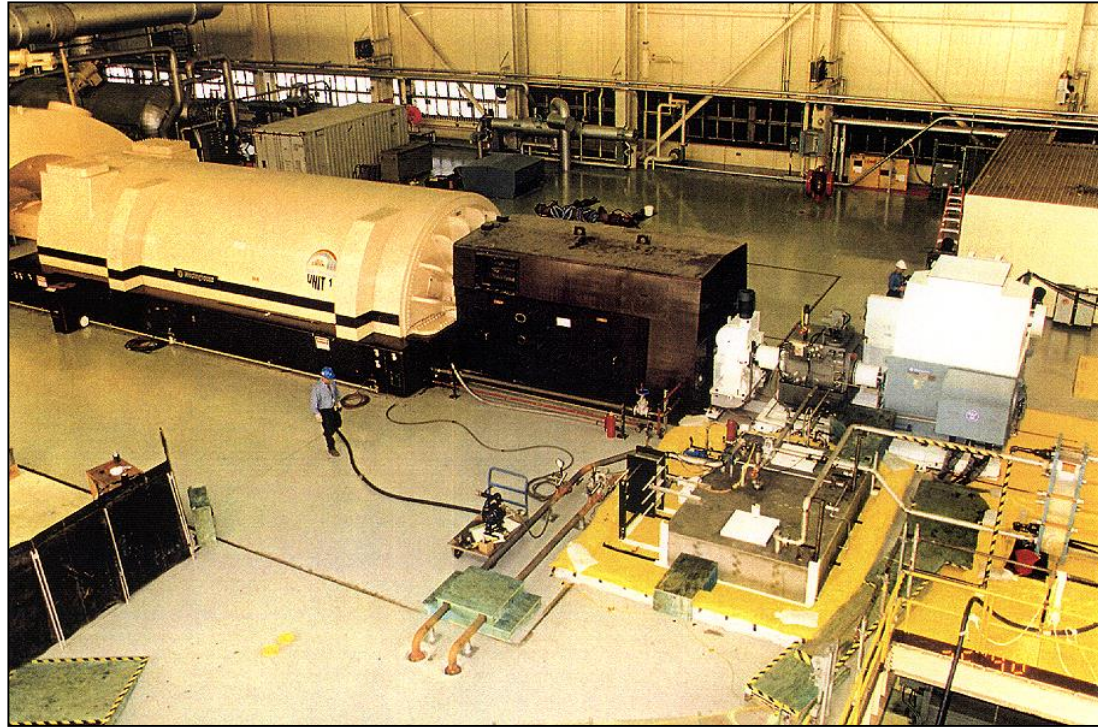
CONCLUSION

The improved power factor and increased voltage stability across transmission lines as a result of the conversion of these 4 machines to synchronous condensers have allowed:

B.C. Hydro to sell additional MW valued at \$100,000 Canadian per machine per day to customers in the U.S. during six months (summer + parts of spring & fall) of the year



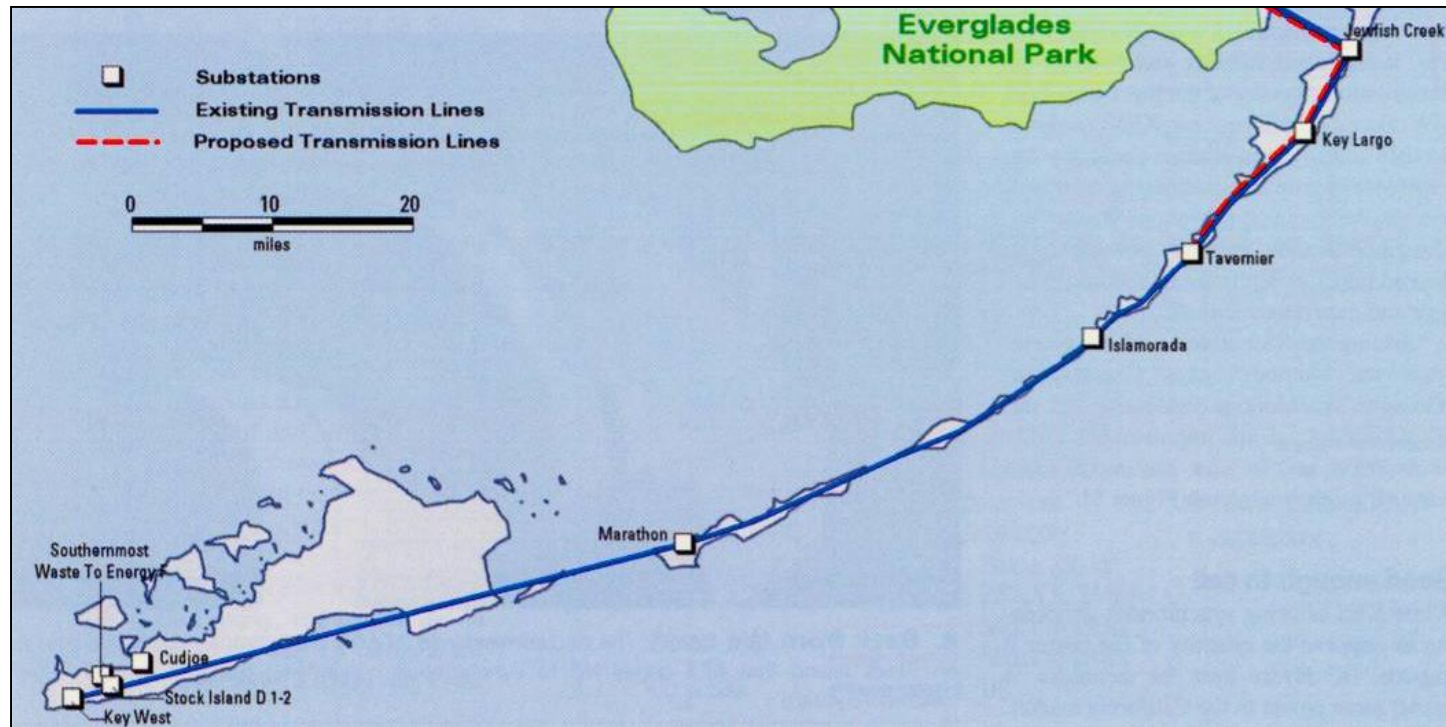
Exelon (formerly Commonwealth Edison) Zion Plant - Synchronous Condensing Conversion Project



Zion Nuclear Plant: Aerial View of Portable Acceleration Package Arrangement. **The result: production of 825 MVAR per machine, for a total of 1650 MVAR, which stabilizes voltage north of Chicago. Both units run in summer at half VAR capacity and one runs in winter.**



Synchronous Condensing Project: Conversion of a Stand-Alone Generator for City Electric System, Key West, Florida

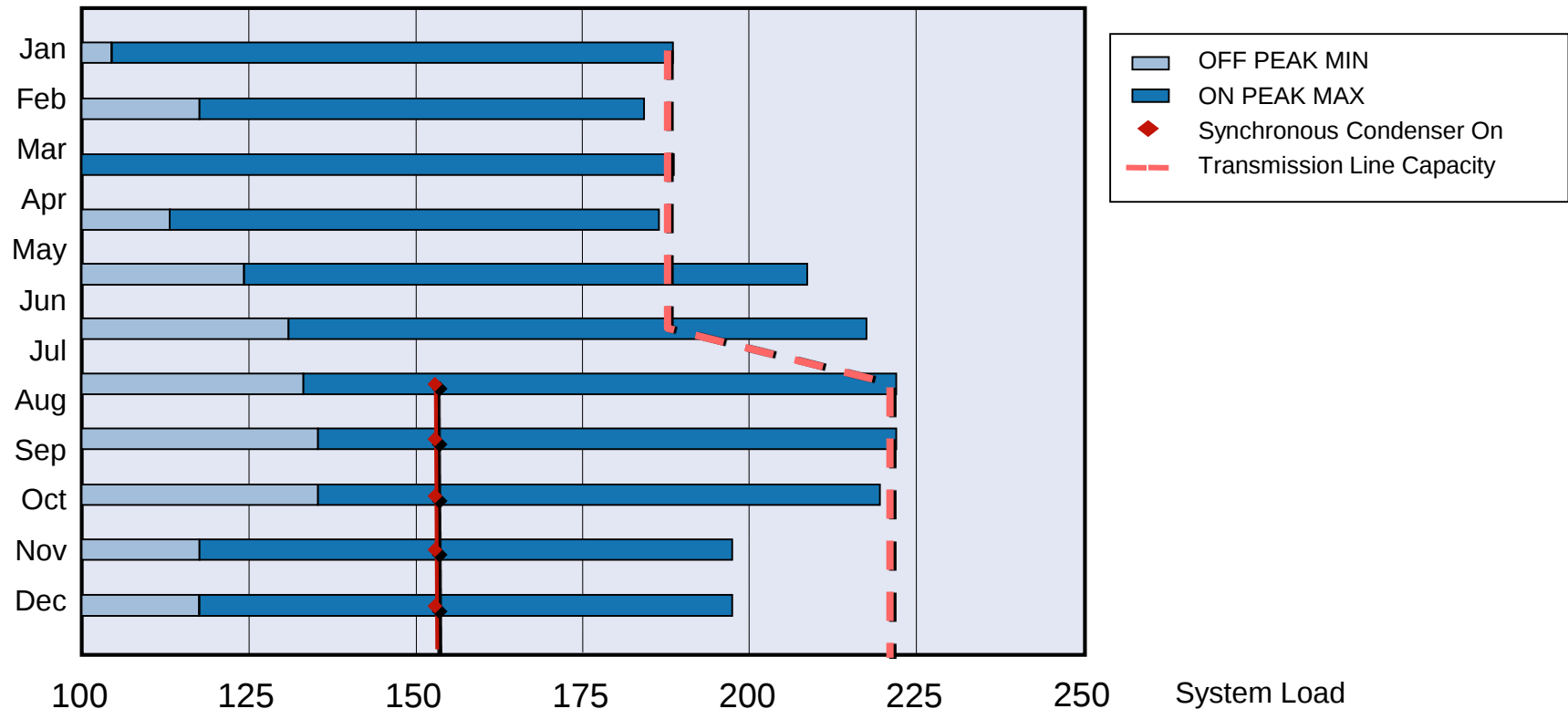


It became necessary for the company to choose between an increase in costly local generation or an increase in MW import capability from the mainland, 185 miles away.



Stand-Alone Generator Turned Into Synchronous Condenser for Key West - \$1 Million annual benefit

Graph of transmission capacity before and after conversion of generator to synchronous condenser. Work was completed in July of 1997.



Stand-Alone Generator Turned Into Synchronous Condenser: the City of Key West

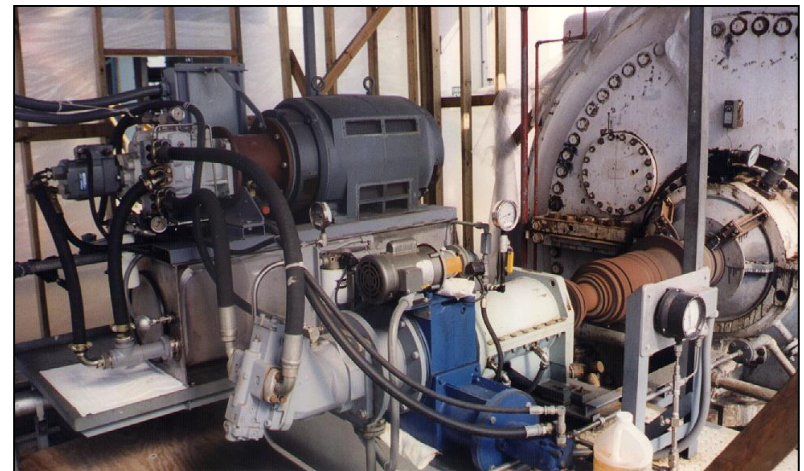
Installation of a new Acceleration System in place of steam turbine at end of 44 MVA hydrogen-cooled generator to permit generator to be used for synchronous condensing at Ralph Garcia Generating Station on Stock Island, Florida.

Completed by GE in January, 1998, it can produce 34 MVAR or absorb up to 22 MVAR.

It enables up to 34 MW additional power to be transmitted from Florida mainland to Florida Keys through existing 138 kV transmission line.

Through February 2004, this unit has operated as a synchronous condenser for 44,952 hours.

\$10 million benefit first ten years of service



Acceleration Systems - Information Needed to Design Generator Acceleration System

- 1. MVA and MW Rating of Generator**
- 2. Speed of Generator**
- 3. Inertia of Generator**
- 4. Generator Rotor Weight and Diameter of all Bearings**
- 5. Do Generator Bearings have Jacking Oil?**
- 6. Is Generator Air or Hydrogen Cooled?**
- 7. Generator Windage Losses at Full Speed?**
- 8. Generator Excitation Losses?**
- 9. Maximum Time Required to Accelerate Generator to Connect to Grid?**
- 10. Details of Shaft End of Generator to Connect to the Acceleration System.**



SSS Regional Case Studies -

Ecuador

- Transmission Line Grid
- Name and Location of Thermal and Hydroelectric Power Generation Plants
- Current Summary of Leading Candidates for Synchronous Condensing Conversion
- Power Stations Considered for Conversion to Synchronous Condensing Capability

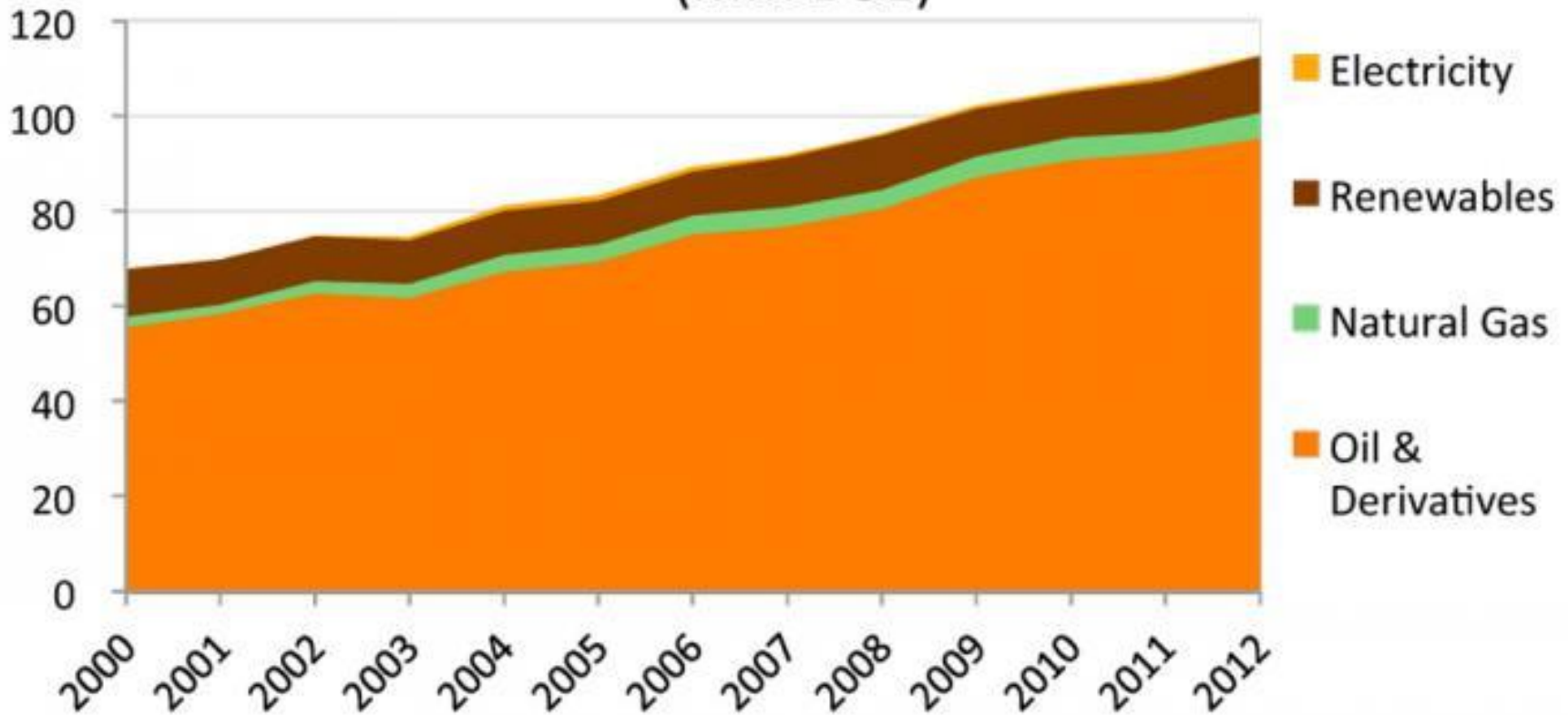


Ecuador Grid System - CELEC



Ecuador Grid System – CELEC ep – Load growth and mix of Country's generation prior to massive renewable energy

Ecuador Gross Energy Supply (MM BOE)



Source: Ministry for the Coordination of Strategic Sectors



CELEC ep - Ecuador Grid System

Since 2007, the nation has invested US \$4,900MM in its electricity grid, necessitated by a doubling of consumption in the last decade, from 7,904 GW in 2002 to 19,377 GW in 2012.

Ecuador's hydroelectric potential was developed, with eight major new projects to increase power production from 30% to nearly 93% of consumption with cheap and clean hydroelectric sources by late 2016.

CELEC studied the transmission grid and needed reactive power support in Quito and Guayaquil areas and have converted one Frame 5 and GE has contract to convert two more Frame 5's and one Frame 6 to Synchronous Condensing by retrofitting SSS Clutches

A Westinghouse W501-D5 and several FT-4 Power Pacs may also be converted



Three Size 194T SSS Clutches installed in Frame 5's at Termopichincha, Santa Rosa Plant, near Quito

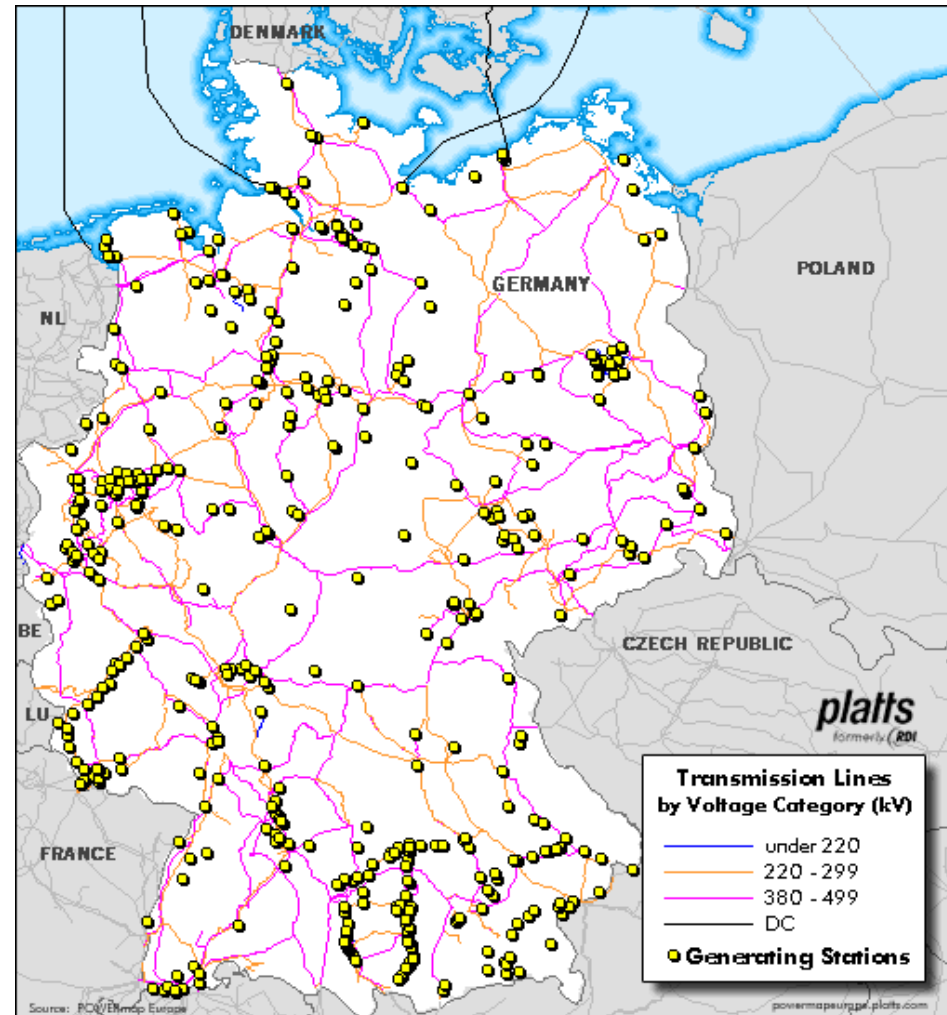


Size 194T SSS Clutch installed in load gear on gas turbine side with quill shaft through Low speed gear to generator



German National Electric Grid

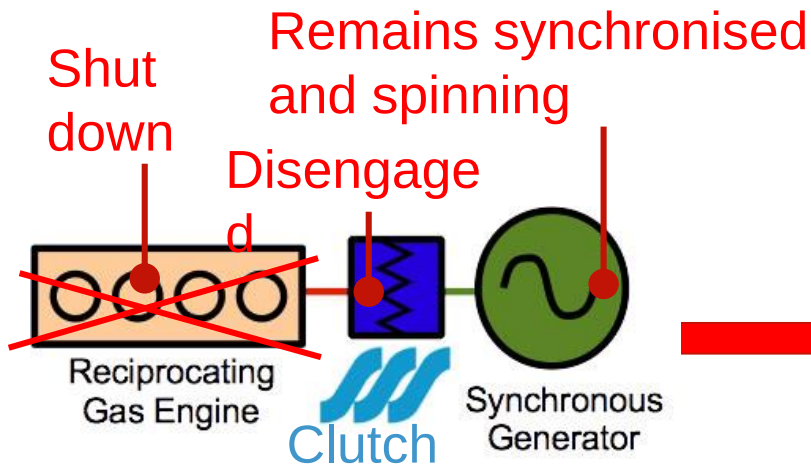
With increasing renewable generation, shutting down of nuclear and coal fired plants, and transmission constraints north to south, power redistribution being considered with addition of peak load gas turbine generators near Mannheim with synchronous condensing SSS Clutches



German National Electric Grid

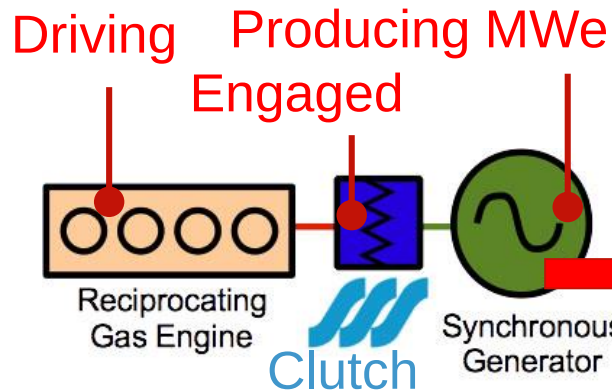
Opportunities for Reciprocating Engines / Generators

Additional Revenues for Generators :



Generator de-clutched from stationary engine :

- Burns no fuel
- Produces zero emissions
- STILL receives payments for :
 - 1 - Synchronous Condensing
 - 2 - Spinning Reserve
 - 3 - Grid inertia



Generator producing MWe :

- STILL receives payments for :
 - 1 - Synchronous Condensing
 - 3 - Grid inertia



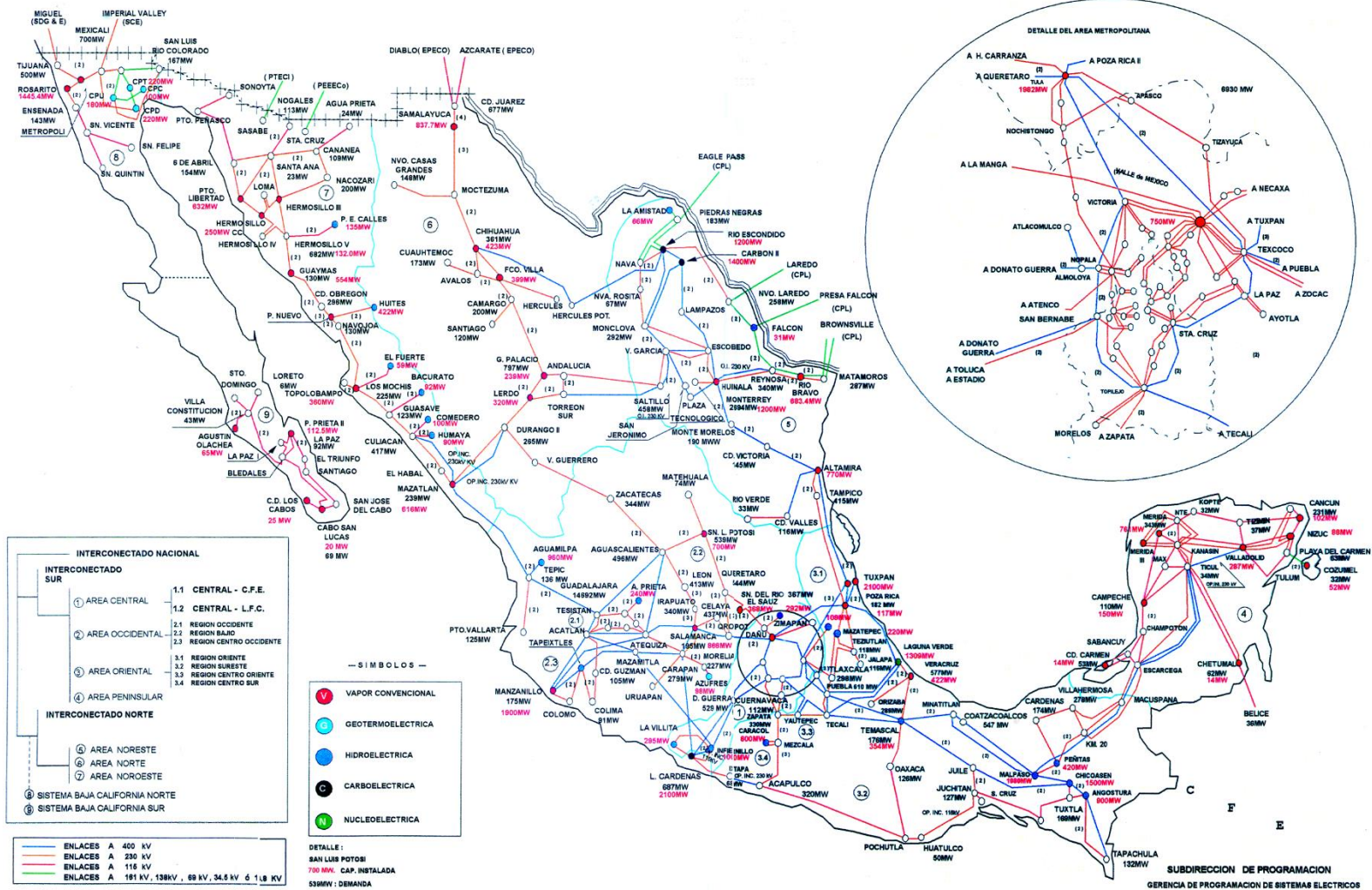
SSS Clutch Company, Inc. Regional Case Studies -

Mexico

- Transmission Line Grid
- Name and Location of Thermal and Hydroelectric Power Generation Plants
- Current Summary of Leading Candidates for Synchronous Condensing Conversion
- Power Stations Considered for Conversion to Synchronous Condensing Capability



Transmission Line Grid



Other Candidates for Synchronous Condensing Conversion

Nº	Central	Lugar	Fecha Visita SSS	Fabricante Turbina	Fabricante Generador	Capacidad MW	Activo/ Inactivo	Capacidad MVAR del generador		Conversión propuesta		Beneficio	Observaciones	Estimado de Costo Total			
								adelantado (+)	atrasado (-)	"A" o "B"	Nº Ref. SSS			Equipo solo (SSS) US \$	Instalación US \$	Estimado plazo de entrega de equipo	Tiempo requerido para completar la obra
1	San Jerónimo	Monterrey, N.L.	16-Ene-03	General Electric	General Electric	37.5	Activo	+22	-34	B	03-029	Soporte del voltaje		\$200,000		6 meses	4-6 semanas
2	San Jerónimo	Monterrey, N.L.	16-Ene-03	General Electric	General Electric	37.5	Activo	+22	-34	B	03-029	Soporte del voltaje		\$200,000		6 meses	4-6 semanas
3	Leona	Monterrey, N.L.	16-Ene-03	BB11L	Brown Boveri	14	Activo	+21	-14	A	03-030	Soporte del voltaje	Embrague síncrono	\$150,000		11 meses	4-6 semanas
4	Leona	Monterrey, N.L.	16-Ene-03	BB11L	Brown Boveri	14	Activo	+21	-14	A	03-030	Soporte del voltaje	Embrague síncrono	\$150,000		11 meses	4-6 semanas
5	Fundidora	Monterrey, N.L.	16-Ene-03	BB11L	Brown Boveri	14	Activo	+21	-14	A	03-030	Soporte del voltaje	Embrague síncrono	\$150,000		11 meses	4-6 semanas
6	Universidad	Monterrey, N.L.	16-Ene-03	BB11L	Brown Boveri	14	Activo	+21	-14	A	03-030	Soporte del voltaje	Embrague síncrono	\$150,000		11 meses	4-6 semanas
7	Universidad	Monterrey, N.L.	16-Ene-03	BB11L	Brown Boveri	14	Activo	+21	-14	A	03-030	Soporte del voltaje	Embrague síncrono	\$150,000		11 meses	4-6 semanas
8	Tecnológico	Monterrey, N.L.	16-Ene-03	BB11B	Brown Boveri	30	Activo			A	03-030	Soporte del voltaje	Embrague síncrono	\$250,000		11 meses	2 meses
9	Turbogas Monclova	Monclova, Coahuila	17-Ene-03	W251AA	ACEC	18	Activo			A	03-028	Soporte del voltaje	Embrague síncrono & cubierta a prueba de aceite	\$225,000		11 meses	2 meses
10	Turbogas Monclova	Monclova, Coahuila	17-Ene-03	W251B	ACEC	30	Activo	+26 min.	-15 min.	A	03-028	Soporte del voltaje	Embrague síncrono & cubierta a prueba de aceite	\$225,000		11 meses	2 meses
11	Cancun	Cancun, Q.R.	4-Feb-07	Pratt & Whitney FT4C-3F	Mitsubishi	50	Activo			A	03-054	Soporte del voltaje		\$250,000***		2 meses	2 meses
12	Cancun	Cancun, Q.R.	4-Feb-07	Fiat TG20	Ercole Marelli	34.33	Activo	+25	-17	A	03-132	Soporte del voltaje	Embrague síncrono & cubierta a prueba de aceite	\$250,000		11 meses	2 meses
13	Cancun	Cancun, Q.R.	4-Feb-07	W191G	Westinghouse	14	Activo	+12	-7	A	03-133	Soporte del voltaje					
14	Cancun	Cancun, Q.R.	4-Feb-07	W191G	Westinghouse	14	Activo	+12	-7	A	03-133	Soporte del voltaje					
15	Nizuc	Cancun, Q.R.	4-Feb-07	Pratt & Whitney FT4C-3F	MELCO	50	Activo			A	03-054	Soporte del voltaje		\$250,000***		2 meses	2 meses
16	Nizuc	Cancun, Q.R.	4-Feb-07	Pratt & Whitney FT4C-3F	Mitsubishi	50	Activo			A	03-054	Soporte del voltaje		\$250,000***		2 meses	2 meses
17	Xul-ha	Chetumal, Q.R.	5-Feb-07	BB11L (gen. solo)	Brown Boveri	0	Inactivo	+15	-8	B	03-131	Soporte del voltaje		\$225,000		6 meses	4-6 semanas
18	Xul-ha	Chetumal, Q.R.	5-Feb-07	MW-191G	Mitsubishi	14	Activo	+12	-7		03-057						
19	Punta Prieta	La Paz, B.C.S.	8-Feb-07	Hitachi Frame 5001N	Hitachi	25	Activo			A	03-064	Soporte del voltaje	Embrague síncrono & embrague de arranque	\$140,000		1 mes	4-6 semanas
20	Los Cabos	Cabo San Lucas, B.C.S.	8-Feb-07	John Brown Frame 6001	Brush	30	Activo	+40	-15	A	03-055	Soporte del voltaje	Embrague síncrono & embrague de arranque	\$160,000#		1 mes	4-6 semanas
21	Las Cruces	Acapulco, Gro.	25-Mar-07	GE Frame M 5000-1	Hitachi	15	Activo			A	03-126	Soporte del voltaje	Embrague síncrono & embrague de arranque	\$140,000		1 mes	4-6 semanas

* A - Embrague interpuesto entre turbina y generador

*** - Al 24/04/03, hab'a 3 unidades en inventario mundial.

- Hay muchas unidades en inventario.

**B - Paquete de aceleración a generador solo

- En la actualidad, existe una unidad en stock. Al agotarse, son 7 meses de fabricación.



Other Candidates for Synchronous Condensing Conversion

Nº	Central	Lugar	Fecha Visita SSS	Fabricante Turbogenerador	Fabricante Generador	Capacidad MW	Activo/ Inactivo	Capacidad MVAR del generador		Conversión propuesta		Beneficio	Observaciones	Estimado de Costo Total			
								adelantado (+)	atrasado (-)	"A" o "B"	Nº Ref. SSS			Equipo solo (SSS)	Instalación	Estimado plazo de entrega de equipo	Tiempo requerido p/ completar la obra
22	Las Cruces	Acapulco, Gro.	25-Mar-07	BB11L - 750	Brown Boveri	14	Activo	+21	-14	A	03-126	Soporte del voltaje	Embrague síncrono	\$150,000		11 meses	4-6 semanas
23	Las Cruces	Acapulco, Gro.	25-Mar-07	BB11L - 750	Brown Boveri	14	Activo	+21	-14	A	03-126	Soporte del voltaje	Embrague síncrono	\$150,000		11 meses	4-6 semanas
24	Las Cruces	Acapulco, Gro.	25-Mar-07	General Electric	General Electric	9	Inactivo			B	03-126	Soporte del voltaje		\$160,000		6 meses	4-6 semanas
25	Las Cruces	Acapulco, Gro.	25-Mar-07	General Electric	General Electric	9	Inactivo			B	03-126	Soporte del voltaje		\$160,000		6 meses	4-6 semanas
26	Guaymas I	Guaymas, Son.	7-Abr-03	Westinghouse	Westinghouse	12.5	Inactivo	+10	-6	B	03-127	Soporte del voltaje		\$160,000		6 meses	4-6 semanas
27	Guaymas I	Guaymas, Son.	7-Abr-03	Westinghouse	Westinghouse	12.5	Inactivo	+10	-6	B	03-127	Soporte del voltaje		\$160,000		6 meses	4-6 semanas
28	Turbogas Caborca	Caborca, Son.	8-Abr-03	W251B8	Westinghouse	30	Activo	+38	-15	A	03-128	Soporte del voltaje	Embrague síncrono & cubierta a prueba de aceite	\$225,000		11 meses	2 meses
29	Turbogas Caborca	Caborca, Son.	8-Abr-03	MW-191G	Mitsubishi	12	Activo	+12.5	-7		03-128						
30	Turbogas Mexicali	Mexicali, B.C.N.	9-Abr-03	Hitachi PGS341	Hitachi	20.75	Activo			A	03-129	Soporte del voltaje	Embrague síncrono & embrague de arranque	\$140,000		1 mes	4-6 semanas
31	Turbogas Mexicali	Mexicali, B.C.N.	9-Abr-03	Hitachi PGS341	Hitachi	20.75	Activo			A	03-129	Soporte del voltaje	Embrague síncrono & embrague de arranque	\$140,000		1 mes	4-6 semanas
32	Turbogas Mexicali	Mexicali, B.C.N.	9-Abr-03	BB11B	Brown Boveri	30	Activo			A	03-129	Soporte del voltaje	Embrague síncrono	\$250,000		11 meses	2 meses
33	Turbogas Constitución	Cd. Constitución, B.C.S.	11-Abr-03	Fiat TG20	Ercole Marelli	34.33	Activo	+25	-17	A	03-130	Soporte del voltaje	Embrague síncrono & cubierta a prueba de aceite	\$250,000		11 meses	2 meses

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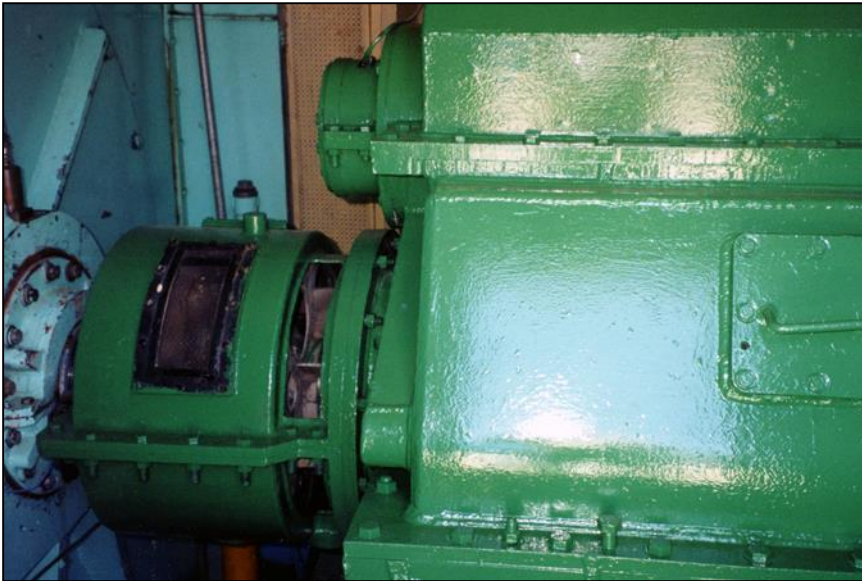
Retrofit of Size 160FT into Brown Boveri BB11-L at CFE in Monterrey, Mexico – Project won Power Magazine “Marmaduke” Award for 2012

Installation of size 160FT SSS Clutch into BB11-L



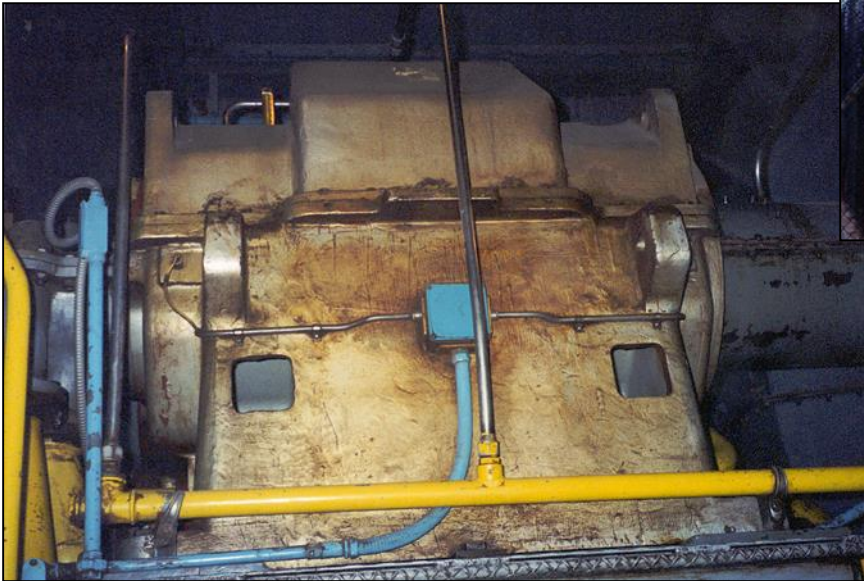
Synchronous Condensing Study for CFE, Caborca, Mexico

Visit to CFE, Caborca, Mexico in March 2003 to consider retrofit of SSS Clutch into reduction gear of Westinghouse W 251B-8 to enable synchronous condensing to produce up to 38 MVAR or absorb up to 15 MVAR.



Synchronous Condensing Study for CFE, Ciudad Constitución

Visit to CFE, Ciudad Constitución, in March 2003 to consider retrofit of an SSS Clutch into reduction gear of Fiat TG-20 to enable synchronous condensing to produce up to 25 MVAR or absorb up to 17 MVAR.

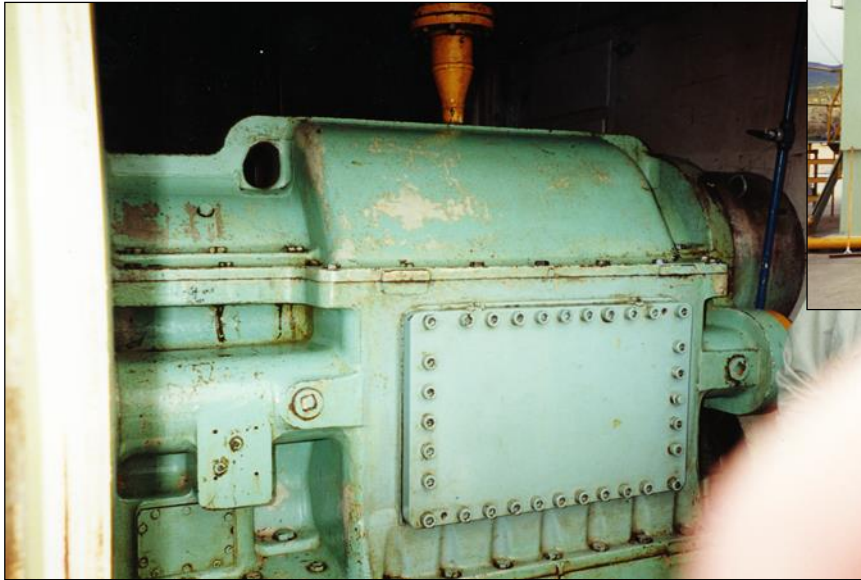


SSS Clutch Company also visited CFE, Cancún, to one of the other two Fiat TG-20s in Mexico for possible conversion as well.



Synchronous Condensing Study for CFE, Los Cabos, Mexico

SSS Clutch Model 194T proposed for installation in load gear of 30 MW John Brown Frame 6 gas turbine generator for reactive power.



**Generator is capable of supplying
35 MVAR or absorbing 15 MVAR
@ 15°C ambient temperature.**



Thank You



Clutch Company, Inc.