

GAS TURBINE SYSTEMS APPLICATIONS

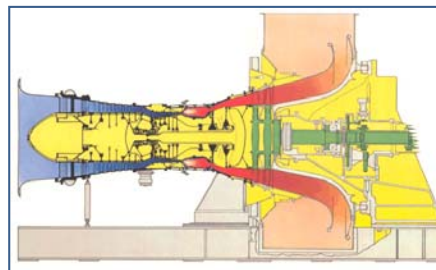
A Canadian Perspective

Session 2 : Part II

- **Some Historical Perspectives on Various Energy Sectors**
- **Examples of 'First' and Unique Installations**
- **Simple & Combined Cycle Power**
- **Natural Gas Production & Pipelines**
- **Cogeneration, WHR and Gasification**



GE LM1500 (S&S)



Cooper Rolls Coberra 6456



OPTI Nexen Gasification

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Gas Turbine Systems in Canadian Industrial Sectors, 2010 estimate (M.Klein)

Installed MW	Simple Cycle	Combined Cycles	Comb. Cycle Cogen	Simple Cogen	Sector total
Electric Power	4240	6650			10890
Gas Pipelines	4950	120			5070
Upstream Gas	80		120	340	540
Oilsands & Refineries	115		575	1400	2075
Chemicals, Forestry, Metals			3175	400	3575
Manufacturing	40		1150	170	1360
Institutional			210	55	265
Est. Total	9425	6770	5230	2365	23790

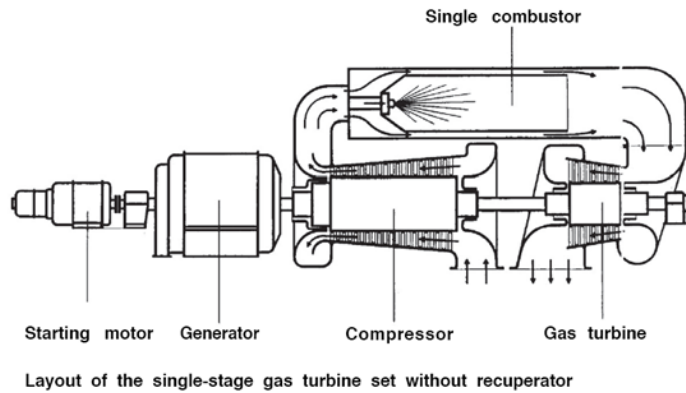
- Not incl. retired units
- 20290 MW GTs, and 3440 MW of steam turbines

Canada's 1st GT cogen plants



Pinetree Line, Old HRSG Boilers

The World's First Industrial Gas Turbine Set at Neuchâtel (1939)



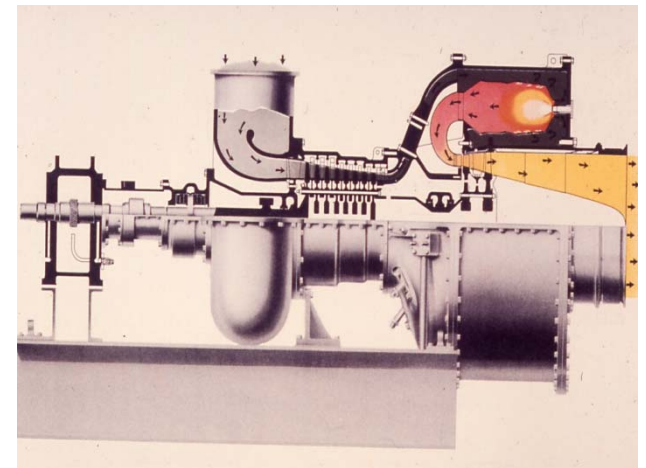
Layout of the single-stage gas turbine set without recuperator



An International Historic Mechanical Engineering Landmark



Brown Boveri, 1939, Switzerland



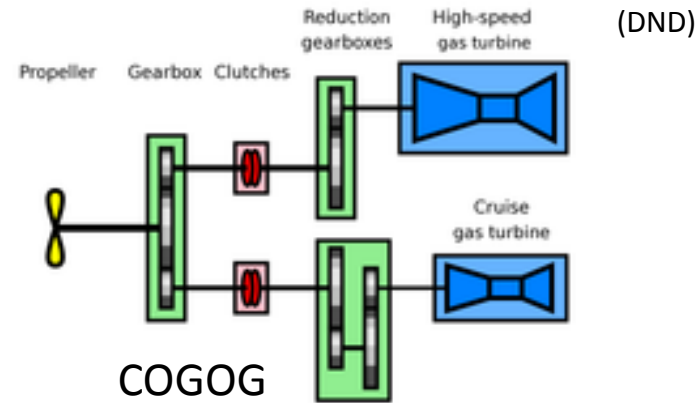
1.5 MW Orenda OT5 (1962, Herb S.)

Marine Gas Turbines

Canadian tribal class destroyers, 1972.
-World's 1st all gas turbine powered ships,
powered by;

- two Pratt & Whitney FT12 of 7,400 shp
- two P&W FT4 gas turbines of 50,000 shp
- 3 Solar Saturn 0.7 MW gensets

TRUMP refit, 1992; 13000 shp Allison 570



12 Halifax Class Patrol Frigates 1992-96 (CODAG)

2 GE LM2500 units, 48000 Hp
Pielstick Cruise Diesel, 12000 Hp

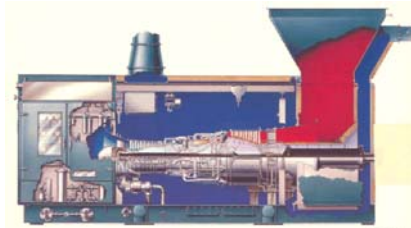


naval-technology.com



PW FT4 & ST-6,
Bras D'Or, 1968

GE LM2500



Electric Power

Peaking Power Stations

- Many installed after 1965
- Eastern power failures
- Remote service
- Nuclear Standby, Emergency



Two JT3 units, Success , Sask.



ABB 11, ATCO Sturgeon AB



ABB 11 Landis, Sask



GE Fr6, Meadow Lake SK



RR Olympus, from Concorde 593 Engine



4 Olympus, 2 Mars OPG Darlington



RR Olympus *POD-50* units Cadillac Stn, Hydro Quebec

Recent Peaking Facilities

- Replacing Old Steam Boilers
- Synchronous Condensers



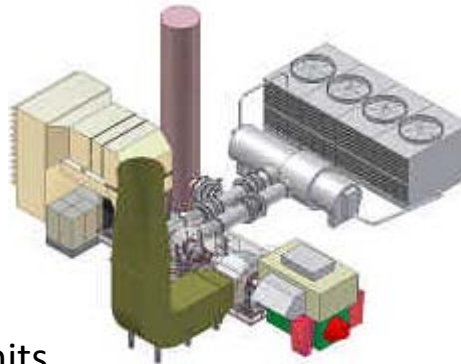
LM6000, ATCO Valleyview, AB



OPG Solar Units, Toronto 2003

EPCOR's Clover Bar 243 MW

- GE LM 6000
- two 100 MW GE LMS100 units



2 Alstom 11N, 260 MW
Brandon, Man Hydro



LM6000, oil, Maritime Elec. PEI



4 GE Fr7, Hydro Quebec
Becancour, Gentilly Standby



Early Aeroderivative Units, Pipelines



Orenda 14 , F86 jet



CF100



Portable unit, TCPL Stn 95, 1986 (NEB)

Orenda OT3 and OT2100



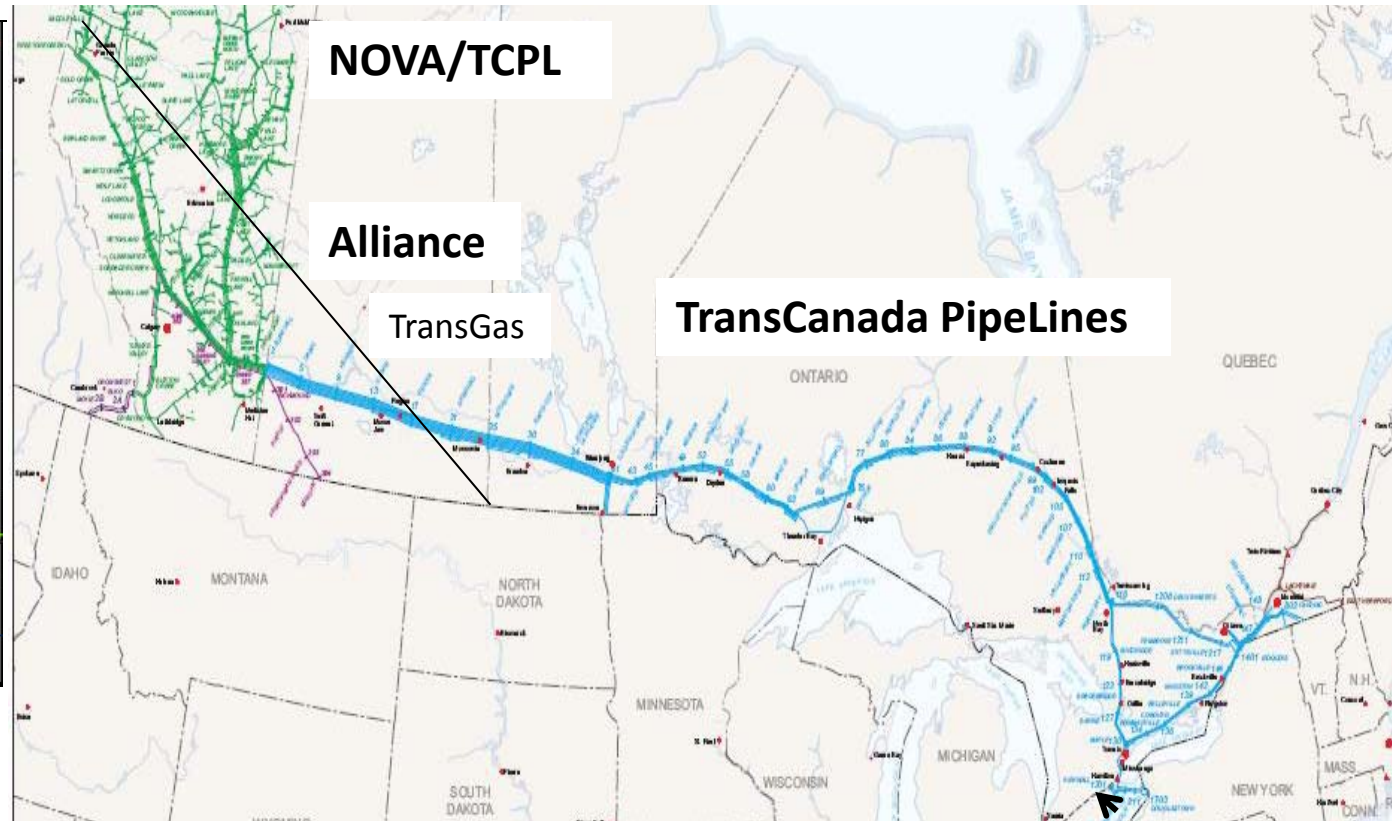
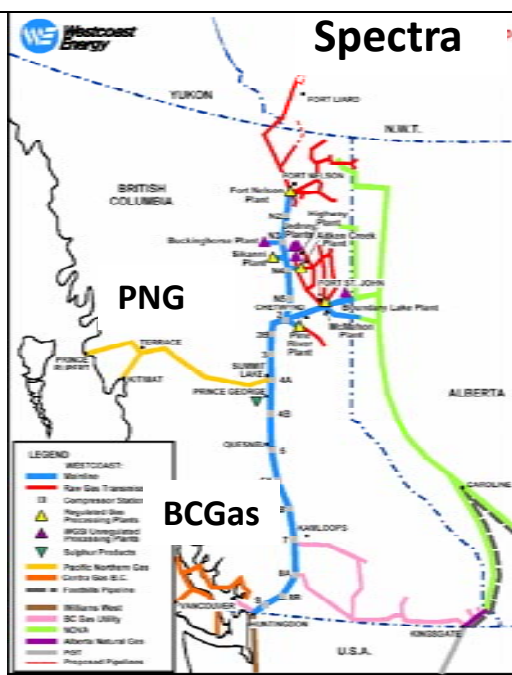
Typical Facts

	OT2100s
Power:	10 MW
Press Ratio:	7.6
Heat Rate:	14 GJ/MW hr
Exh. Temp:	500°C
Mass Flow:	64 kg/s



Orenda Portable Unit, Kapuskasing ON

First Generation Gas turbine Units on Canadian Gas Pipelines



- 1955-60 recip engines installed across systems

1960's

- First Industrial gas turbines , TCPL (*Clark, W62, W92*)
- 1st aeros on WEI, NOVA, TCPL; *GE LM1500, Orenda OT2*
- 1964-73 40 Rolls Royce Avons, on TCPL and Union Gas

First Rolls Royce Aeroderivative unit in Pipeline service, at TransCanada Stn 13, Caron, Sask.



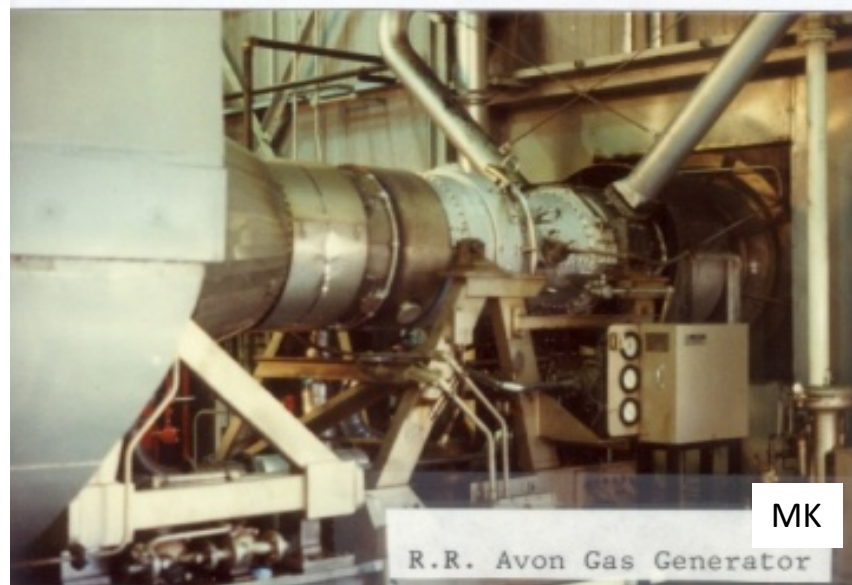
wikipedia.org

Rolls Royce Avon (AP1, RT121, RT248, RT160)

Typical Facts

RR Avon 76G

Power:	10 MW
Press Ratio:	9
Heat Rate:	12.8 GJ/MWh
Exh. Temp:	550°C
Mass Flow:	77 kg/s



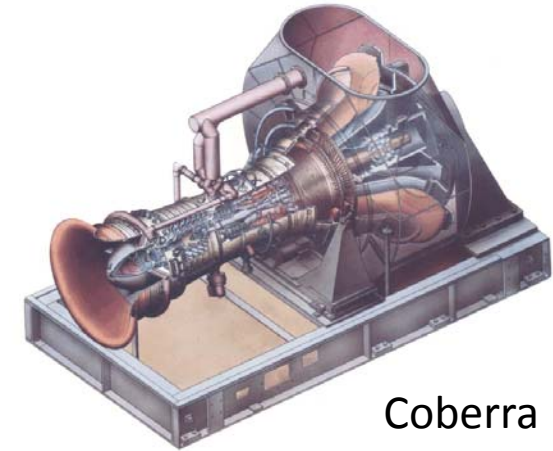
Two 10 MW Avons, TCPL Stn 17, Regina SK.

2nd Generation Aeroderivative Units

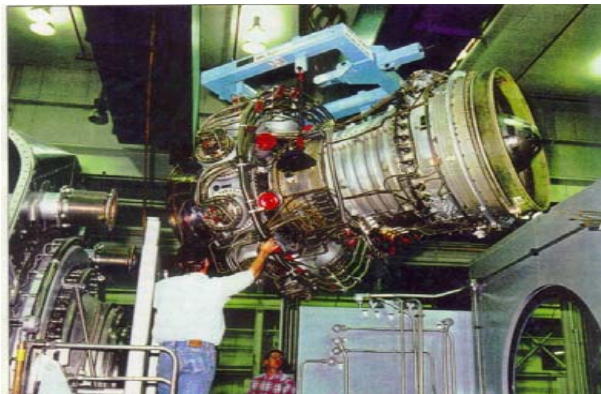
- **First Rolls Royce RB211 on Pipeline (1974)**
- Coberra 264 at TCPL Stn 2, Burstall, Sask.



RR Avon, 3 RB211s 2 GE LM2500 (Total 143 MW)



Coberra
6256



RB211 dle, TCPL



33 MW RR 6761, TCPL Nordegg, AB



RB211 driven compressors,
Union Gas Storage, Dawn ON

Versatile Applications - GE LM2500

- First Unit Installed on NOVA Princess, 1972
- then at Westcoast P/L in BC, 1973



Galaxy

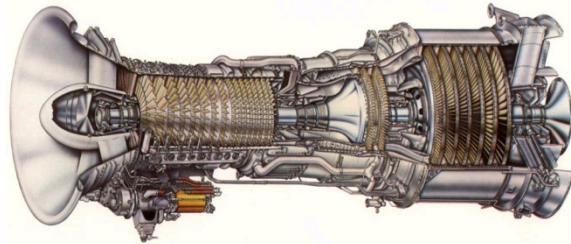
From CF6-50, TF39



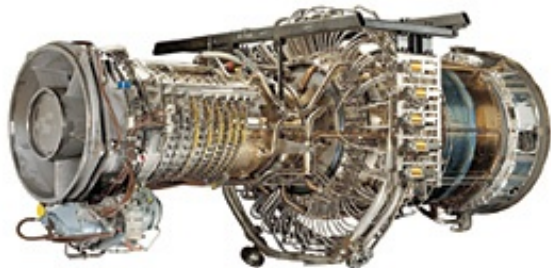
Northland Peaker, Kirkland L. ON
(Gryphon)



GTCC , Cochrane Ont, Algonquin



LM2500



LM2500+ G4 DLE



4 LM2500 units, 1994
Hibernia Platform, Nfld



PGT25+, Spectra Gas, BC



GT Operations and Maintenance Symposium

Oct 21-23, 1974 Edmonton AB

(NRCC Associate Committee on Propulsion)

Chair: Ray Stauffer, AGTL

Session Topics

- *Inlet Icing Problems*
- *Performance Testing*
- *Trend Monitoring*
- *Compressor Cleaning*
- *Panel Session - Lube Oil*

Papers by;

**Rolls Royce, Cooper, FARR
Westinghouse, Orenda,
United Aircraft**

**TCPL, Westcoast, AGTL,
DND, DOW**

**NRCC, Carleton U,
Texas A&M, IPEL**

- *Led to formation of 'Canadian GT Users Assoc' – then IAGT*
- *1st organizers - Herb Saravanamuttoo and Bernie Maclsaac, Carleton University*
- *Hosted by Nat'l Research Council, then by Cdn Gas Assoc. in 1990 (now both)*



Natural Gas Processing

NGL Extraction

Lean Oil Absorption

- Older process for heavy NGLs - needs Heat

Cryogenic Process

- For removal of C2, C3
- Turboexpander cooling



**First large Canadian CHP with
Aeroderivative GT, (RB211) 1978**

Shell Waterton Gas Plant



McMahon BC, ATCO/Spectra
2 x W251B12 (SGT-900)



Interpipe Cochrane AB (ANG)
Two RB211 GTCHP units

Siemens Cyclone
Unocal Aitken Ck, BC



SableGas Goldboro, NS
4 Solar Mars & Centaur units

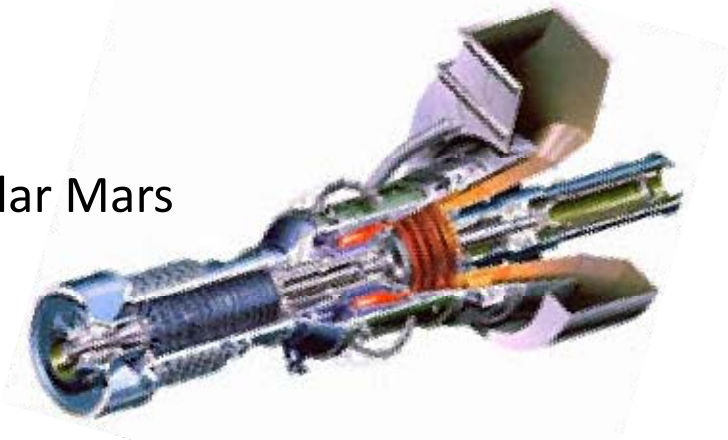


2 A501K, Spectra, Pine R. BC

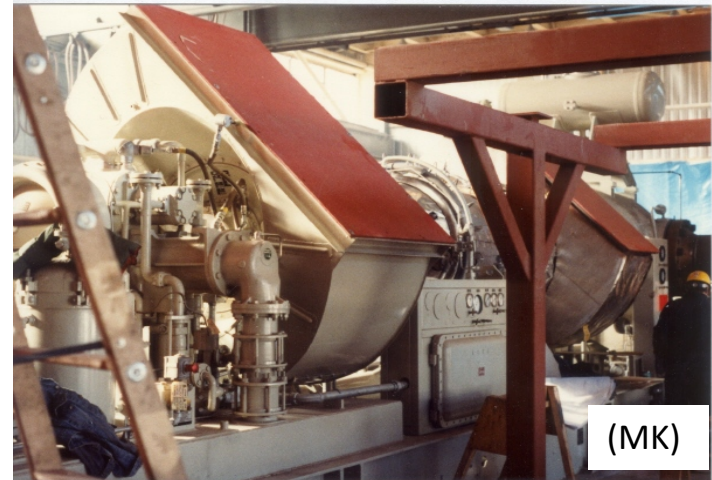
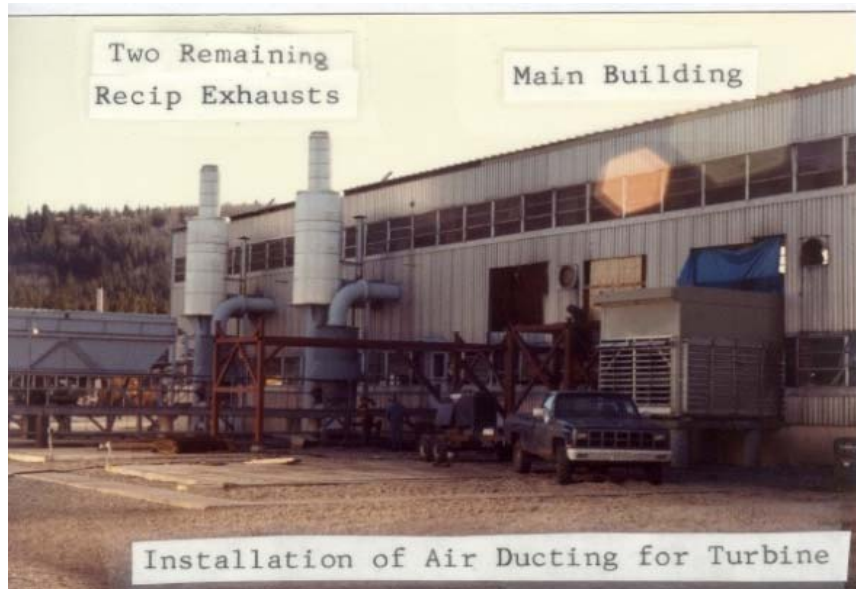
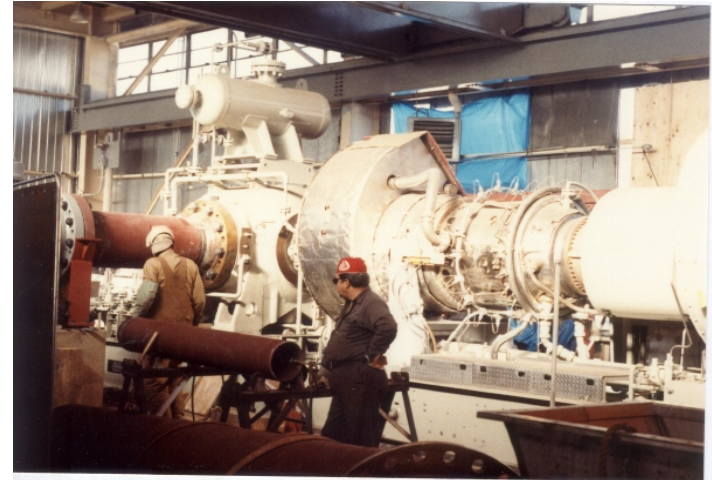


Replacement of Recip Engines on Canadian Pipelines

Solar Mars



- **First pipeline Mars unit installed at NOVA, 1977**
- ~ 200 Solar Saturn, Centaur, Taurus and Mars units installed on pipelines



New 8 MW Solar Mars GT Installation at ANG Crowsnest BC , 1981

Third Generation Gas Turbines

General Electric LM1600

- **1st installed at NOVA Knight AB, 1988**
- Only DLE at Elko, ANG (+ 4 water Injected units)



TCPL Stn 55, Dryden ON



F404



(geps)

Borex/Cascades
Cogen - 1st & only in
Quebec, (2 LM1600)
Kingsey Falls



**First Rolls Royce Spey
installed at TCPL Stn 41,
Winnipeg, 1976**

Typical Facts

Power:	14 MW
Press Ratio:	20
Heat Rate:	10 GJ/MW hr
Exh. Temp:	490°C
Mass Flow:	47 kg/s



PGT16, TCPL Stittsville ON

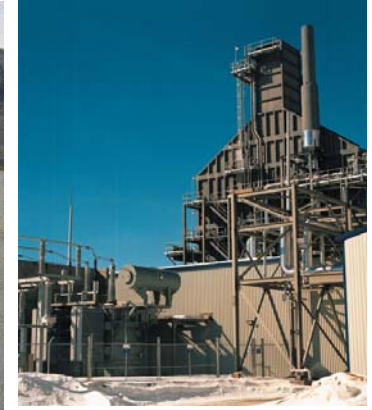
Industrial Spey



Rolls Royce Trent – First unit at Whitby Cogeneration, 1997



Trent 3-spool gas turbine (50-60 MW)



80 MW CHP, TCPL/Weyerhaeuser, Bear Ck, AB



Atlantic Packaging, Whitby, ON 50 MWe



RR Atwater Test Cell, Montreal

Waste Heat Recovery and CHP

Use of high temp exhaust energy - waste heat for electricity

WHR = 'Renewable' = Zero Emissions

Steam

- Five Ontario Plants, one in Alberta

Organic Rankine Cycles

- 8 plants in BC, Sask, AB

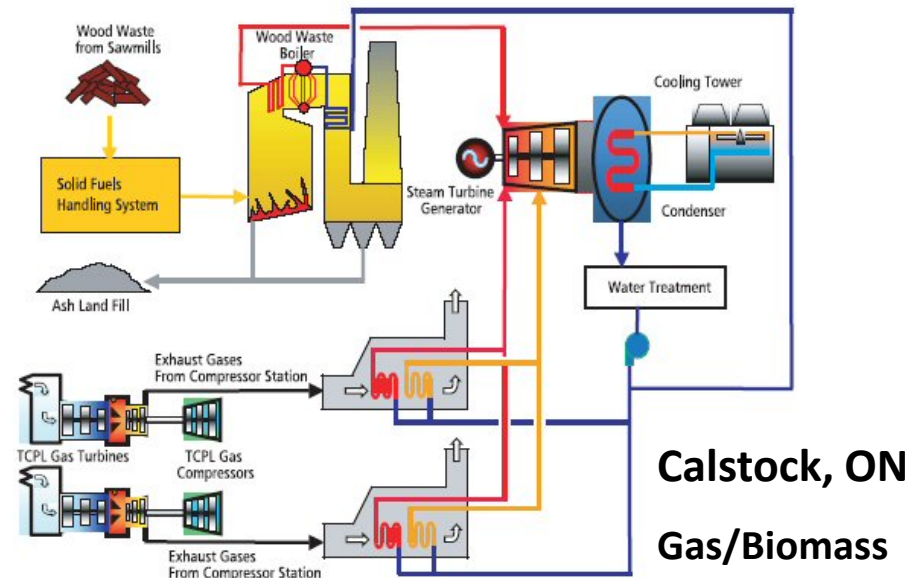
Turboexpanders for pressure recovery



RB211 WHR, LM2500 1991, North Bay ON

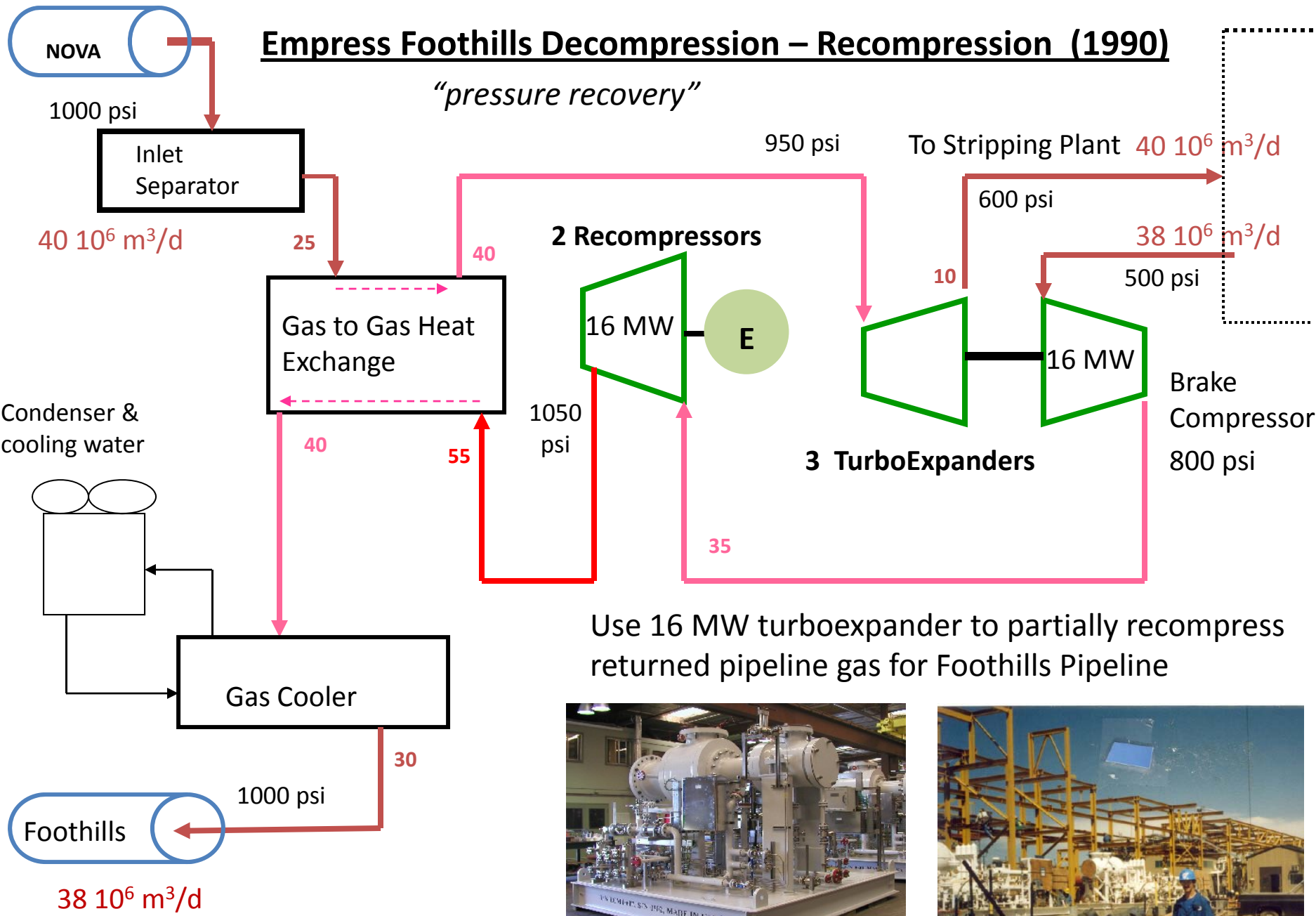


ORMAT Pentane Turbine Set



Empress Foothills Decompression – Recompression (1990)

“pressure recovery”



Use 16 MW turboexpander to partially recompress returned pipeline gas for Foothills Pipeline

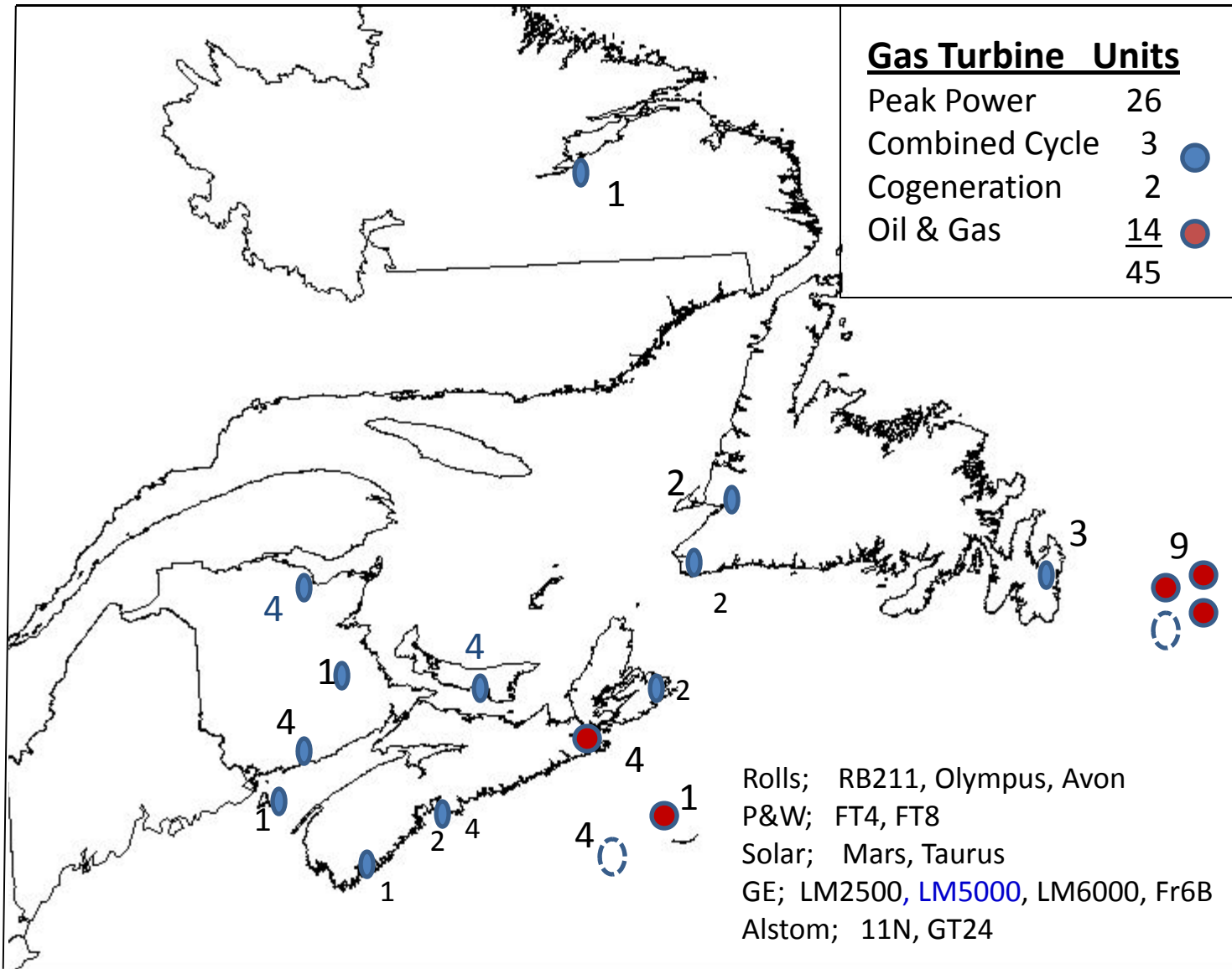


mafitrench.com



MK

Gas Turbines in Atlantic Canada (1500 MW)



Offshore Applications

- Hibernia
- Sable Gas
- PetroCan Terra Nova FPSO
- Husky White Rose FPSO



SableGas Thebaud (RB211)



Husky SeaRose



Terra Nova FPSO, Two GE Frame 6B

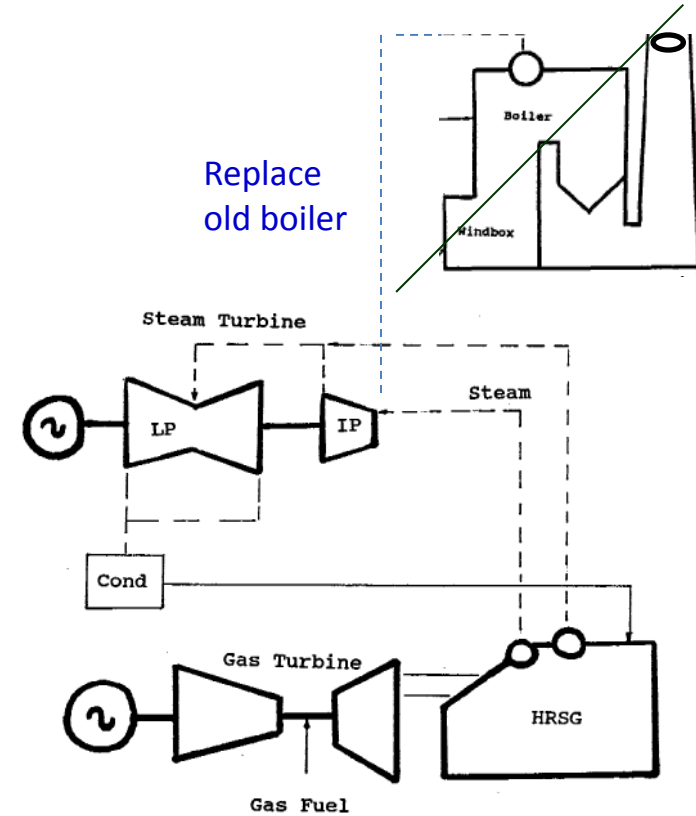


White Rose Power, 3 RB211, Husky, Nfld

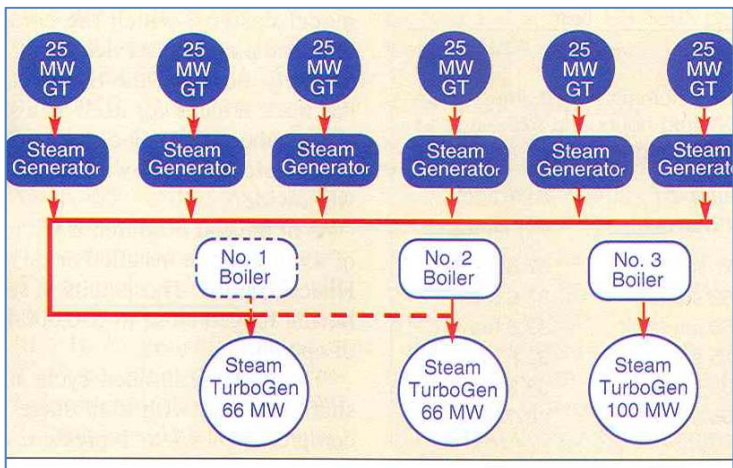
Utility Boiler Repowering

Replacing boiler supply for steam turbines with HRSG steam, plus gas turbine primary power

- 1st Utility Plant, Medicine Hat AB, 1980-2003
- Six projects over last decade (1600 MWe)



Queen Elizabeth Repowering, Saskatoon SK



(courtesy; *Gas Turbine World*)



Six Hitachi H25 units, IST HRSGs

Combined Cycle Repowering of Steam Boiler Systems



ATCO Brighton Beach, 580 MW Windsor ON (OPA)
(replaced Ont Hydro Keith Stn, 2004)



Bayside 285 MW, Saint John NB
(Alstom GT24 repowers Courtney Bay oil-fired
steam turbine in 2001, NB Power)



TCPL Portlands , Toronto 550 MW, 2008
(2 GE Frame 7F replace RL. Hearn Stn.)



Tufts Cove Emera NSP, Dartmouth, NS
Two GE LM6000, with IST OTSGs added in 2009

New Combined Cycles

- Largest source of merchant power generation over last decade
- Mostly for intermittent duty
- 14 new plants, 5100 MWe

Alberta; 750 MWe

Ontario; 3800 MWe



2 LM6000 GTCC, Nexen Balzac, AB (MK)



Siemens SGT6-5000, Calpine Calgary



2 GE Fr7FA, Invenergy St. Clair (OPA)



A close-up of the GE Fr7FB combustion turbine at Goreway

GE Fr7FB, Site Goreway (OPA)

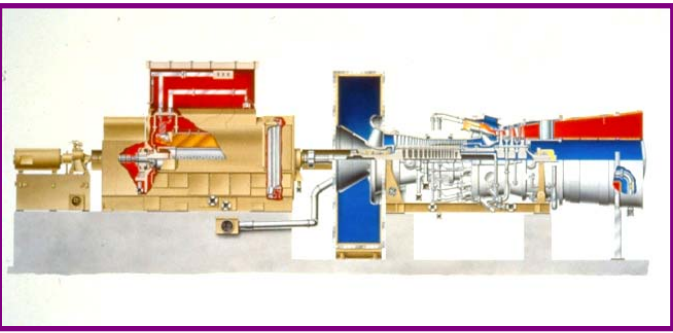
Canada's 1st large Industrial Cogen Facility, DOW Sarnia, 1972



TransAlta Sarnia 650 MWe (JP Zanyk)

Three Alstom GT11N2 units

- First Two baseload Frame 7B units
- Repowering of industrial coal unit

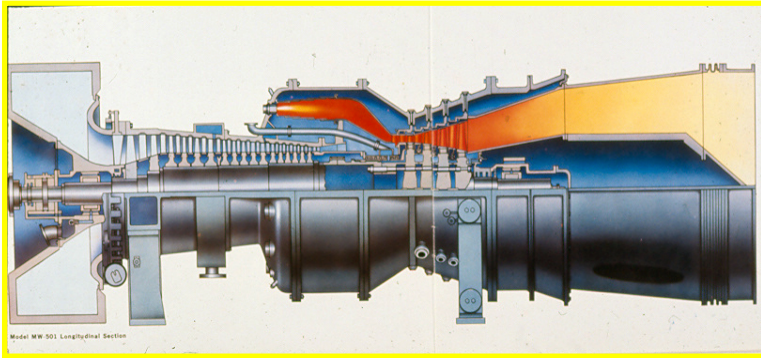


52 MW GE Frame 7B (BTEC Turbines)



GT11N2, 110 MW

Canada's 3rd large industrial CHP, 1994
- **First large gas turbine with DLN combustion in Canada**

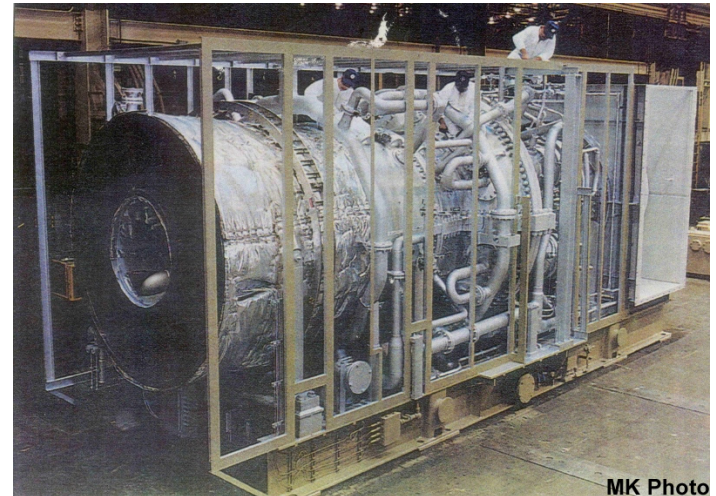


110 MW Westinghouse W501D (SGT6-2000)
Herb S.



Sithe/CASCO Cardinal, ON (Macquarie)

First GE Frame 6FA unit
- Installed at AES Kingston Cogen plant 1997 (Celanese/KOSA)



1st 6FA unit, AES Kingston, ON

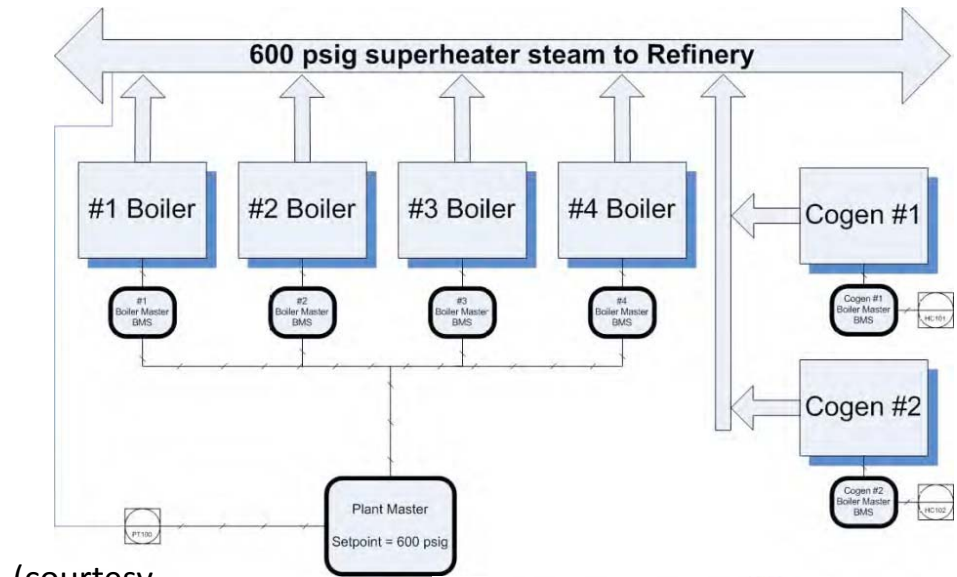


Kingston (GE Fr 6FA)

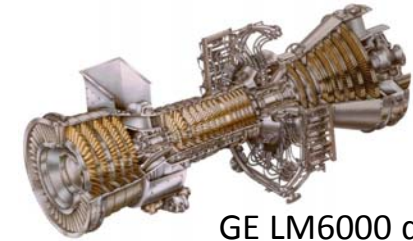
Other Industrial CHP facilities with Aeroderivative GT units



TCPL Grandview, Irving Refinery, Saint John NB



(courtesy
B. Mintern,
Irving Oil)



GE LM6000 dle



ATCO Power, Rainbow Lake AB
90 MW peaking & CHP facility, Husky gas plant



2 LM6000, GTAA Pearson Airport CHP (OPA)

Cogeneration in the Alberta Oilsands 'Mining' Sector (with onsite Upgrading)



(MK)

Two GE Fr 5 units, Syncrude, Mildred Lake
WHR with IST OTSGs in 1998



TransAlta, SUNCOR Poplar R. 2001

2- 115 MW Alstom GT11N2
2 Steam Turbines, 130 MW

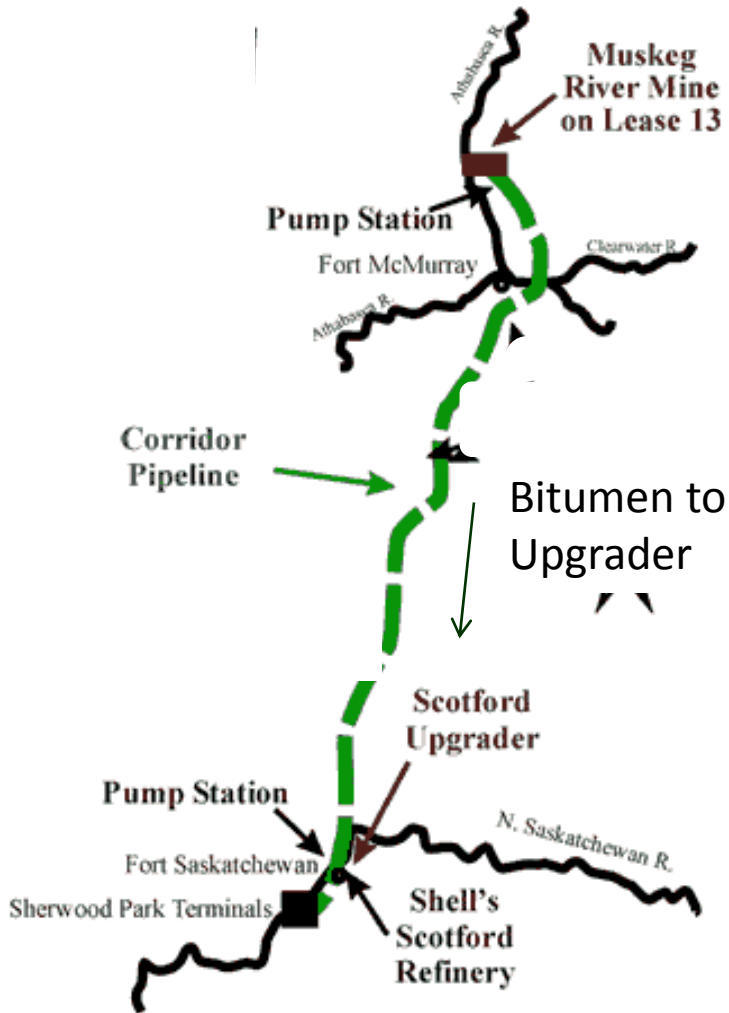


80 MWe Cogen Plants, Aurora 1&2 (GE 7EA)



TransAlta

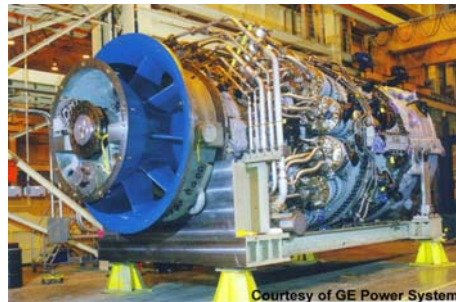
Shell Muskeg Oilsands Project



(Shell)



Two GE 7EA turbines use heat recovery to produce steam for Muskeg Mine (ATCO Power)



Courtesy of GE Power Systems

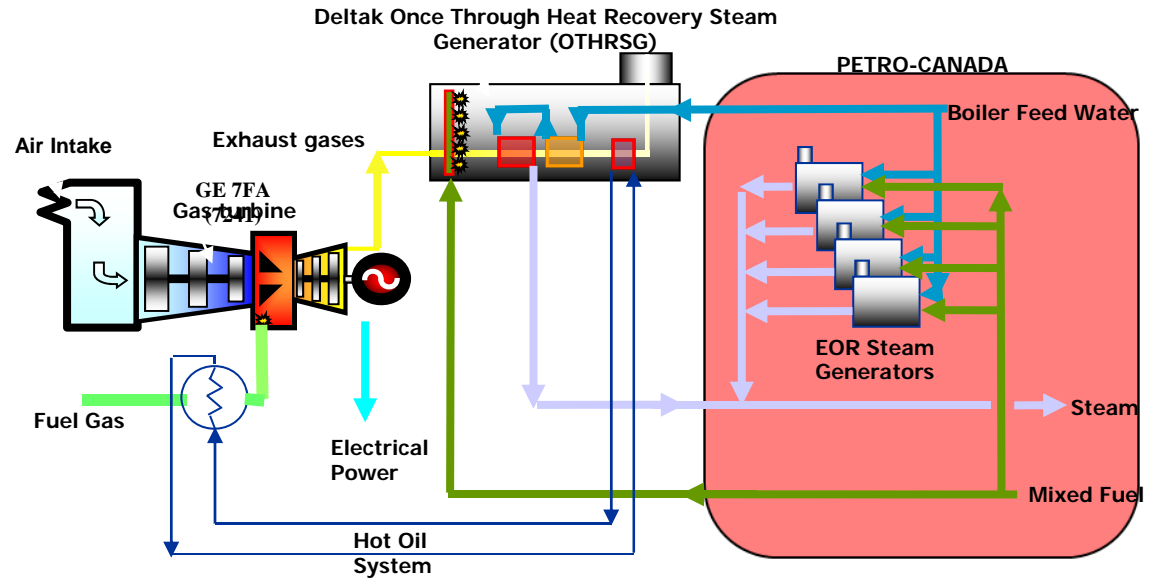


150 MW ATCO cogen plant at the Scotford Upgrader.
One GE 7EA with DLN, output 80 MW

Oilsands Steam Assisted Gravity Drainage (SAGD)

- ATCO CNRL Primrose
- Esso Cold Lake
- EnCana Foster Ck
- OPTI Nexen Long Lake
- CNRL Horizon
- SUNCOR Firebag

- 170 MW GE 7FA gas turbine
- Deltak Once Through Heat Recovery Steam Generator



Mackay River Cogeneration , TCPL PetroCan

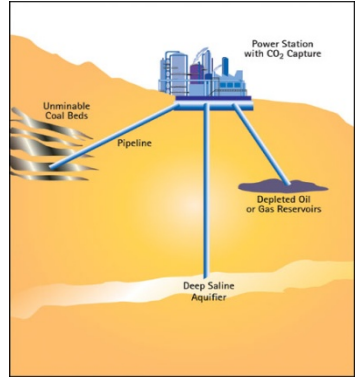
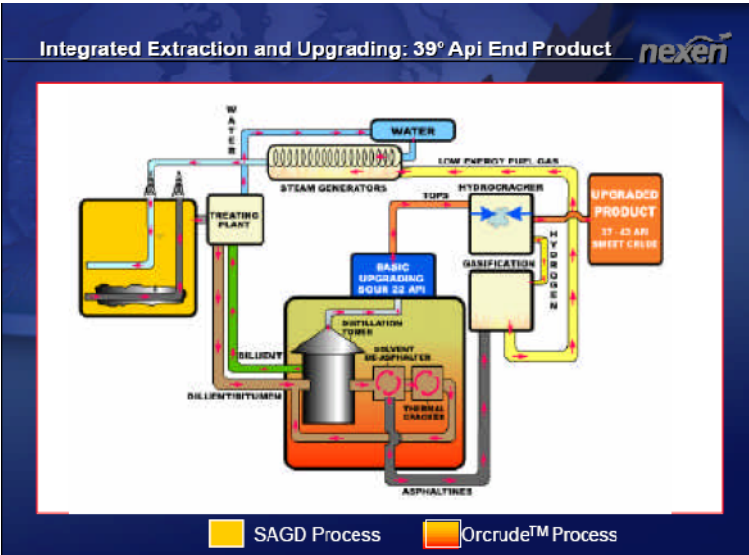
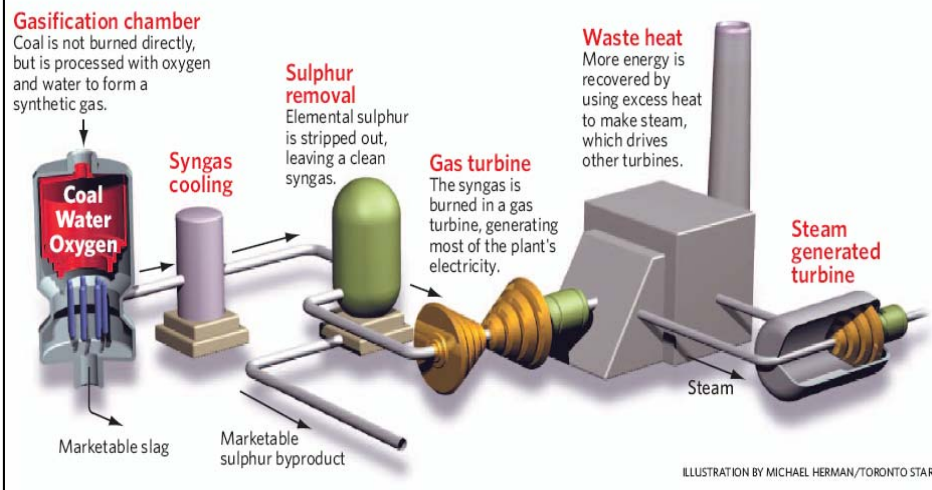


(courtesy; J. Szyszkowski, TCPL, IAGT 2005)

Gasification & Syngas in Power and Oilsands

- Minimize natural gas use
- Polygeneration with H₂
- Onsite Upgrading
- Reliable H₂/CO combustion
- Future CO₂ Capture and Storage

A cleaner alternative How a clean-coal gasification plant works.



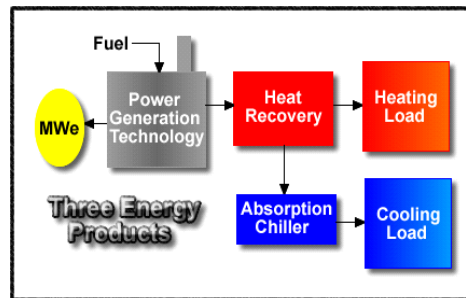
Future CCS ?

OPTI Nexen
Long Lake

1st Cdn Gasification Project, Long Lake AB

Gas Turbine CHP in Municipal and Institutional Applications

- Small GT systems, sized to thermal loads
- Can use absorption chilling in summer
- District energy
- Most plants in Ontario



York U., Two Solar Taurus (JP Zanyk)



Microturbine CHP, Minto Hotel, Ottawa



London Health Sciences (OPA)



Queens Kingston Hospital (2 Solar Taurus)



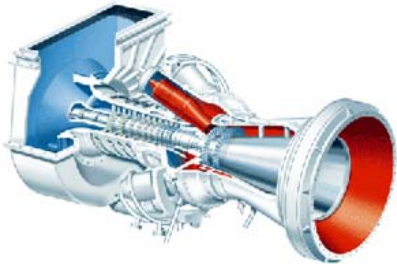
Countryside DES, London ON (OPA)

NRCC Heating / Power Plant - Canada's only Federal GT CHP (1993)

(courtesy, S. Vohra, NRC)



NRC Bldg M6



SIEMENS SGT100
GT GENSET
4.5 MW

HEAT RECOVERY
BOILER
(on mezzanine)

CONDENSER

BOILER
No. 4

BOILER
No. 3

BOILER
No. 2

BOILER
No. 1

CONTROL ROOM

ABSORPTION CHILLER – 200 Tons



Heating, lbs/hr:
Summer 12,000
Winter 55,000
Power : 4 of 12 MW total load

Some Lessons Learned

- Many varied Gas Turbine unit types and ‘industrial’ systems
- Several “*World’s First*” applications in Canadian sectors
- Fuel flexibility, Reliability, Gasification are important GT challenges
- GTs in various systems represent key solutions, to contribute to about ¼ of world’s total energy/GHG solutions (GTCC, CHP, IGCC ...)
- Clean Energy success depends on balanced ‘System Integration’ plus New Cycles, Alternative Fuels, and a better Business Case



TCPL Stittsville



GTAA Pearson Airport (IST)



GTAA Plant Tour, IAGT 2006