Increasing competitiveness of CCGT plants in a dynamic market: An owner´s approach

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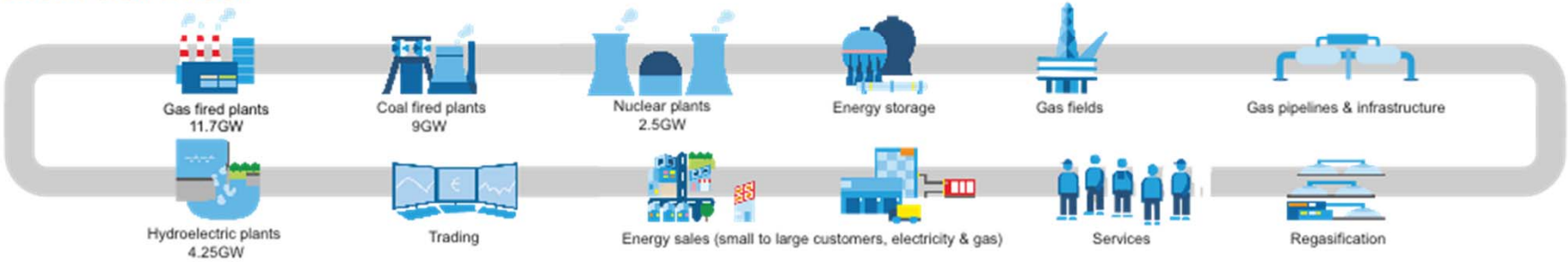
Content

- Background & Motivation

- Increasing operational flexibility
  - Decreasing minimum-load of a CCGT with GE GT26
  - Decreasing minimum-load of a CCGT with Siemens 4000F
  - Faster start-up of CCGTs with GE 9 FA
  - Increasing part-load efficiency in a CCGT with Siemens V64.3
- Summary

We are Uniper

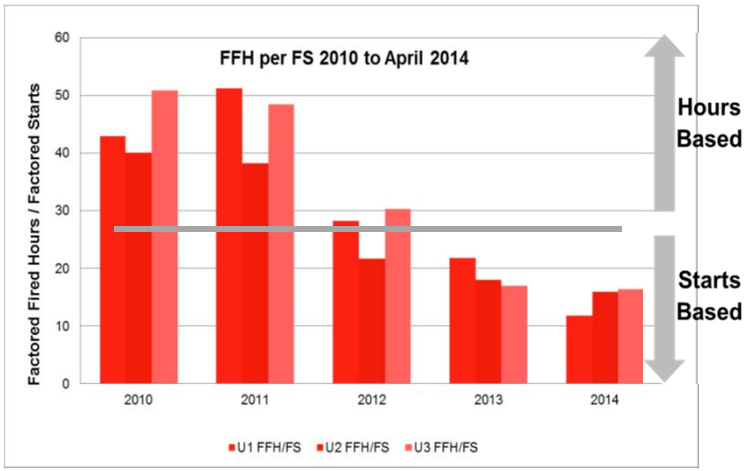
Main activities:

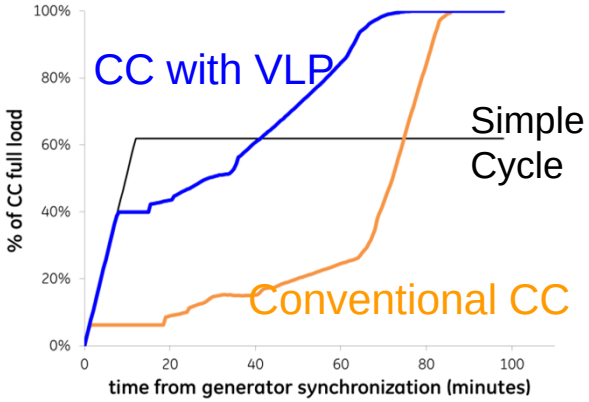


Background: Changed market conditions

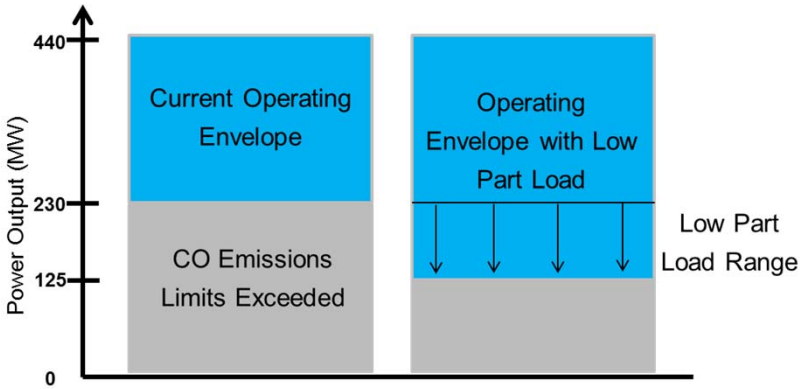
- Maintenance regimes have moved from hours-based toward starts-based
- This is largely due to commodity prices, demand and renewables growth
- Start cost is key for driving value in markets with low power prices and spreads

=> Measures to improve competitiveness:





Reducing PLANT start-up times



Increasing Low Part Load Range

CCPP Grain – Main plant data

min. load CCGT with GT26

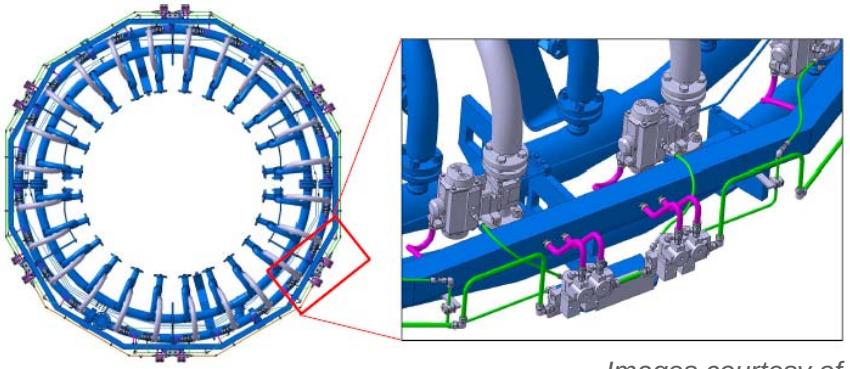
Units	EOH	OH	Starts
61, 71,81	~ 50,000	~30,000	~ 1,250

Basic Plant Data	
GT Type & Configuration	3 x GT26 single shaft
Combustion	sequential lean-premix
HRSG	Drum type, Triple Pressure Reheat
ST	Alstom STF15c
Generator	Alstom TOPGAS, hydrogen cooled
COD	June 2011
Capacity, CC	425 MWe (3x)
Pmin original	230 MWe

Modifications made and result

min. load CCGT with GT26

Switching off SEV burners individually



Images courtesy of GE

- Hardware modifications to the GT
  - Installation of 24 new shut-off valves in SEV fuel distribution system
- Software modifications of the logic were required covering the GT and BoP
- A review of Risk Assessments and a HAZID/HAZOP led by Uniper Technologies to assess the new risks to GT, HRSG and BoP was completed
- A Unit trial was completed on Grain Unit 6 to enable the assessment of:
  - Performance testing including confirmation of environmental performance at LPL
  - Operation of HRSG and BoP in various conditions
  - GB Grid Code testing

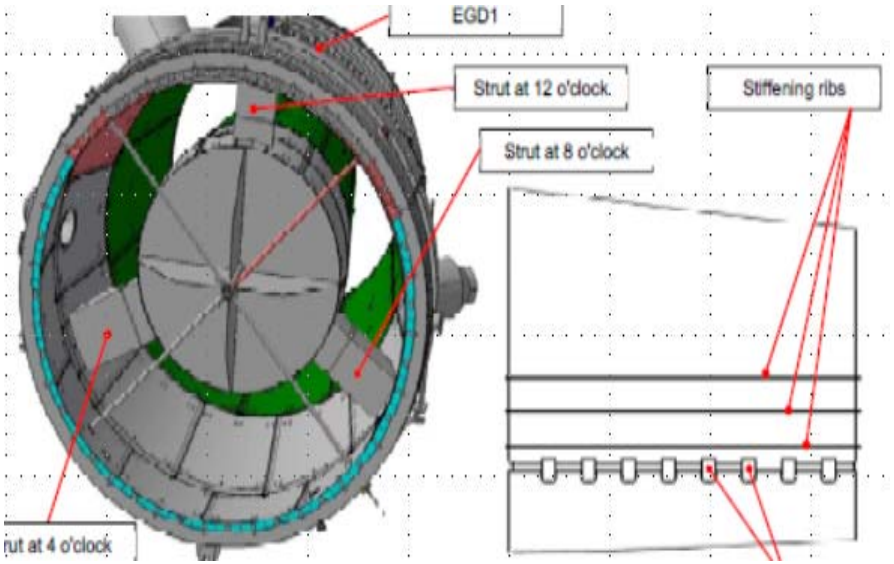
⇒ **Emission compliant load could be reduced from 230 MW to 115 MW**

Operating experience at Grain

min. load CCGT with GT26

- Early operating experience at Grain has been positive.
- Since installation in autumn 2015, Unit 6 has spent prolonged periods operating in LPL
- The overnight shutdown has generally not been eliminated from Grain Unit 6 operating regime.

- Defects associated with the “Mercedes” strut which supports the hot end bearing.
- Modifications implemented to prevent overheating of the jacking oil system.
- The full impact of the uneven temperature profile on the LPT has still to be assessed and will continue to be monitored.



Images courtesy of GE

CCPP Gönyű – Main plant data

min. load CCGT with 4000F

Unit	EOH	OH	Starts
1	26,468	16,826	765

as of 01st April 2016

Basic Plant Data	
GT Type & Configuration	1 x SGT5-4000F(6), single shaft
Combustion	Premix pilot, Dual Fuel
HRSG	STF, Triple Pressure (HP Benson) + Reheat
ST	Siemens SST5-5000, HP/IP + LP
Generator	Siemens SGen5-3000W
COD	May 2011
Capacity, CC	429 MWe
Pmin original	250 MWe

Part Load upgrade scope

min. load CCGT with 4000F

- Implementation of CO Reduction (COR) package
  - Additional pressure measurements at compressor extractions
  - Activation of Air Pre-Heater (APH) during part load
  - OTC part load increase

- Installation of about 50 additional thermocouples at various HP evaporator harps. All TC's are permanently connected to DCS

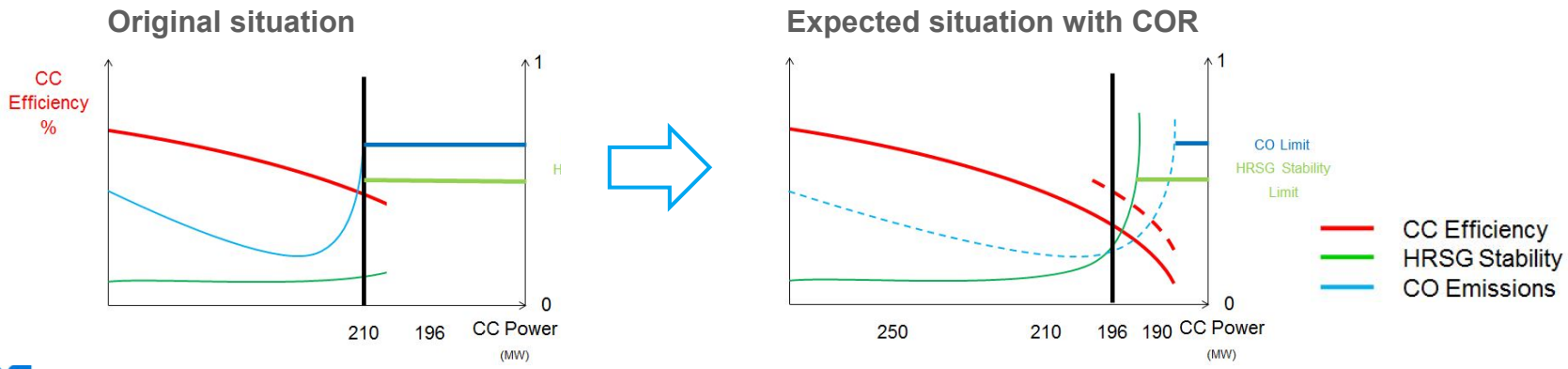
  → Early detection of instabilities

  → Ability to approach real HRSG load limit and to verify effectiveness of counter-measures

Expectations of COR Package

min. load CCGT with 4000F

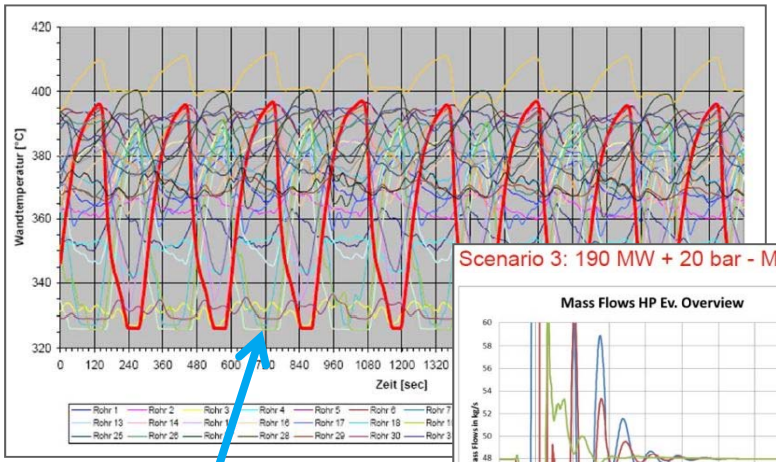
- Reduction of Minimum Environmental Load (site CO limit: 100mg/Nm3); Siemens expected value was **~196MW CC load**
- Increase of part load efficiency during a certain load range
- HRSG instabilities expected at low loads. Siemens advised to
  - increase HP system pressure to 95 bar (from 75bar)
  - increase blow-down rate in order to increase the mass flow
  - install additional orifices between HP Evap 1 and 2



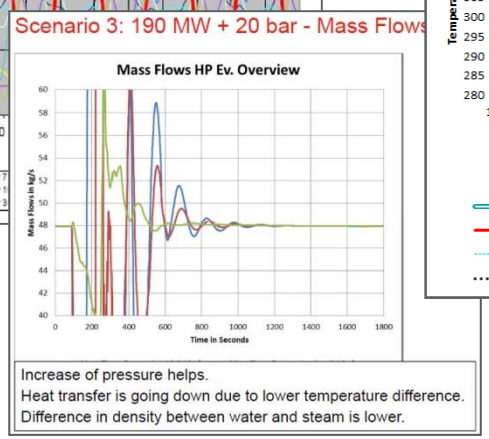
Owner´s verification by dynamic modelling

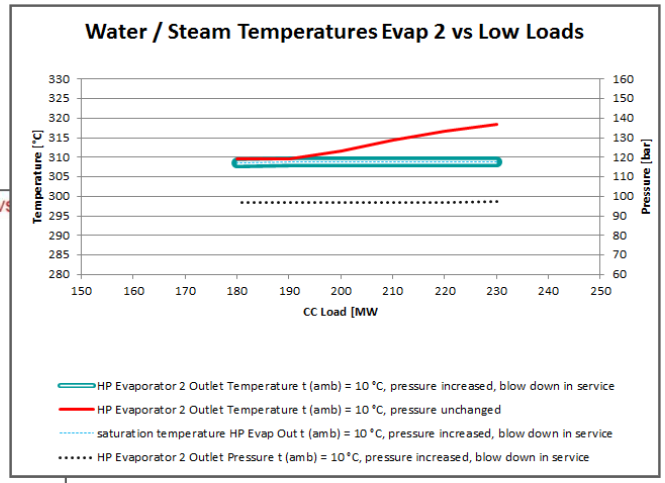
min. load CCGT with 4000F

- Uniper in-house engineering company Uniper Technologies (UTG) created steady-state and dynamic HRSG models to verify Siemens statements



„Ledinegg“ instabilities seen at different plant





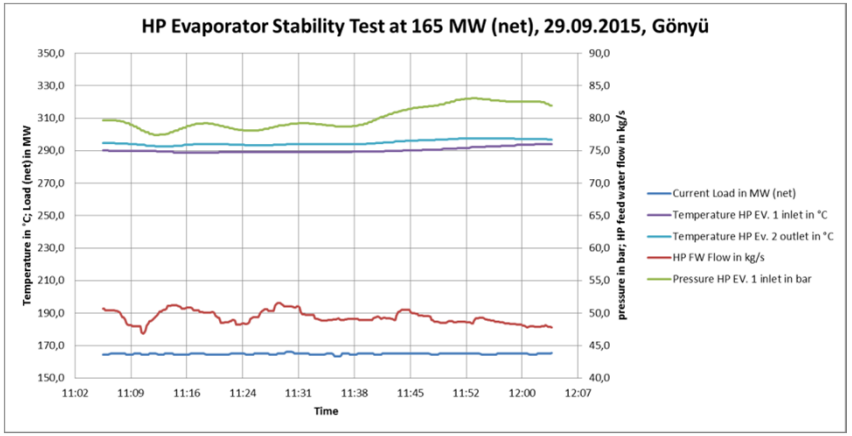
→ **Siemens predictions verified but at even lower loads plus**

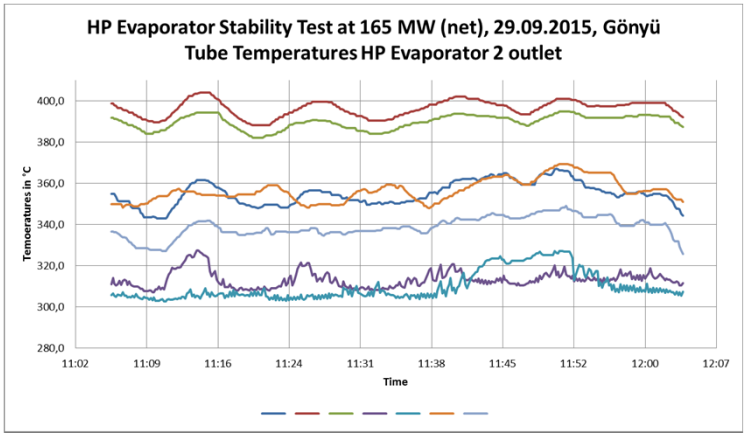
→ **Confidence given that no HRSG hardware modification is required**

Results

min. load CCGT with 4000F

- CO compliant minimum load could be reduced to 165MW (net)
- HRSG generally stable during tests, only at lowest test load some instabilities could be observed, mitigated by increasing HP system pressure





- COR package can be beneficial to improve a plants situation
- HRSG and BoP influences are better to be checked as well independently

➔ **It was decided to set the minimum load to 180MW$_{net}$**

in order to utilise the wider load range while offering ancillary services

CCPP Connah‘s Quay – Main plant data

Fast start up
VLP on GE 9FA

Unit	EOH	OH	Starts
1-4	~125,000*	~107,000*	~1,500*

*varies by Unit, figures for Unit 3 June 2015

Basic Plant Data	
GT Type & Configuration	4 x GE 9 FA, DLN 2.6+,
Combustion	Natural Gas
HRSG	Stein, vertical Triple Pressure + Reheat
ST	Alstom
Generator	Alstom Type T255-420 three phase
COD	Mar 1996
Capacity, CC	4 x 355 MWe

Uniper/GE partnership overview

Fast start up
VLP on GE 9FA

Multi-year agreement initiated December 2011 for joint development of more flexible CCGT operation

GE scope:

-Develop and conduct test program;
- Develop, validate, and implement new GT control software

Uniper scope:

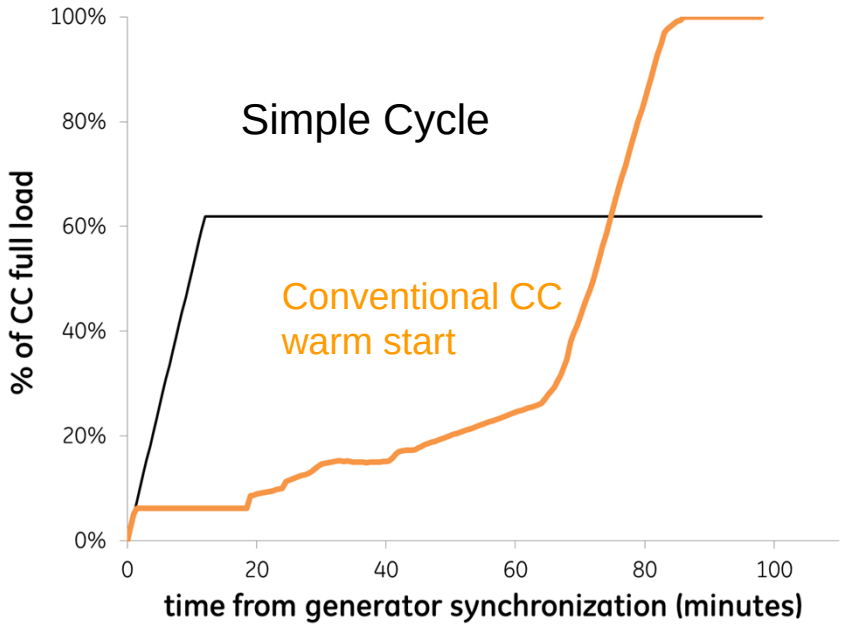
- Conduct combined cycle plant modeling
- Analyses to evaluate operational impacts of new technology
- Develop risk mitigation measures;
- Make plants available for field testing;
- Implement necessary plant control software changes

⇒ **Partnership approach results in better overall plant-level solution by engaging end-user throughout product development process**

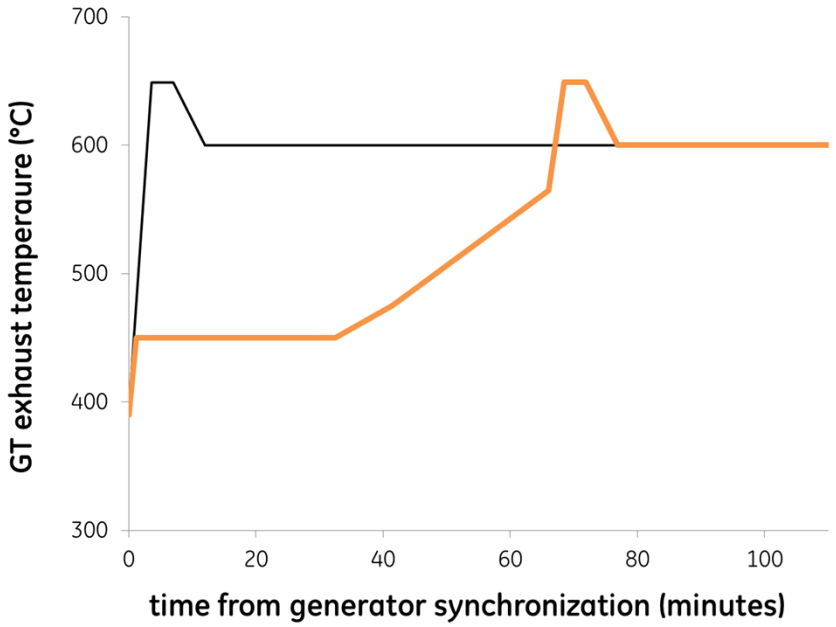
CC and SC startup curves

Fast start up
VLP on GE 9FA

CC load vs. time



GT exhaust temperature vs. time



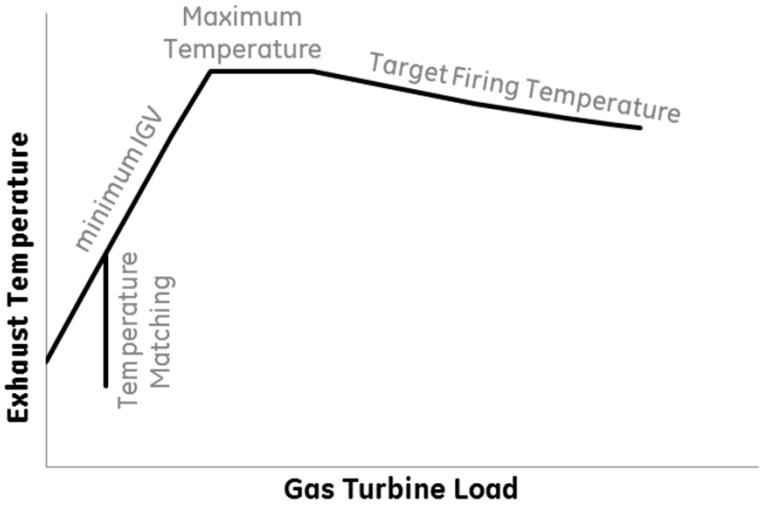
→ Conventional combined cycle plant starts too slow and costly to compete in real-time power markets … cost, time to dispatch, and load profile

⇒ **Need near-simple cycle load profile**
… while controlling exhaust temperature to manage plant stress

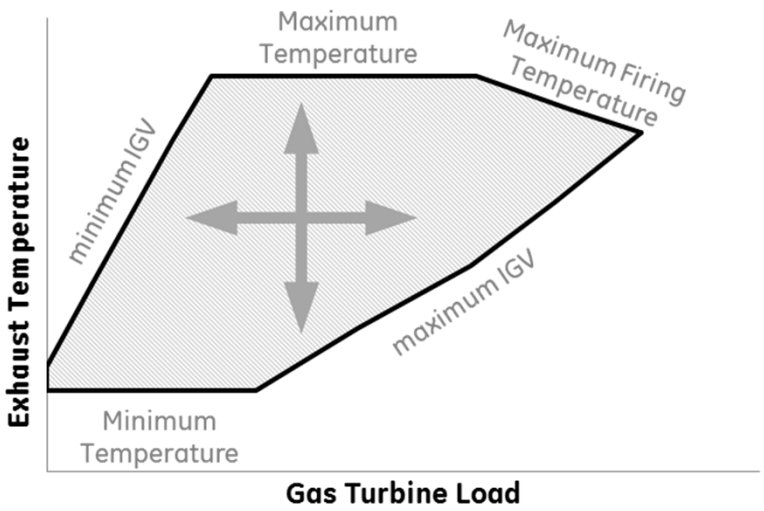
What is OpFlex* VLP?

Fast start up
VLP on GE 9FA

Conventional operating "path"



VLP operating space



- Gas turbine control feature
- Allows **independent control of load and exhaust temperature** within the gas turbine boundaries … true GT flexibility product
- Simple interfaces for integrating into existing plant operation
- Requires OpFlex AutoTune to manage combustor operability

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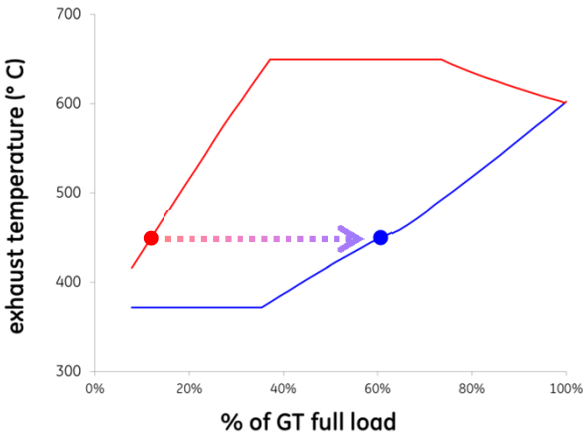
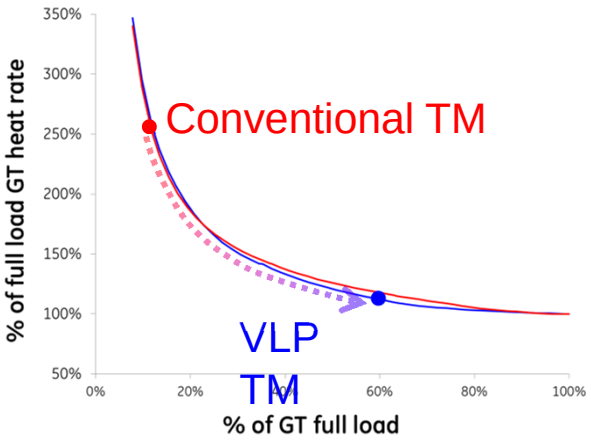
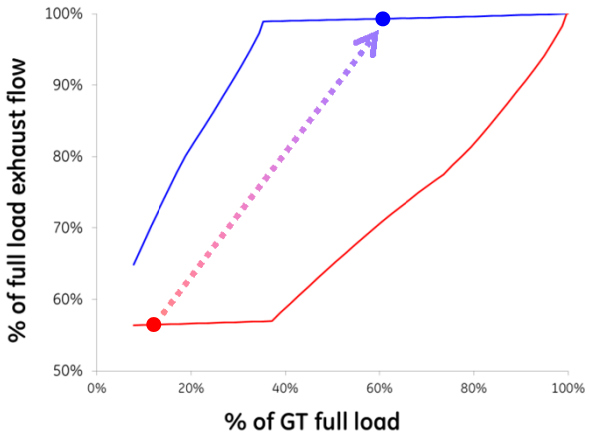
* Trademark of General Electric Company.

Plant operating benefits with VLP

Startup comparison – steam temperature matching (TM) & ramping







⬆ exhaust flow/energy	accelerate boiler and ST startup
⬆ GT pressure ratio	near base load GT heat rate
⬆ combustion temperature	CO emissions compliance at lower exhaust
⬆ temperature	
load flexibility	reduced load imbalance

Example: 450°C exhaust temperature

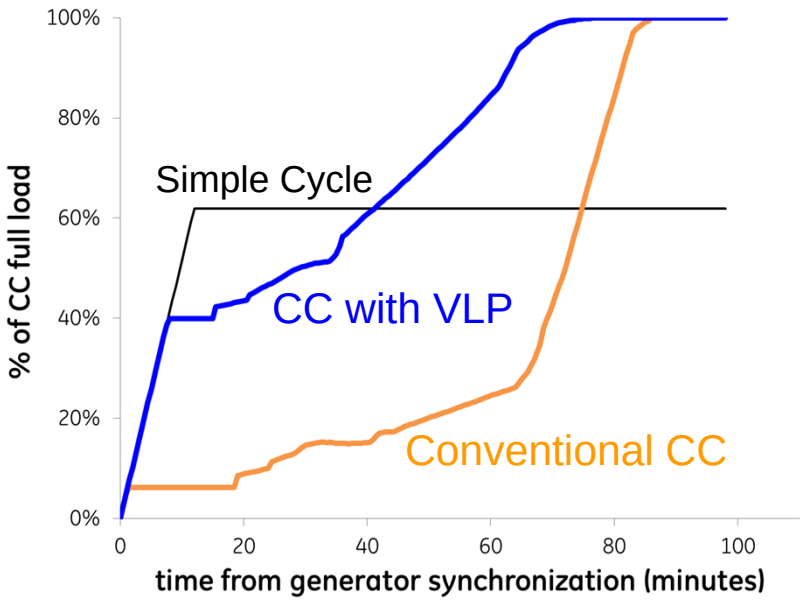
~130 MW increase

~40% increase in exhaust flow

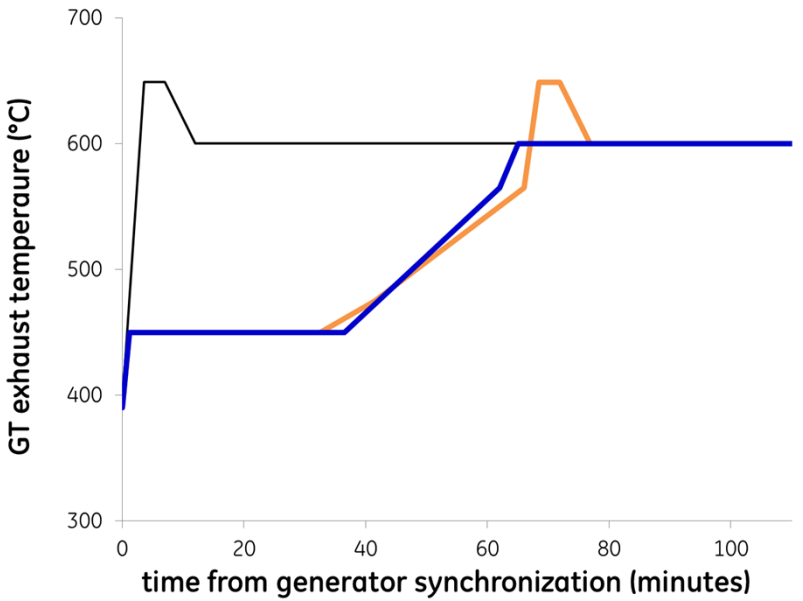
~60% reduction in heat rate

Comparison of conventional versus VLP combined cycle start-up curves (predicted)

CC load vs. time



GT exhaust temperature vs. time



With VLP:

- Near simple cycle load profile … higher load sooner
- Near simple cycle full load heat rate

With VLP:

- Exhaust temperature still controlled to limit equipment stress
- Reduce maximum exhaust temperature during start

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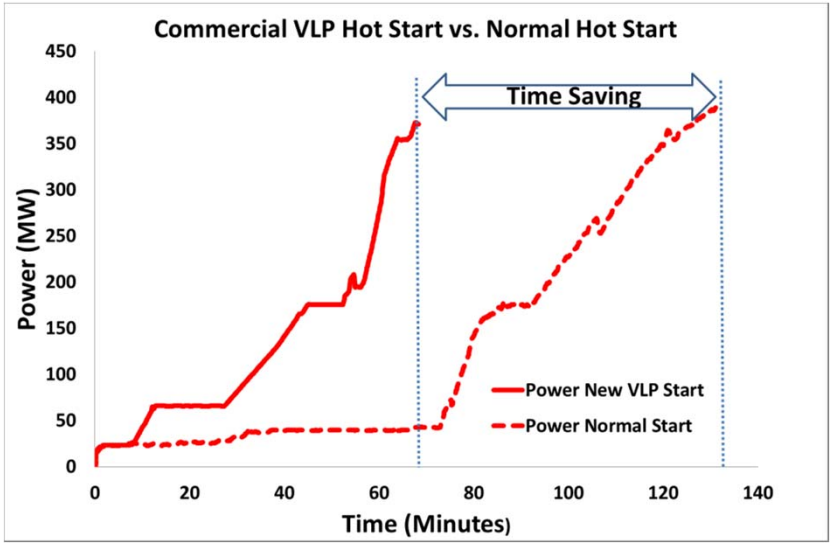
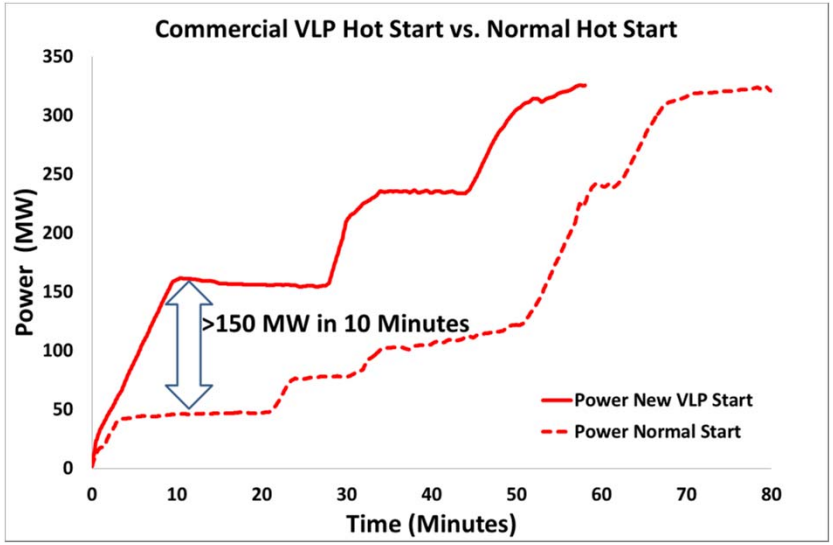
Results





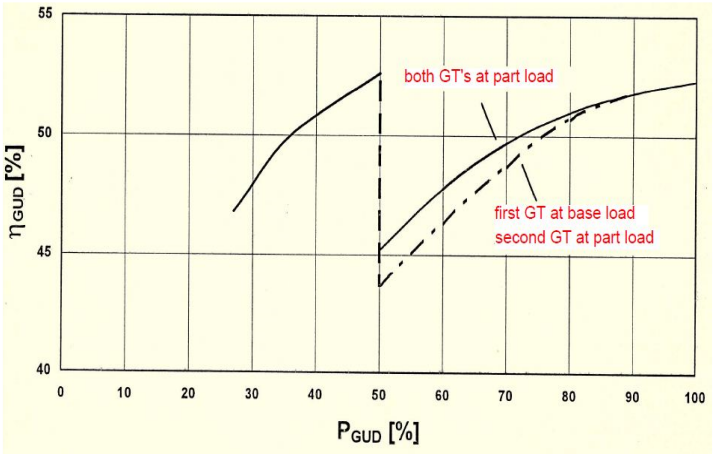
Plant A Hot Start Comparison		
	Pre-VLP	VLP
Start-up Fuel Cost Savings		40%
Start Time	c.130 mins	c.65 mins

Plant B Hot Start Comparison		
	Original Unit	VLP Unit
Compare Op Jun'14 – May'15	143 Starts 1,900 Hours	233 Starts 3,100 Hours
Time to 150MW	55 mins	10 mins

Combined cycle plant delivered near simple cycle start capability:

- More MW
- Less time
- Less fuel

Increase of part load efficiency



Situation

- CCGT Plant Kirchmöser with V64.3, COD 1994

Challenge

- Like most CCGT plants, the design is optimized for base load
- Plant rarely operates in base load as the power demand is determined by the rail network.

Solution

- Creation of HRSG and thermodynamic plant models, investigate possible operational and plant modifications to improve part load efficiency.
- Evaluate proposed modifications in terms of NPV and plant risk.

Value

- Improvement of about 1.0% point on part load efficiency.
- => NPV of about 1 Million €

Conclusion

- Uniper / OEM partnership delivered successful product enabling higher CCGT flexibility, e.g.
  - Low Part Load for GT 26 plant
  - Low Part Load for 4000F plant
  - Fast start up with VLP for 9FA

- Significant effort required to manage plant impacts and engineer implementations on site … partnership approach a best practice

- OEMs have valuable solutions for improving flexibility,
  but: They should be challenged

- Using our Owner´s technical capabilities has led to considerable improvement of our CCGT assets

Thank you!

Questions?