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Perspectives on Economic Flexible Operation (EFO)

December, 2017

Uniper is a global energy company

Our operations:

- Power Generation
- Commodity Trading
- Energy Storage
- Energy Sales
- Energy Services

Where we operate:



Employees: 13,000



- Power generation, Storage, Services - Europe
- Power generation - International
- Commodity Trading, Energy Sales



Main activities:



Employee data December 31, 2015.
Capacity figures April 26, 2016.

Uniper has 100 year heritage serving 600 power sector, industrial clients in 40+ countries



Gas fired generation



Coal fired generation



Industrial generation



Nuclear



Renewables



Energy from waste and biomass



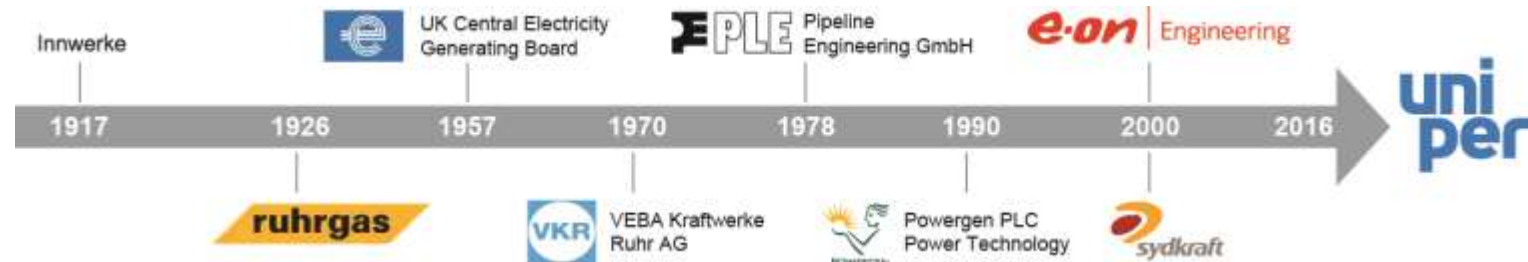
Insurance, banking and finance



Energy distribution

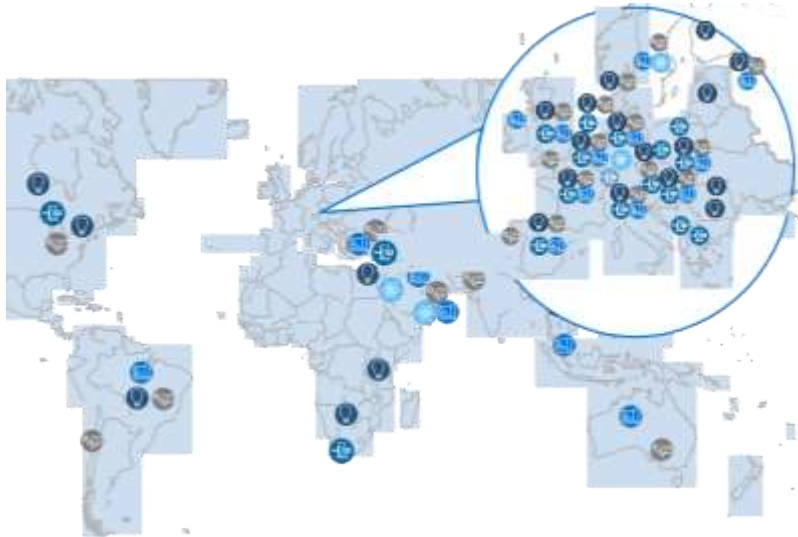


Gas pipelines, storage and LNG



Uniper's portfolio and capabilities allows to offer technology services with global footprint

Global footprint and broad service offerings



Innovation delivery



Engineering services



Maintenance and asset optimization



Project management / development



Nuclear services

Value proposition

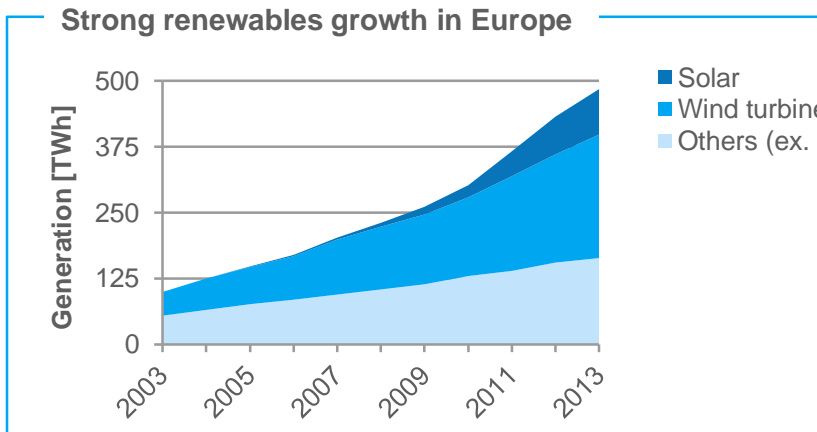
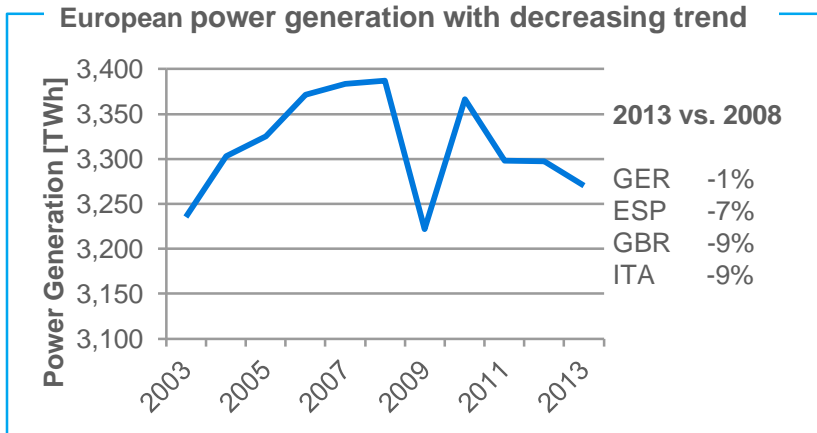
Leading one-stop-shop energy solutions provider with services across the value chain and life-cycle

Optionality to tap into global new-build project opportunities

Business at a glance (UEG¹)

- Expertise across multiple technologies
- Services to more than 600 customers²
- Active in more than 40 countries²

European market has changed significantly over 10 years



Source: Eurostat (code: nrg_105a)

1. Reduction in Demand

- Global recession has destroyed power demand across Europe

2. Global Commodity Prices

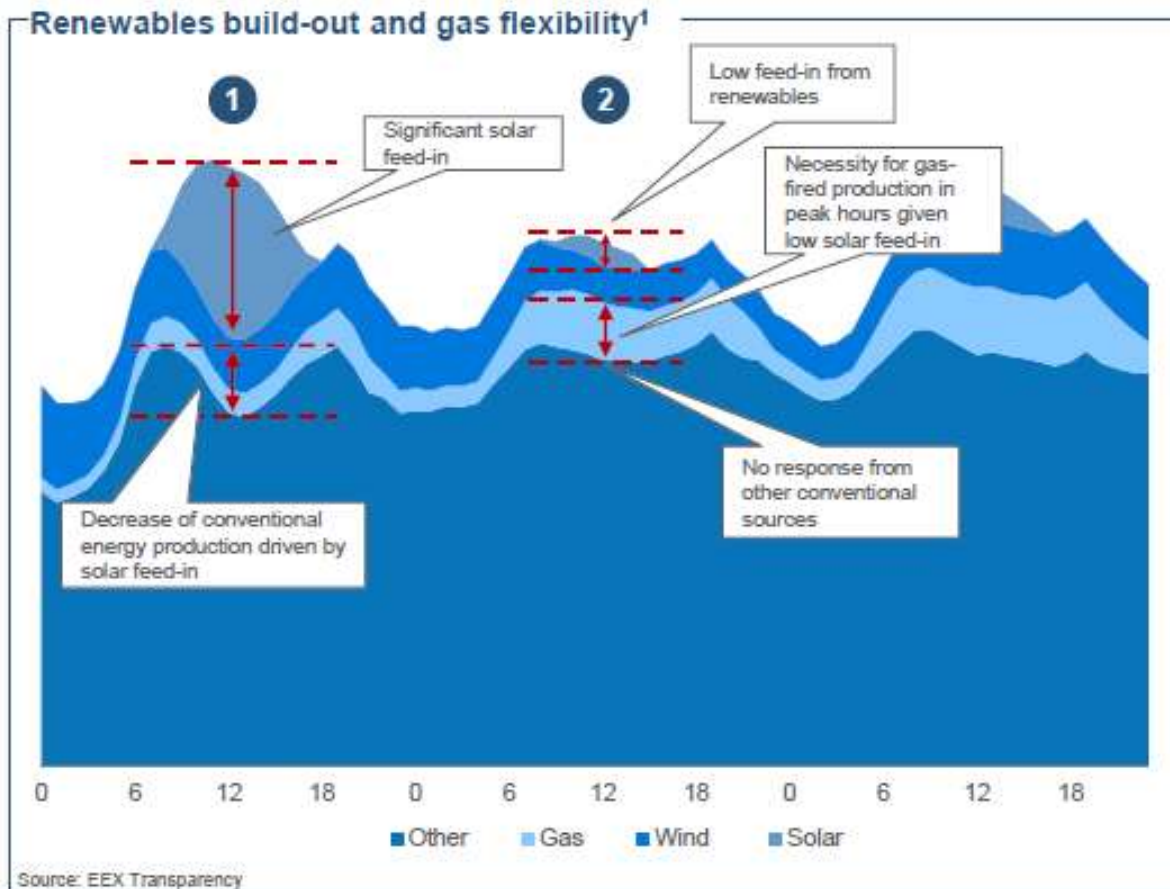
- CO₂ prices have dramatically fallen caused by oversupply – attempts to reform have failed to date
- US shale gas has increased US coal exports making coal generation cheaper than gas
- However global gas prices have and oil prices putting coal at margin

3. Renewables Growth

- Incentive schemes designed to deliver European 2020 targets have caused the strong and constant growth of Renewables

4. Political Intervention

Conventional generation as base load needed on days of low yield of wind and solar



Key considerations

- 1** Significant renewables feed-in with direct impact on electricity production from conventional power plants

Very limited production by conventional power plants in times of high renewables feed-in
- 2** Conventional power plants required to address hours of limited renewables production

Higher renewable penetration on particular days can completely change the energy pattern

NG Control Room @NGControlRoom · May 26
#Solar has just broken another record in Great Britain, providing 8.7 GW (24.3% of demand)



33 1.1K 1.2K

NG Control Room @NGControlRoom · 47m
GB generation mix at 8:00am: gas 46.1%, nuclear 24.0%, imports 9.8%, biomass 6.7%, wind 6.5%, solar 3.6%, coal 1.9%

- Reduction in absolute MWh from coal and gas units
- Coal and gas switch on short run marginal costs (fuel)
- The future is uncertain with many more questions – what will electric cars mean?

NG Control Room @NGControlRoom
National Grid can confirm that for the past 24 hours, it has supplied GB's electricity demand without the need for #coal generation.

Great Britain goes without Coal Generation for 24 hours
(Friday 7th April 2017 was the first 24-hour period since the 1890s where Great Britain went without coal-fired power plants.)



nationalgrid | nationalgrid.com/uk
3:11 PM - 21 Apr 2017
1,946 Retweets 1,761 Likes

Gas to Power JOURNAL

Home Projects Markets Technology Regulation

Tuesday, 18 August 2017
Glut in LNG to push European gas prices through coal floor
Written by Arpa Kati

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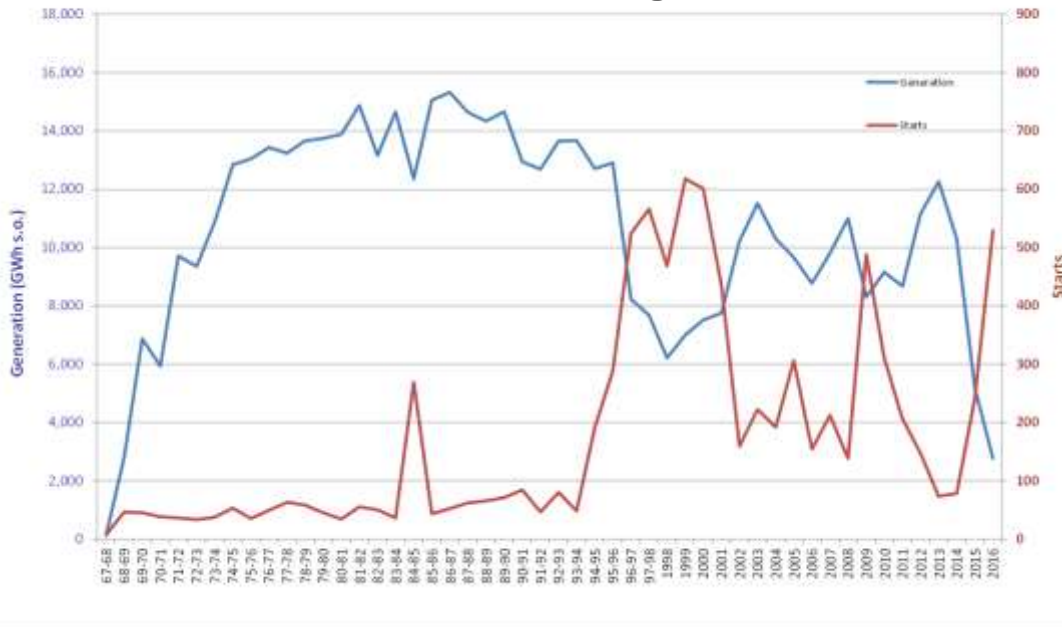
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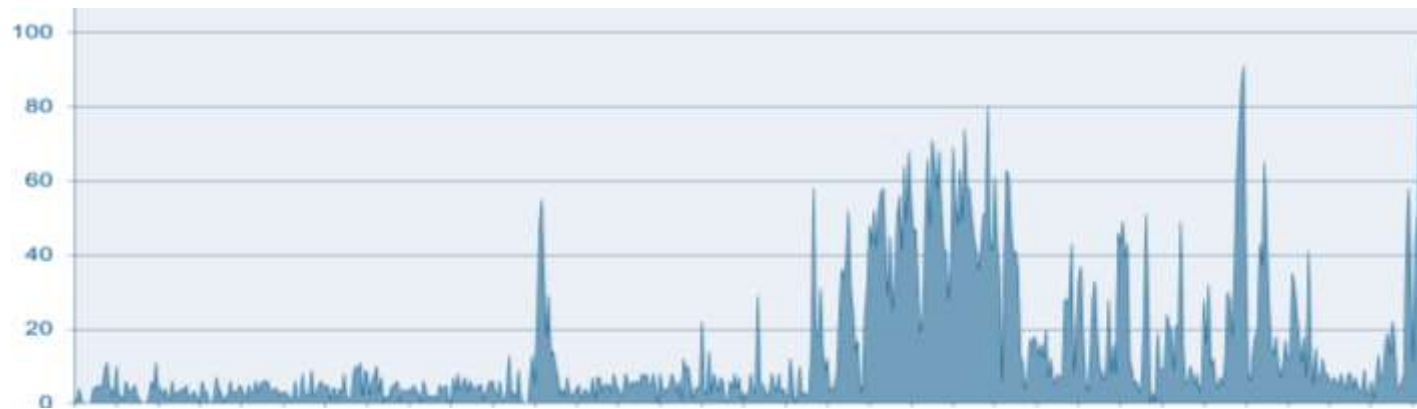
Excess growth in global LNG supply, notably through the ramp-up of US LNG through 2013 and into 2015, will make European gas prices 'move through the coal floor price'. Fuel-switching in the Western European power market, according to Société Générale, will ultimately be determined by short-term gas prices hitting at the

Flexibility at Ratcliffe power station

Operating Hours and Starts Per year Since Commissioning



Monthly starts over time for a coal fired plant



Uniper's Economic Flexible Operation (EFO)

- Uniper has developed a low cost commercial solution
- Unique and expert flexibility support in a single package
- A turnkey, holistic approach with optional components
- Immediate, mid, and long term issues
- A focus on economic operation, maximising income & reducing risk
- Developed & demonstrated over decades
- We can help you get the most from your existing assets



Potential Value of EFO

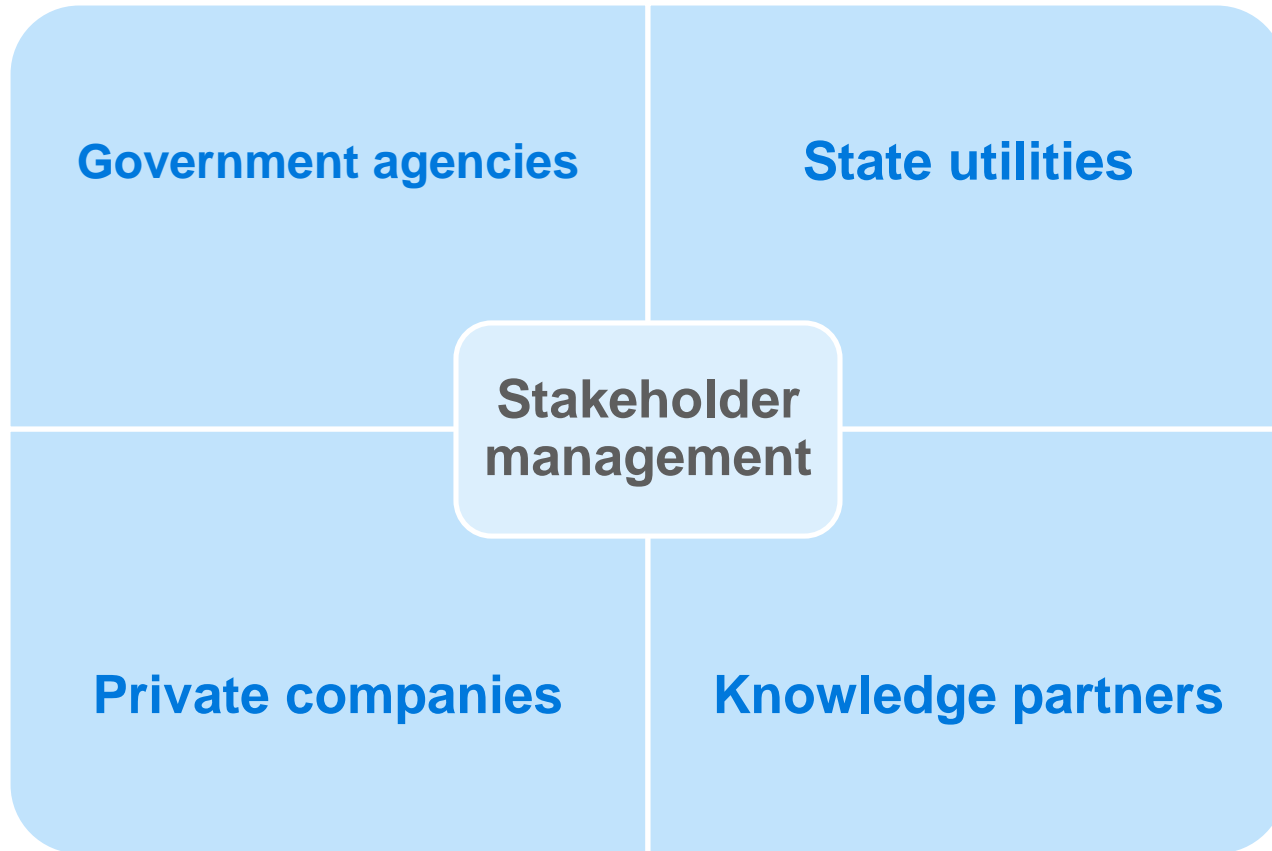
The potential real world value of EFO approach typically includes*:

- Shorten start-up times by 20-50%
- Improve ramp rate and load following by 50%
- Reduce major component replacement costs by 20-30%
- Increase max load by 5-10% of P_{\max}
- Reduce minimum load to 10-20% of P_{\max}
- Increase major outage intervals by 20-40%
- Reduce daily maintenance costs by 10-20%
- Reduce fuel oil and water consumption by 10-20%
- Extend economic plant life by 5-15 years

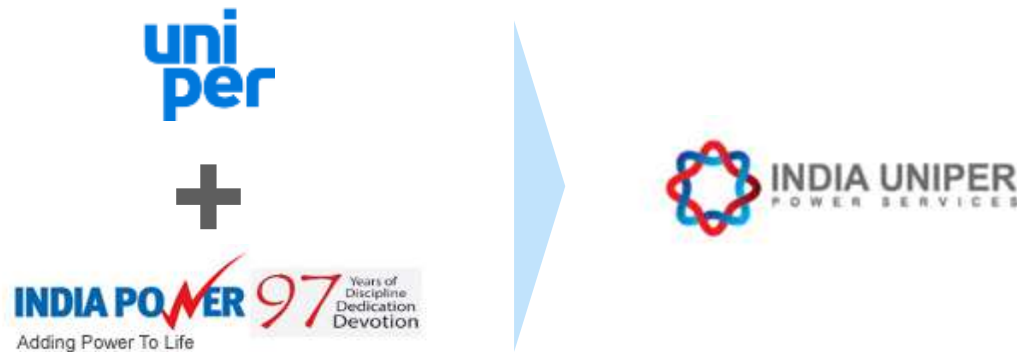


A significant increase in useful asset utilisation, life and profitability

Our journey so far and learning from you...



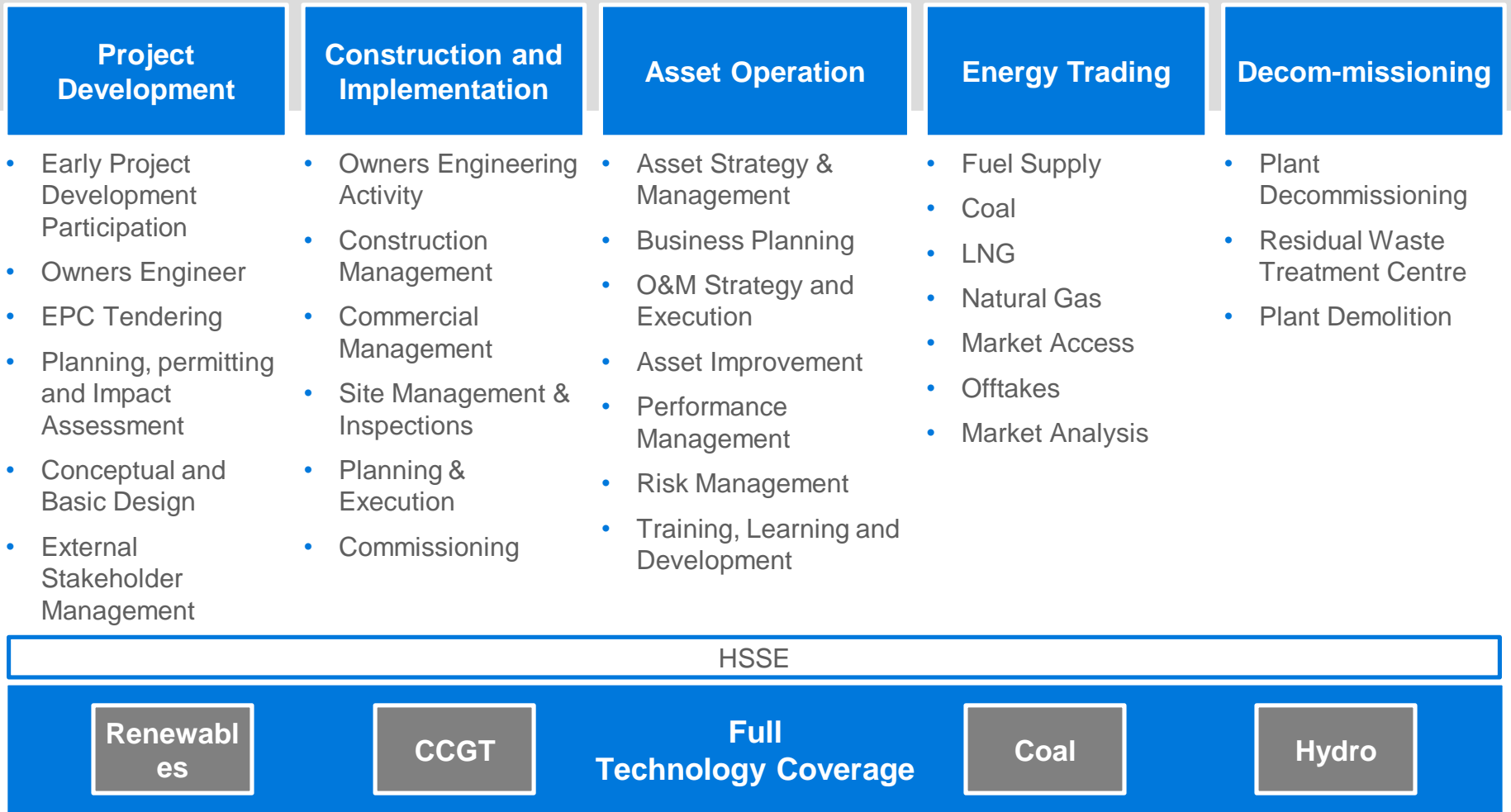
Uniper & India Power have formed a strategic partnership to develop, service power sector



India Uniper Power Services (IUPS)

- 50:50 joint venture in power plant services
- A value-based service provider
- Offering a broad range of flexible and customised services
- Highly skilled talent pool of ~600 employees in India
- Supported by expertise from UK and Germany

Our experience as owner and operator allows us to offer services across the value chain



Coal: reliable partner for fluctuating solar and wind production ...



Power Plant Heyden – technical data

General:

Installed Capacity	1987 start operation
Today's capacity	800 MW _{el}
Efficiency Full load	875 MW _{el}
	41 %

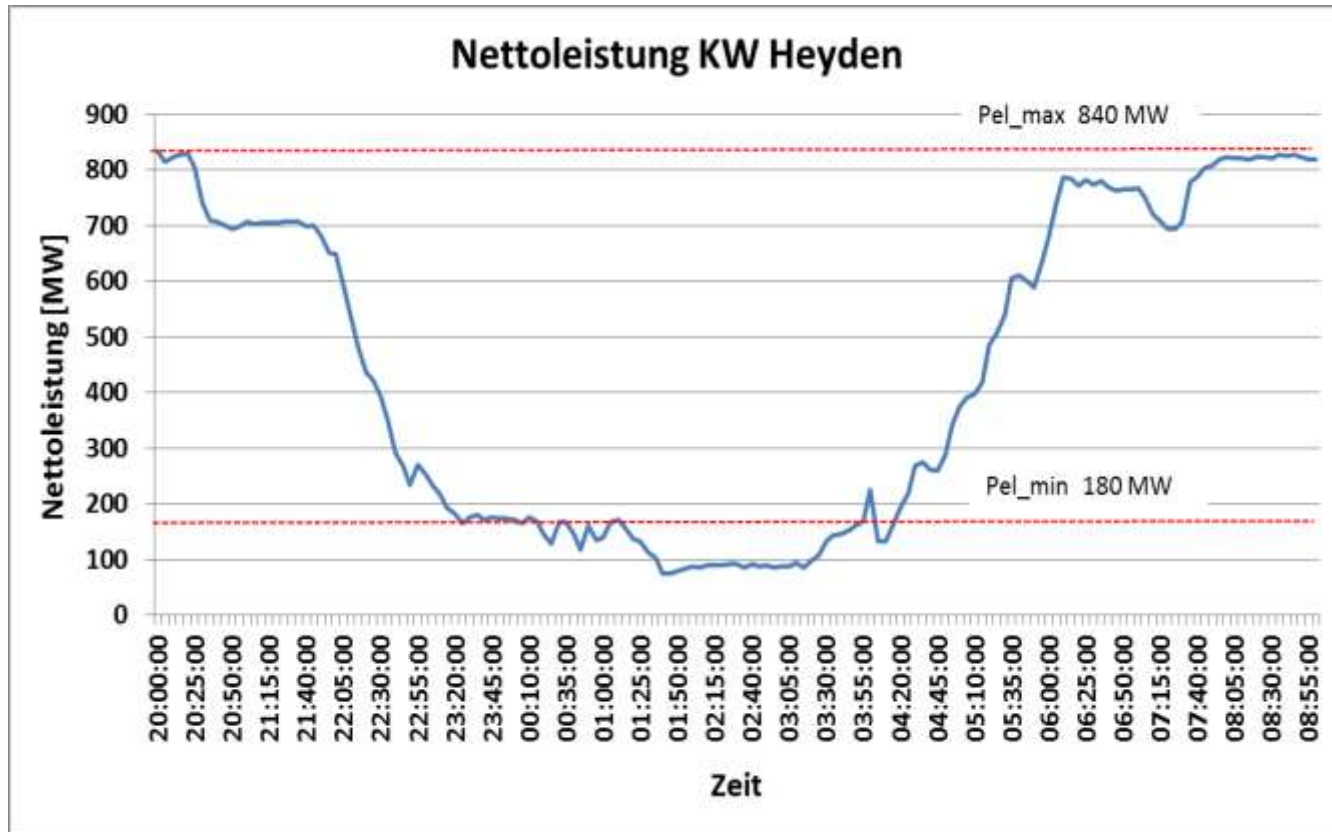
Steam

Supercritical pressure	2700 t/h
Supercritical temperature	215 bar
Intermediate pressure / Temp	544 °C
	46 bar / 545 °C

Flexibility

Min load	20% / 180MW
Since 01.06.2017	11% / 100MW
Ramp rate	15...20MW/Min
Hot start time to grid	1 hour
Hot start time to full load	3 hours

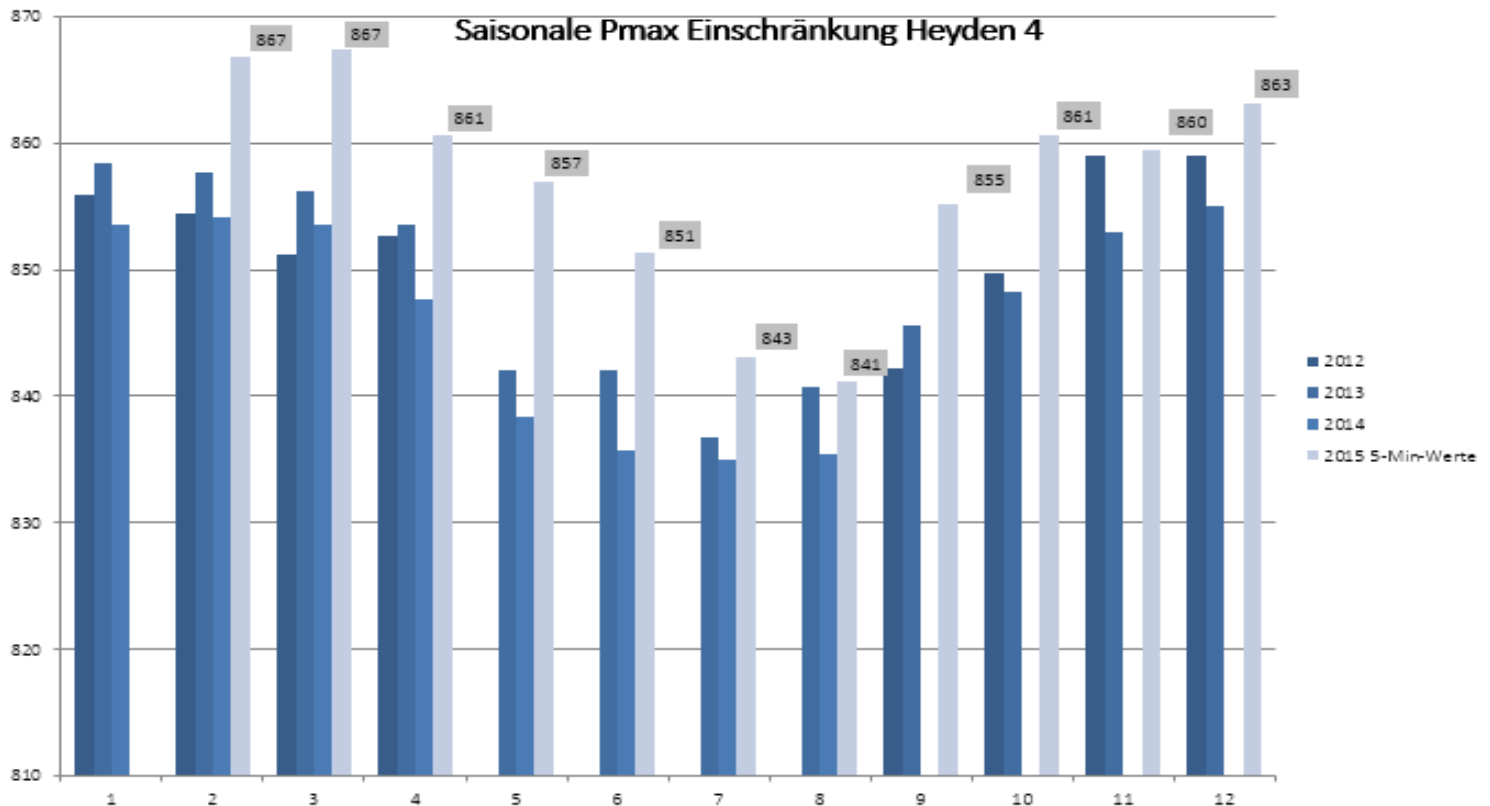
One Mill operation for ~10% min load



- 2015: planning and checking technical feasibility
- 2016: testintg
- 2017 optimizing, as normal operation since 01.06.2017

Increase of max Capacity

1987	Start operation	800 MW brutto
1993	Increase output	880 MW brutto
1998.	Increase output	910 MW brutto
2005.	Increase output	920 MW brutto
2015	Optimize output	Back to 920MW brutto



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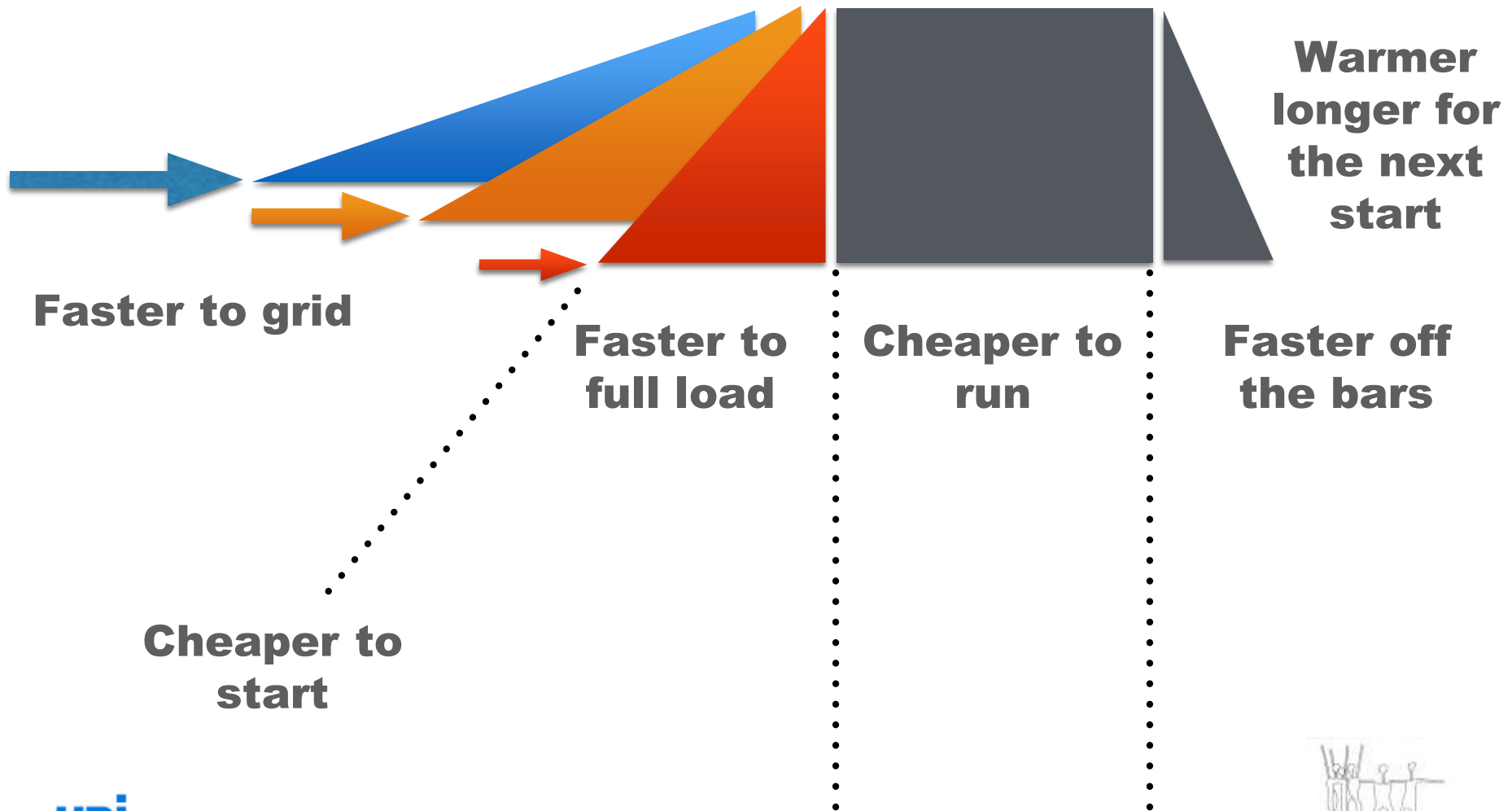
Production @Ratcliffe:

Increasing Ratcliffe's flexibility and commercial offer to meet current and future energy market demands

December 2017

Production@Ratcliffe:

More competitive in every aspect



Faster to grid

Faster to full load

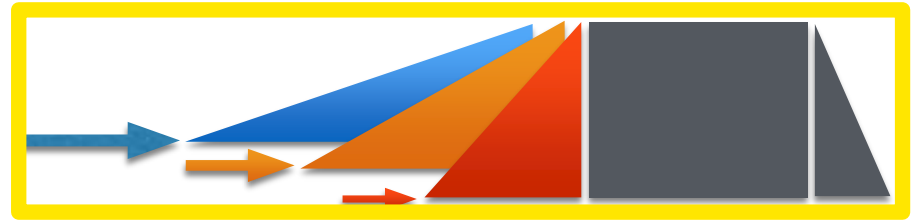
Cheaper to run

Faster off the bars

Warmer longer for the next start

Cheaper to start

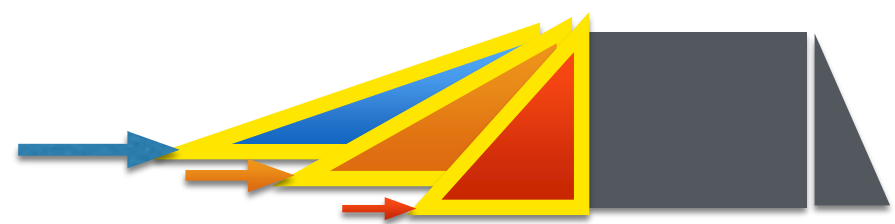
Production@Ratcliffe: Taking Responsibility



- Pond Fines and Fuel Mix
- Hot Warm & Cold Starts
- Faster to Grid (improved NDZ)
- Access to market if NDZ within 90 minutes – more attractive for hot standby
- Fast Shutdown from SEL
- Super SEL
- Loading Rates / Hold Points
- NDZ/MZT/MNZT - Parameters
- On-load Oil Use
- 3 Mill Loading
- Boiler pressure raising with coal prior to sync



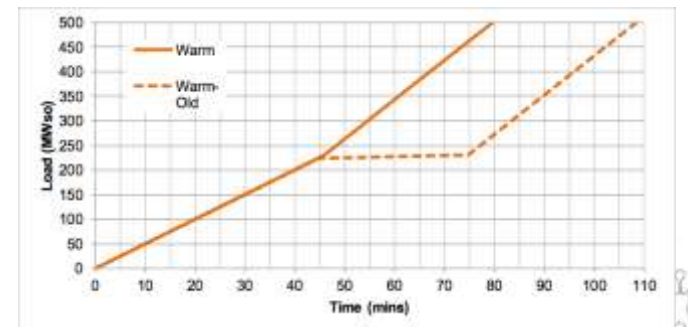
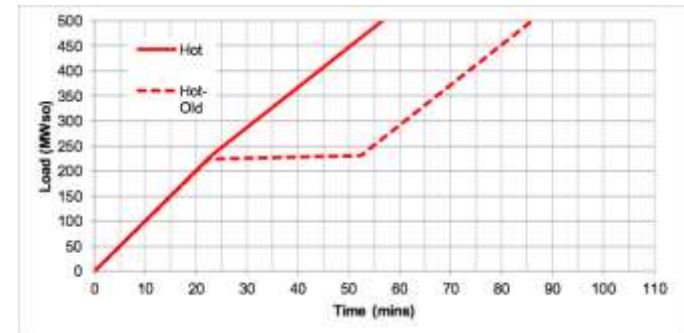
Production@Ratcliffe: Faster to full load



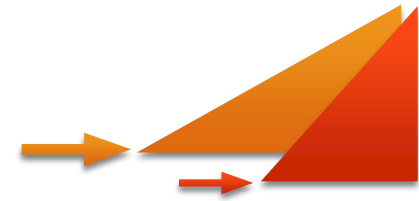
- Objective
 - Increase loading rates and reduced hold points
- Benefit
 - Supports reduced oil burn
 - 'Extrinsic' commercial value
- Status
 - Hold points removed from all starts
 - Aspiration to return to 5min hot turbine run-up to speed
 - Aspiration to achieve 50MW block load after synch (hot start)
 - 2MW/min load rate to 50MW trialled (cold start) [currently 0.5MW/min]

Underpinned by work on start-ups
 + Improved reliability of sequences (e.g. FGD)
 + Improved familiarity with soft desk

State	Then (mins)	Now (mins)
Hot	86	57
Hot / Warm	67	67
Warm	109	80
Cold	190	190



Startup Hot & Hot/Warm



- Objective
 - Reduce oil burn, reduce firing time & target oil burners out by 100MWso
 - Extend Hot status window into Hot/Warm
 - Reduce Notice to reach BOA market (85 mins on Hot now with trading)
- Benefit
 - Oil burn saving £750k – £1.25m
 - Normalise UO workload & avoid ‘peaks’
 - Increased value from more runs
- Status
 - Stage 1 testing completed (oil burners O/O/S by 160MW), New Ops procedure written & rolled out to all shifts.
 - Stage 2 testing in progress - oil burners O/O/S by 100MW, aim for ~60 mins first fire to unit sync

Startup - Warm

- Objective
 - Similar principle to Hot & Hot/Warm (faster & cheaper!)
- Benefit
 - Oil burn saving £200k - £400k
- Status
 - To start following Hot & Hot/Warm trials

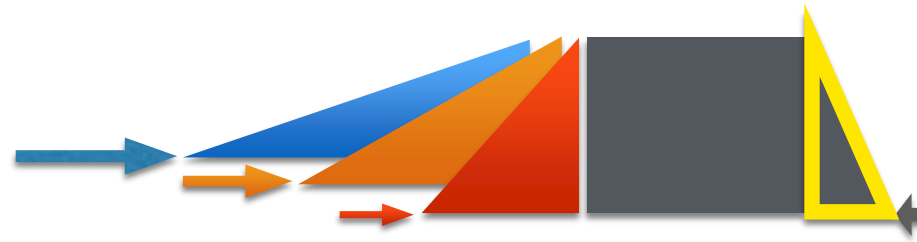
Now seeing benefits from other areas will influence ability to deliver
Data shows learning points from other states are already being embedded

Startup - Cold



- Objective
 - Reduce total cold start time by ~3hrs (7 hrs down to 4 hrs)
 - Reduce time from Sync to SEL.
- Benefit
 - Unit in the money faster after sync
 - Oil burn saving £250k - £500k
 - Reduce cold NDZ to <300Mins (if boiler N2 capped) or <479 (if boiler 'wet stored')
- Status
 - 2 Cold start trials carried out – U3 30/07/2017 & U2 04/09/2017
 - Initial trials successful.– 27.4T of oil saved, total time from first burner to sync 4hrs, and then Sync to 230MW 1hr.
 - Area's identified where further improvements can be made – Aim to target oil usage of <50t for cold start.

Production@Ratcliffe: Faster off the bars



- Objective

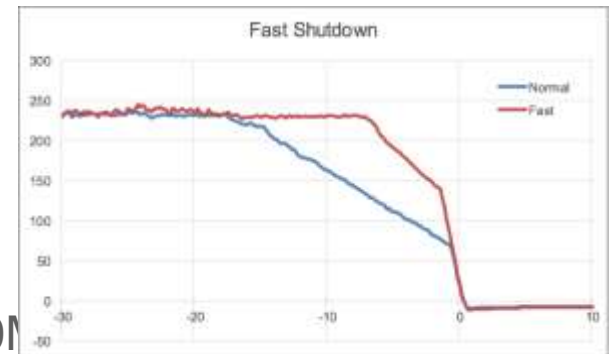
- Reduce shut down time and oil burn
- Retain more heat in turbine to facilitate faster return and extended warmth states (stay hotter for longer)

- Benefit

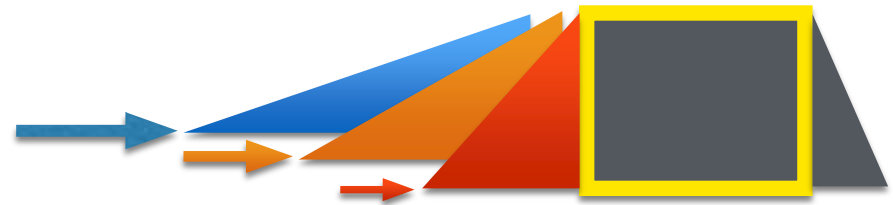
- Oil burn saving ~ £250k

- Status

- Plant Sim for 140MW shutdown permissive & 80M implemented for testing on all available units.
- Shut down time reduced from 17mins to 9mins for 230MWso – 0MW.
- 9 mins shut down now being achieved consistently.
- Ready to be rolled out



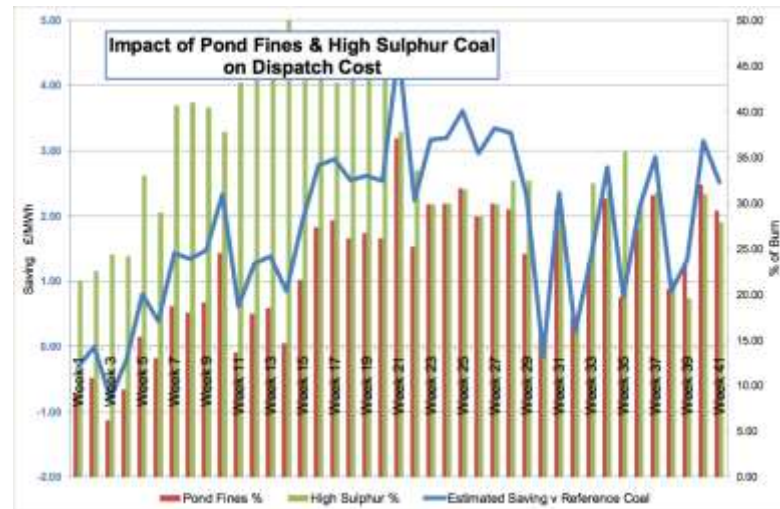
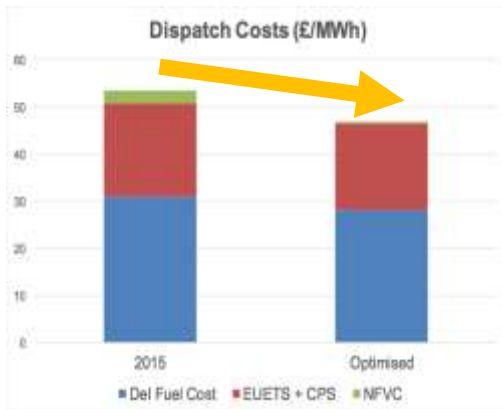
Production@Ratcliffe: Cheaper to Run



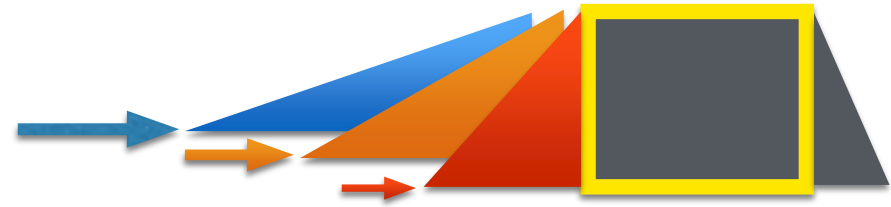
Focus on actual fuel mix to bunkers. Increasing pond fines and USHS proportions

Improved ash & gypsum sales

Integrated work with trading to reflect actual costs in dispatch



On-Load Oil Use



- Objective
 - Reduce on-load oil usage
 - No oil burners for 5th/ 6th /7th mills In/Out of service
- Benefit
 - Supports reduced oil burn (£300k - £600k)
- Status
 - Test procedure written and circulated for comment
 - Testing planned to start in October

3 Mill Loading

4 Mills I/S @ 230MW

- Nox emissions close to monthly limit c.440mg



3 Mills I/S @ 230MW

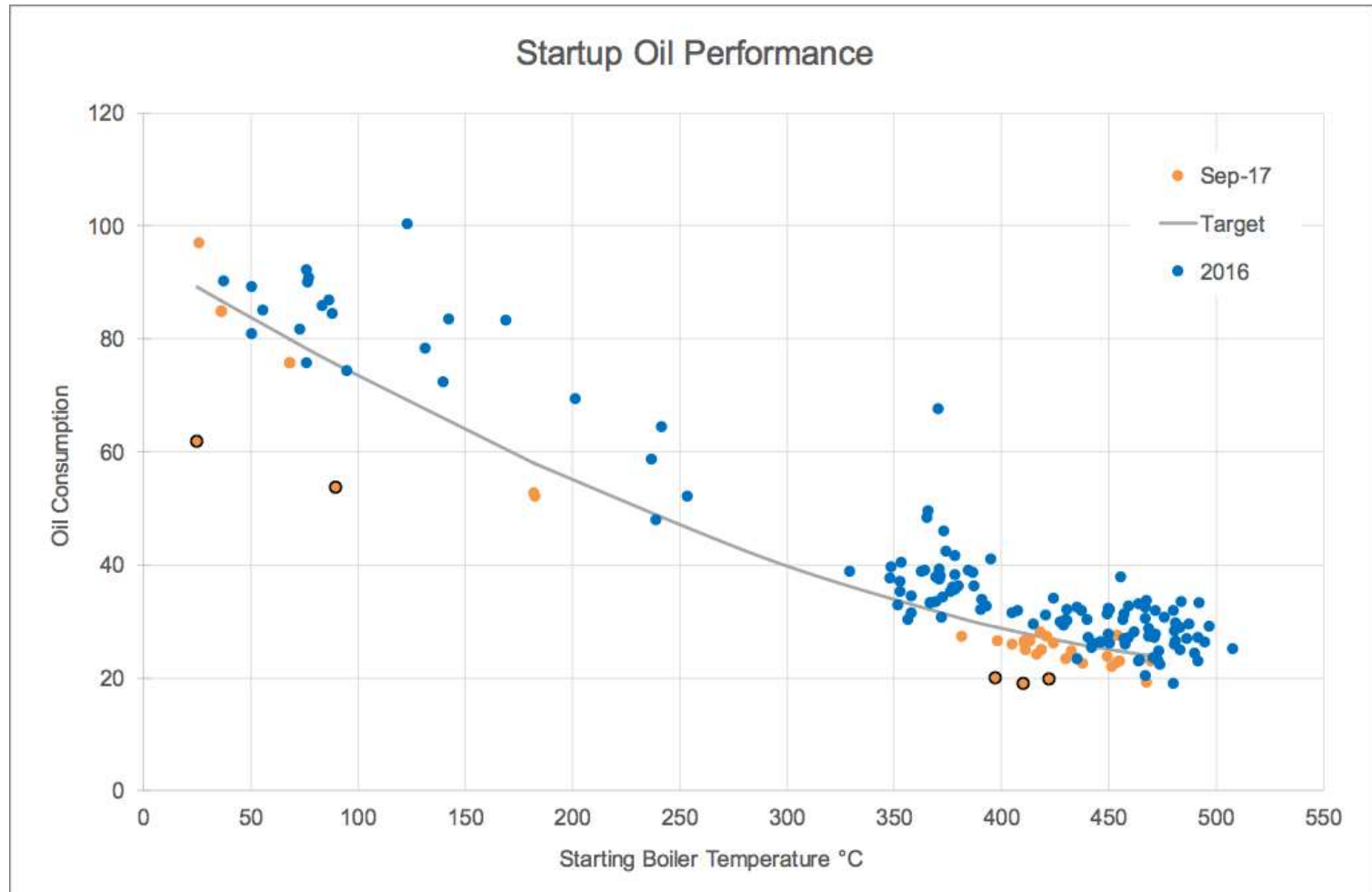
- Nox emissions very good c.350mg.



In both Cases

- No supporting ignition fuel required for stable flame
 - Fire was clean and stable
- No impingement of burner flame on furnace rear wall
 - PF flame 'well rooted' to the ignition tube
 - No pulsating of the flame
- Furnace pressure stable and maintaining \sim -0.5 mbar

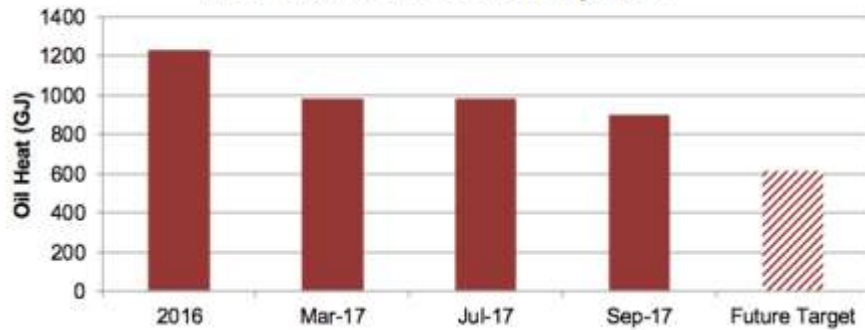
Startup Oil



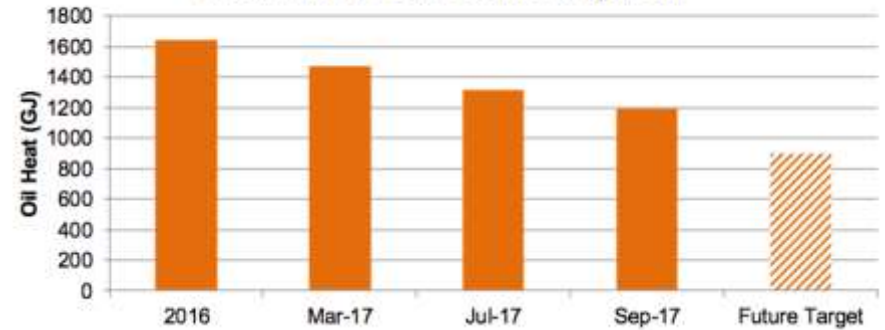
*Reduced Consumption
Reduced Variation
Future Targets*

Start Oil Reductions – achieved and target

Hot Start Oil Consumption



Hot/Warm Oil Consumption



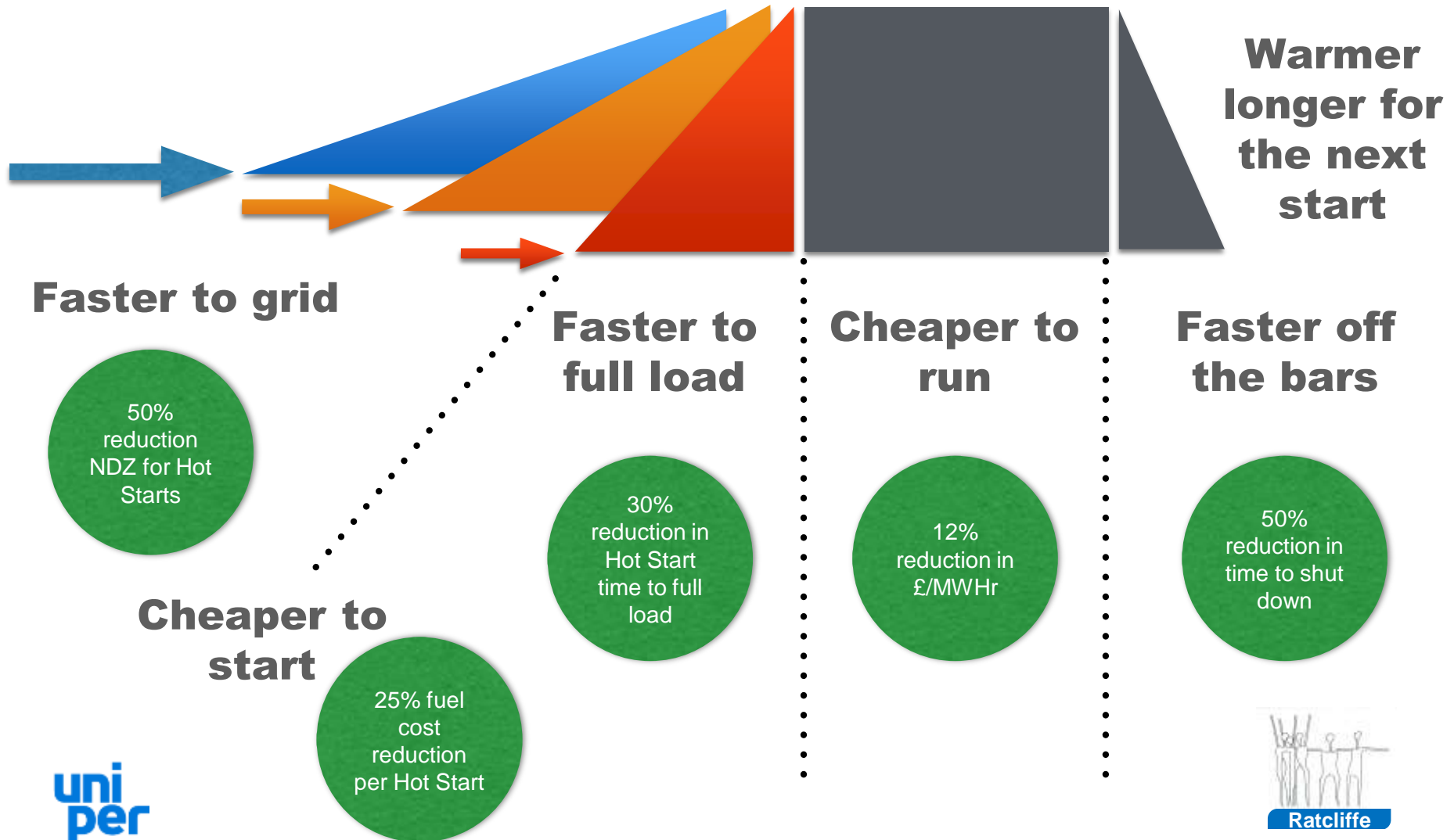
Warm Oil Consumption



Cold Oil Consumption



Production@Ratcliffe: More Competitive



Faster to grid

50%
reduction
NDZ for Hot
Starts

**Faster to
full load**

30%
reduction in
Hot Start
time to full
load

**Cheaper to
run**

12%
reduction in
£/MWhr

**Faster off
the bars**

50%
reduction in
time to shut
down

**Cheaper to
start**

25% fuel
cost
reduction
per Hot Start

**Warmer
longer for
the next
start**

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