



Jordan International Oil Shale Symposium

 #JIOSS2014

2014

MODERN OIL SHALE PROCESSING FLEXIBILITY Improved Technology for Difficult Ores

Daniel Melo, P. Eng.



Modern Oil Shale Processing Flexibility Improved Technology for Difficult Shale Ores

International Oil Shale Symposium, Jordan 2014

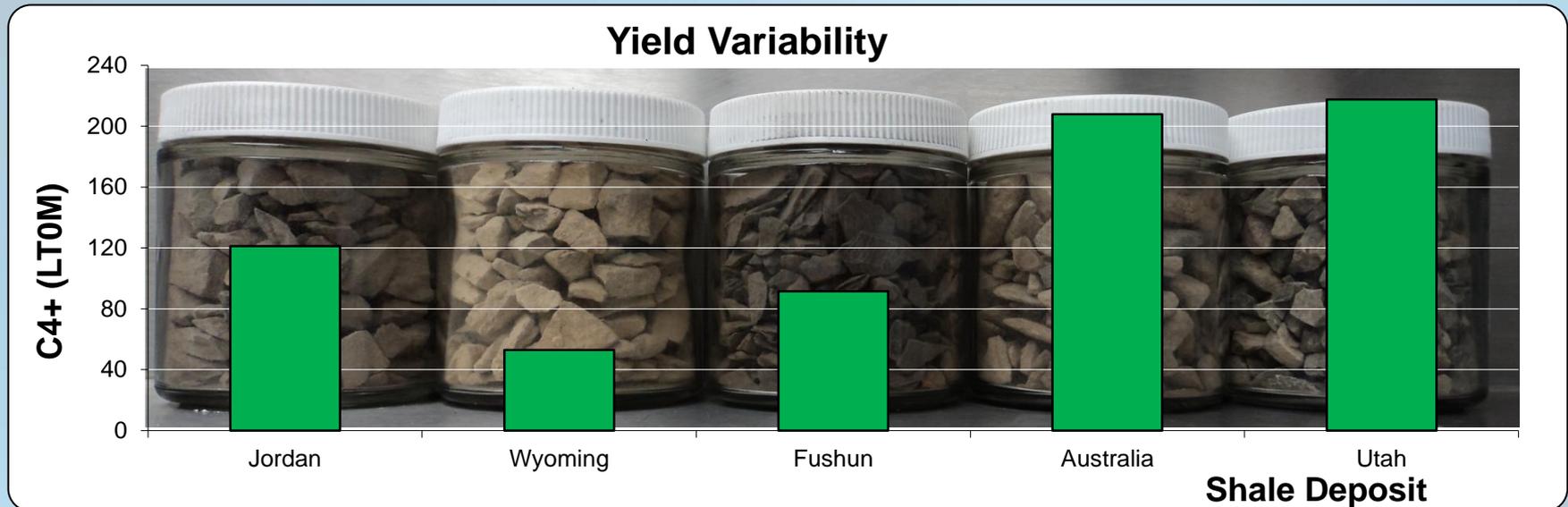
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Uniqueness of Shale Deposits

Oil shale:

- No specific chemical formula
- No definite geological definition
- Broad term for fine-grained sedimentary rocks that yield “oil” upon pyrolysis



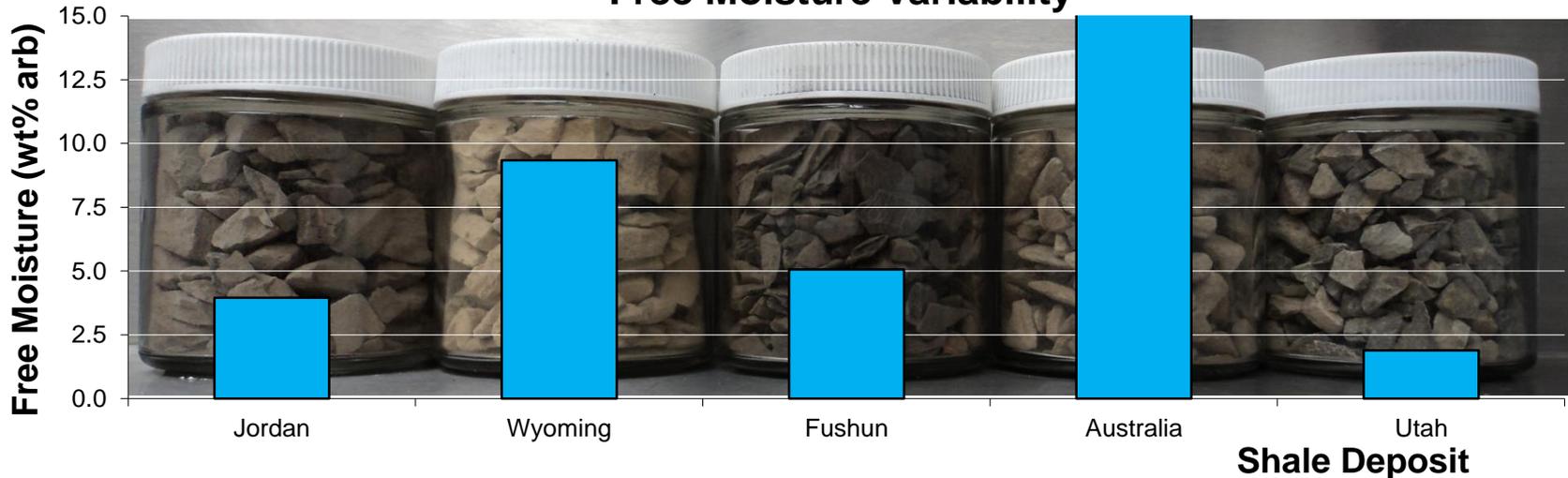
Every oil shale is unique. Expect unique challenges!

Uniqueness of Shale Deposits

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- Broad term for fine-grained sedimentary rocks that yield “oil” upon pyrolysis

Free Moisture Variability



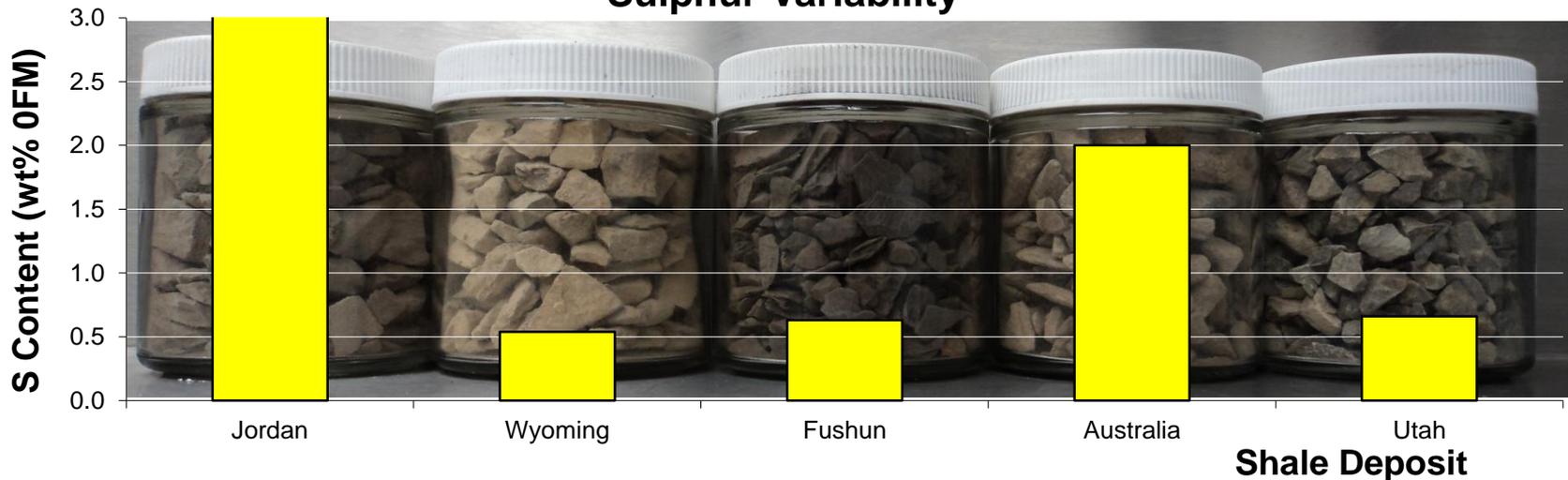
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Uniqueness of Shale Deposits

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Sulphur Variability



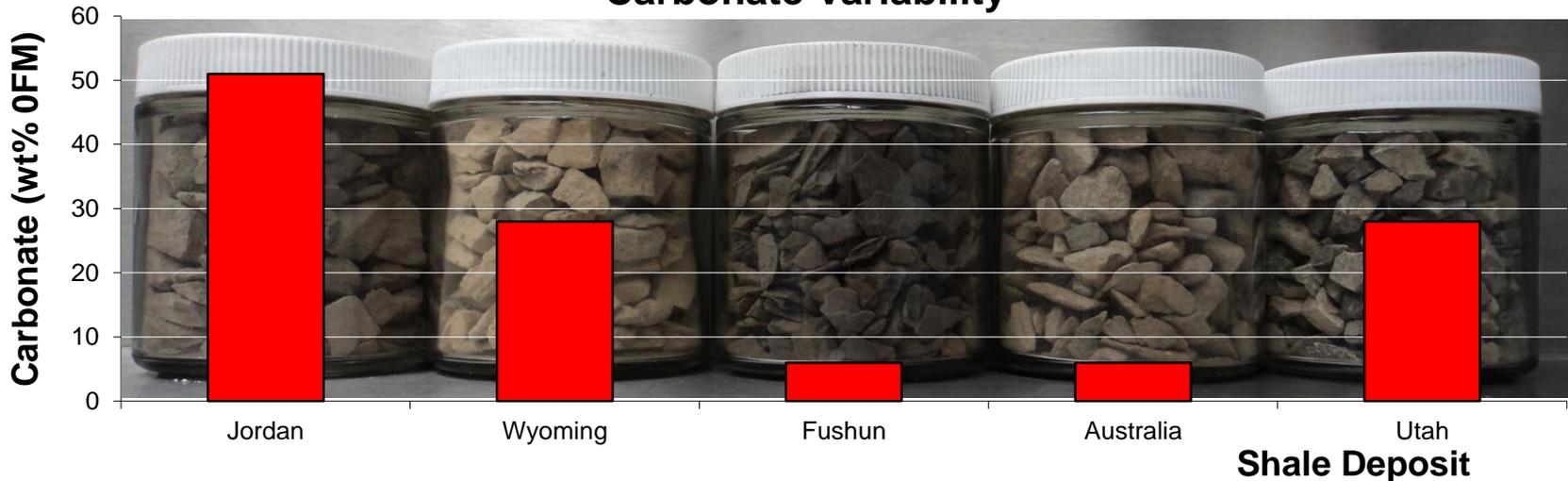
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Uniqueness of Shale Deposits

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Carbonate Variability



Every oil shale is unique. Expect unique challenges!

Ore Properties



Physical Properties

- Static angle of repose
- Dynamic angle of repose
- Loose bulk density
- Tapped bulk density
- Friability
- Attrition tests
- Heat capacity
- Thermal conductivity
- PSD
- Particle density
- Abrasion



Chemical Properties

- Soluble oil
- Water saturation
- Free moisture
- HC grade
- Gas make & composition
- Carbonate content
- C, H, N, O, S
- Calorific value
- Fixed Carbon
- Sulfur forms
- Mineralogy



Streams and Properties



Raw shale



Dry shale



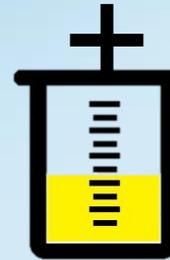
Spent shale



Free Moisture



PH Vent



Sour Water



Off Gas



Oil

Properties

- Alkalinity & pH
- NH_3
- Chlorides & Fluoride
- Sulfate & Sulfite
- COD & BOD
- Bottom solids
- H_2S and Sulfide as S
- VOC Scan
- PAH Scan
- Nitrate & Nitrite
- Regulated Metals
- Chromium (hexavalent, trivalent)
- Total Phosphorous
- Dissolved Ortho Phosphorous
- TSS
- Residue, Filterable (TDS)
- Residue, Volatile @ 550°C
- Free Cyanide
- Total Cyanide
- Semi Volatile Phenol Scan
- Total Recoverable Oil & Grease
- SVBNA (Isophorone, Benzoic Acid)
- TPH (C_{10} to C_{28})
- Total Organic Carbon
- Total Inorganic Carbon
- Phenols
- Total Kjeldahl Nitrogen

Streams and Properties



Raw shale



Dry shale



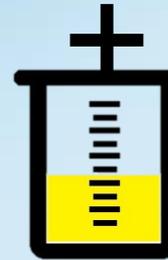
Spent shale



Free Moisture



PH Vent



Sour Water



Off Gas



Oil

Properties

- C₁-C₅ Gas Chromatography
- C₆+
- H₂
- NH₃
- SO₂
- H₂S
- Gas make
- Fixed Gases N₂ & O₂
- Refinery Gas Analysis
- Molecular Weight
- Calorific Value
- Humidity
- Heat Capacity
- Trace Sulphur in Gas



Streams and Properties



Raw shale



Dry shale



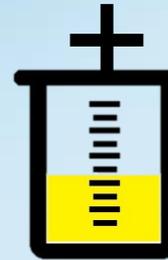
Spent shale



Free Moisture



PH Vent



Sour Water



Off Gas



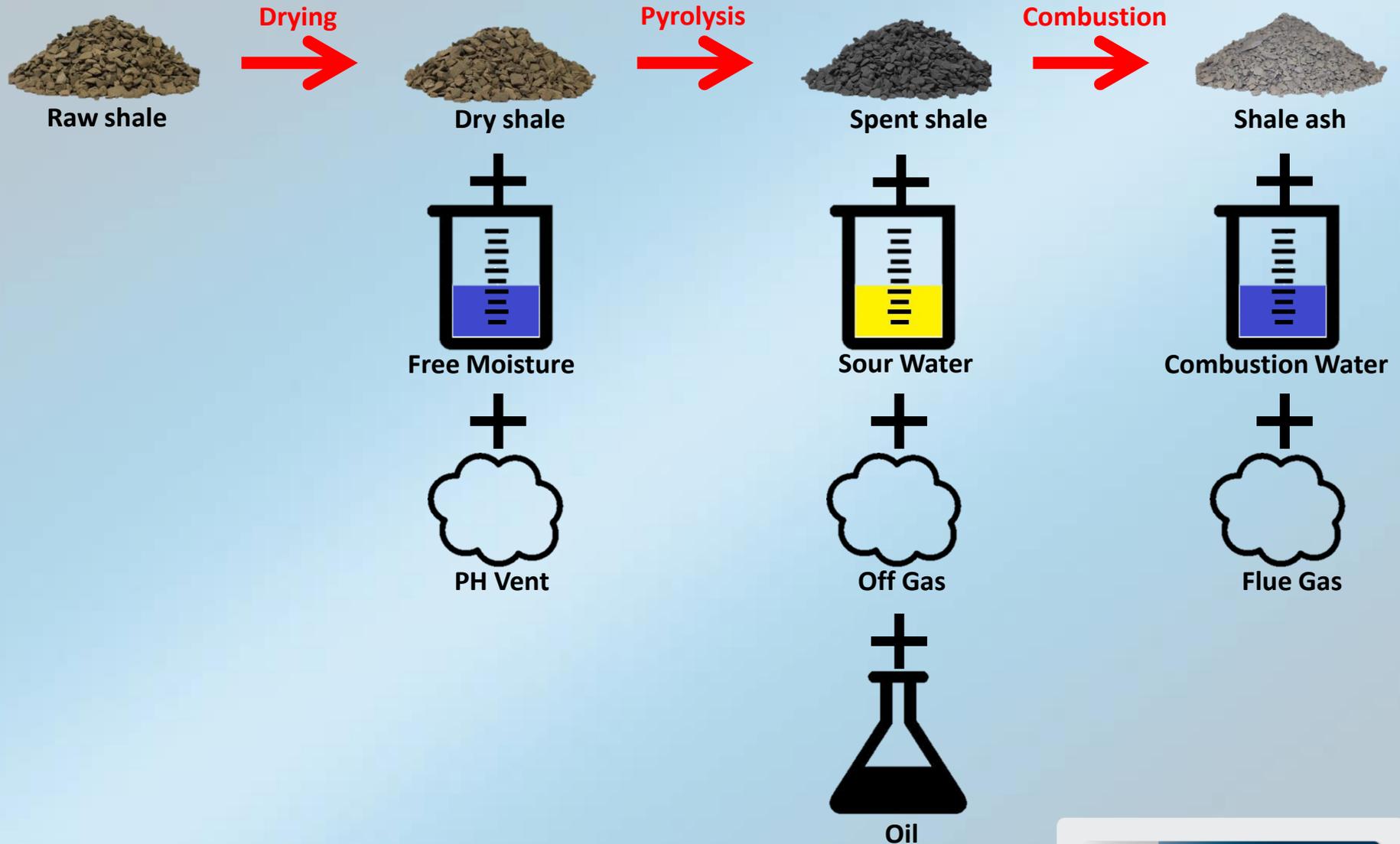
Oil

Properties

- D86 Distillation
- Vacuum Distillation
- Bottoms Solids and Water
- Large Spinning Band Distillation
- Density of Petroleum Liquids
- SimDist 50-735°C and Residue
- Reid Vapour Pressure
- Flash Point
- Pour Point
- Calorific Value
- Carbon, Hydrogen, Nitrogen
- Total Sulphur
- Ash Content
- Metals in Oil
- Inorganic Salt
- Viscosity
- Total Acid Number
- Sulphur Compound Distribution
- Nitrogen Compound Distribution
- Bromine Number
- Total Naphthenic Acids (SPE-IR)
- Micro Carbon Residue (MCRT)
- Cetane Number
- PIONA Analysis, IBP-204°C
- SARA
- Organic Chlorine
- Upgrading studies



Streams and Properties



Impact of Properties on Design



Physical Properties

- Static angle of repose
- Dynamic angle of repose
- Loose bulk density
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- Heat capacity
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Chemical Properties

- Soluble oil
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- C, H, N, O, S
- Calorific value
- Fixed Carbon
- Sulfur forms

Design Implication

- Dynamics of solid bed transport
- Flow through Retort
- Solids elutriation / heat transfer
- Energy balance/ Heat transfer properties
- Resource evaluation / solids elutriation
- PH Zone exit temperature / PH HC handling system
- Design of PH zone / Thermal load variation
- Resource evaluation / Mass balance / ROI
- Gas compression / Light ends recovery / Fuel gas system
- CO₂ emissions
- Burner chemistry / Mineral balance
- Elemental balance
- Heat balance
- Coke formation
- Emissions / Upgrading



Impact of Properties on Design



Properties

- Atm / Vacuum Distillations
- Bottoms solids and water
- SimDist 50-735°C and Residue
- Density
- Viscosity
- Reid Vapour Pressure
- Flash Point
- Pour Point
- Cetane Number
- Octane Number
- Calorific Value
- Ash Content
- Metals in oil
- Inorganic Salt
- Total Acid Number
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- Nitrogen Distribution
- Total Sulphur
- Organic Chlorine
- Micro Carbon Residue
- Bromine Number
- PIONA Analysis IBP-204°C
- SARA

Design Implication

- Boiling point distribution / Oil recovery plant design
- Design of separation equipment
- Bottoms oil recycle system
- Fluid dynamics
- Properties of final upgraded products
- Energy balance
- Impurities in oil
- Oil recovery plant metallurgy
- Heteroatom removal during upgrading
- Coking tendency of oil
- Saturation H₂ demand
- Upgrading



Choose the Right Partners



UMATAC has worldwide experience in testing oil shale

UMATAC Industrial Processes

A company of ThyssenKrupp Industrial Solutions

ThyssenKrupp Industrial Solutions



ThyssenKrupp

UMATAC R&D Centre in Calgary

UMATAC R&D Centre available for testing of clients' oil shales

UMATAC Industrial Processes
A Company of Polysius
Oil Shales / Oil Sands Research Centre



UMATAC Industrial Processes

A company of ThyssenKrupp Industrial Solutions

ThyssenKrupp Industrial Solutions



ThyssenKrupp

TKRS Minerals and Upgrading R&D Facilities in Germany



UMATAC Industrial Processes

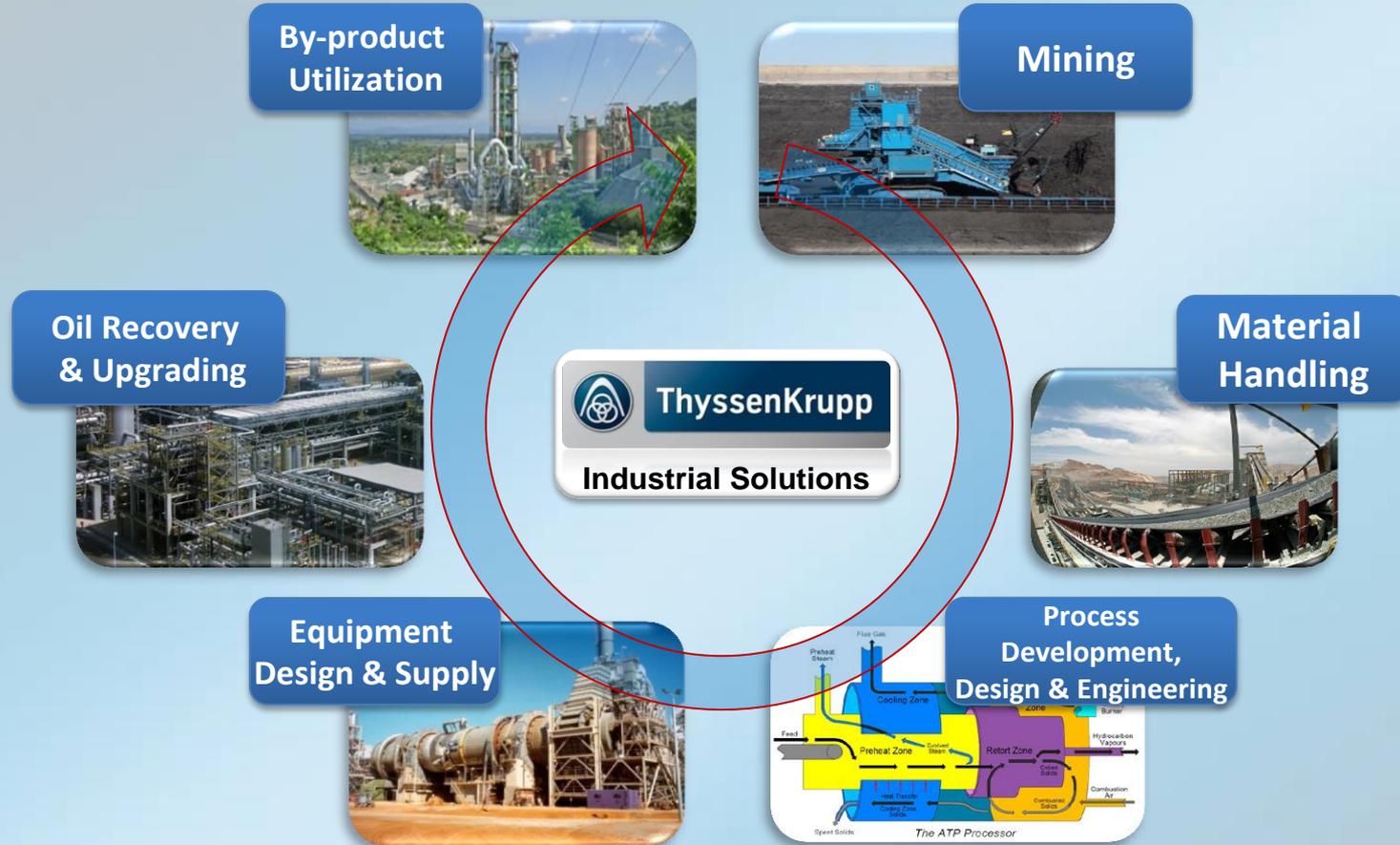
A company of ThyssenKrupp Industrial Solutions

ThyssenKrupp Industrial Solutions



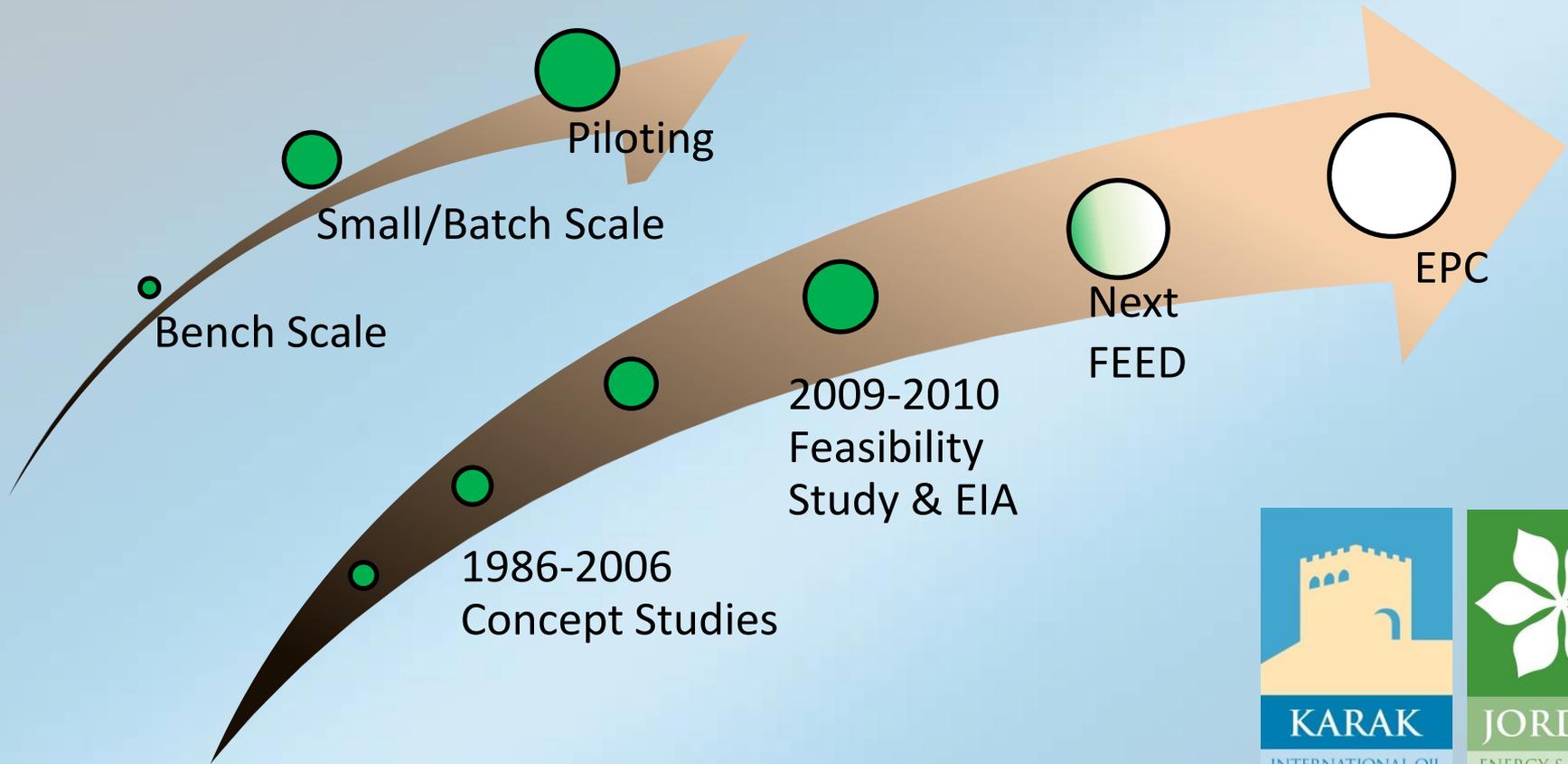
ThyssenKrupp

ThyssenKrupp Industrial Solutions



TKIS offers complete & integrated solutions for oil shale industry

Tailor your Design to the Ore



KIO project ATP – Specifically designed for the Al Lajjun shale



Some Project Specific Examples

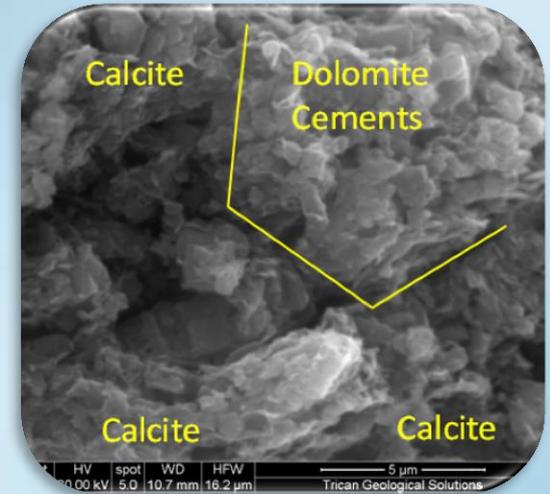


KIO project – Meeting the needs of Jordan

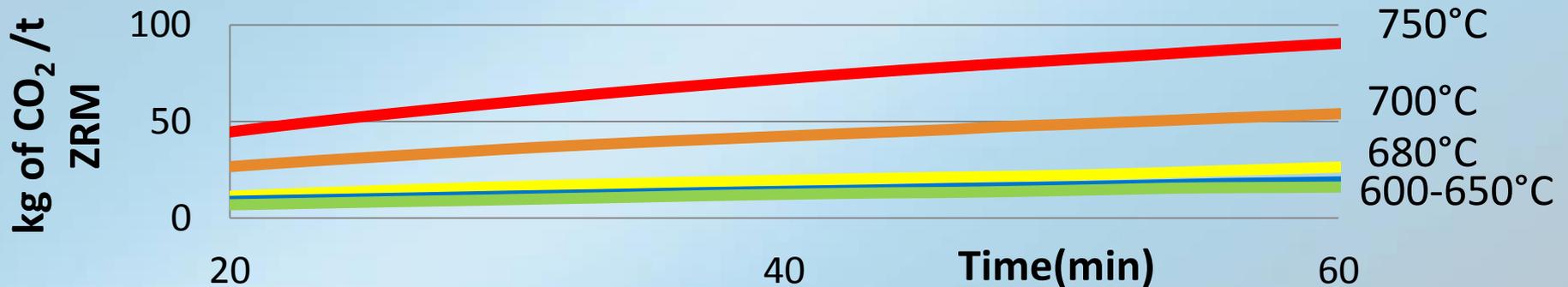


High Carbonate Content

- 32 – 57 wt% - Mainly Calcite and Dolomite
- Decomposes at temperatures $>250^{\circ}\text{C}$
- Study on CO_2 sequestration by CaO on ash
- Study done to reduce CO_2 formation from Carbonates by temperature adjustment



CO_2 from Thermal Decomposition of Carbonates



Potential for CO_2 emissions reduction

Low free moisture & Local Water Availability Issues

- ATP Processor preheat zone sized for Al Lajjun ore water content
- PH system equipment sized accordingly
- Water from ore is recovered and re-utilized
- Minimized water usage
- Air-cooled heat exchangers + Central cooling
- Looked for means to maximize water treatment and re-use / recycling
- Studies on waterless dust suppression



Ash handling water target: 100% recycled water

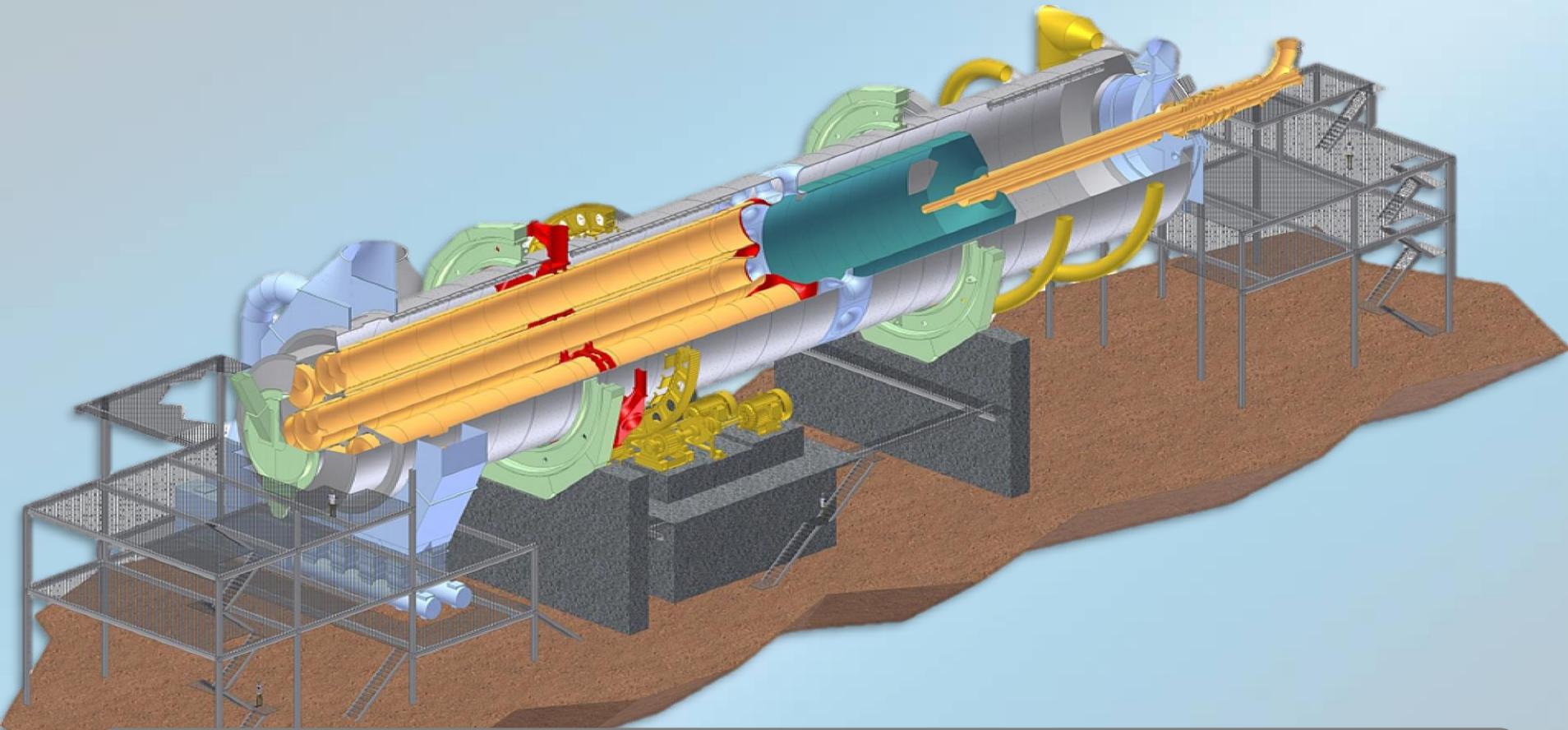
High Sulphur Content

- Organic/Inorganic: $S_{(s)}$, $SO_{2(g)}$, Sulfites_(aq), Sulfates_(aq), and $H_2S_{(g)}$
- Selected metallurgy for oil recovery plant and flue gas system
- Studied Sulphur (and Ammonia) salts build-up in gas compression system
- Wet scrubbing for Sulphur oxides in flue gas
- Oil upgrading H_2 uptake



ATP designed to handle high sulphur

Choose Technology with Built-in Flexibility



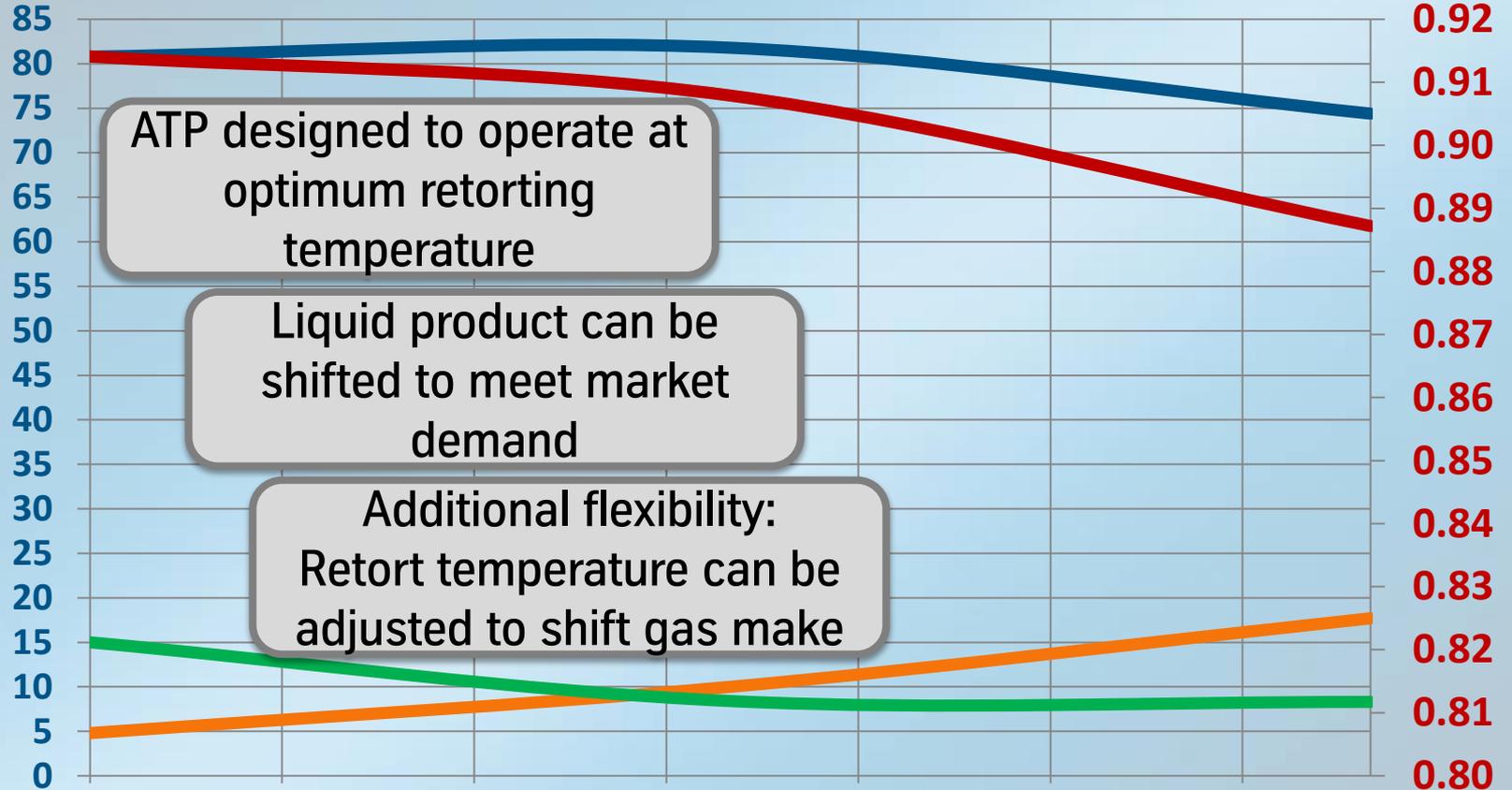
ATP Processor can handle wide variations in ore grade, moisture content, and process conditions

Example: Retort Temperature

% of Recov'd
HC Product

Gas Coke Liquid HC S.G.

Product
Oil S.G.



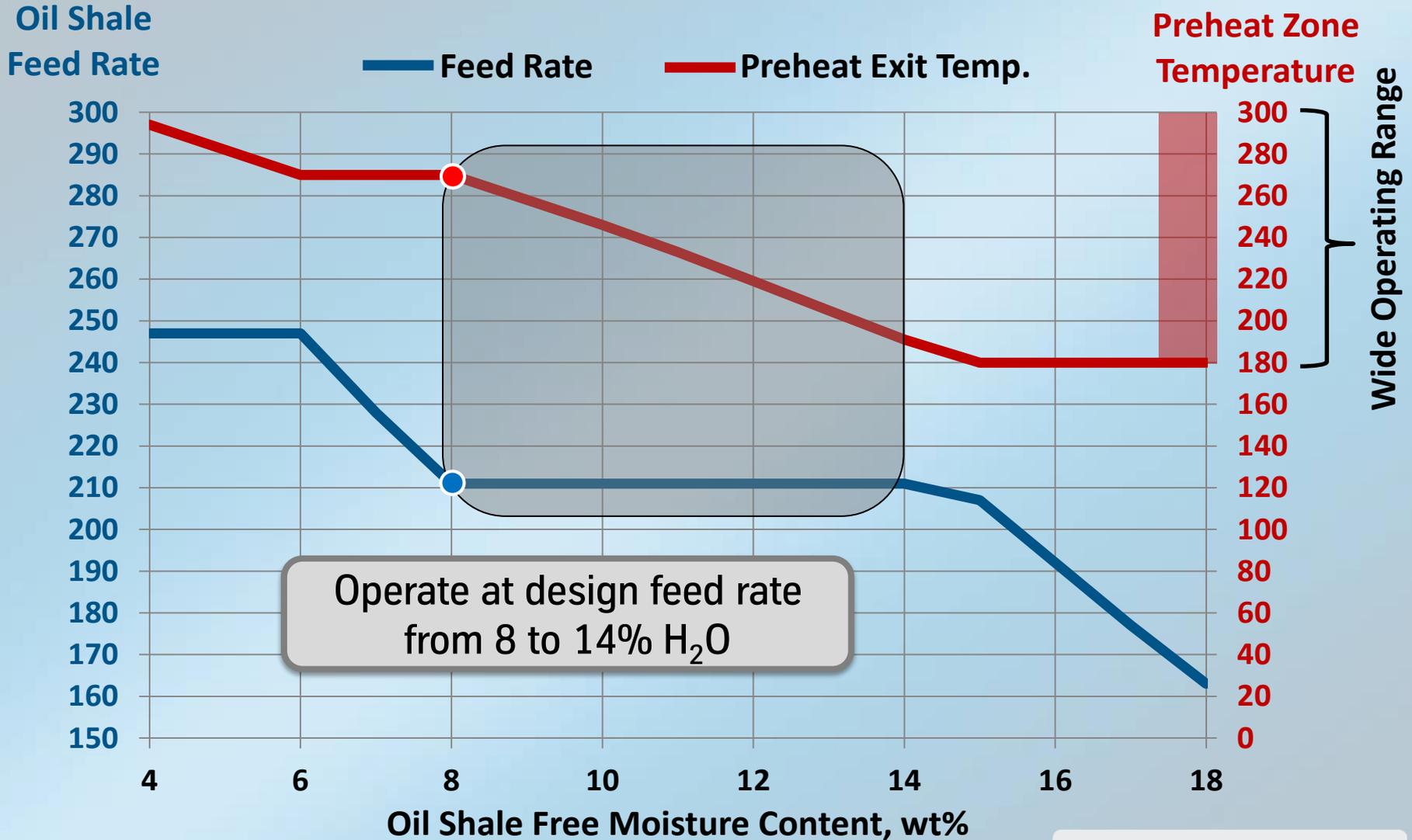
ATP designed to operate at optimum retorting temperature

Liquid product can be shifted to meet market demand

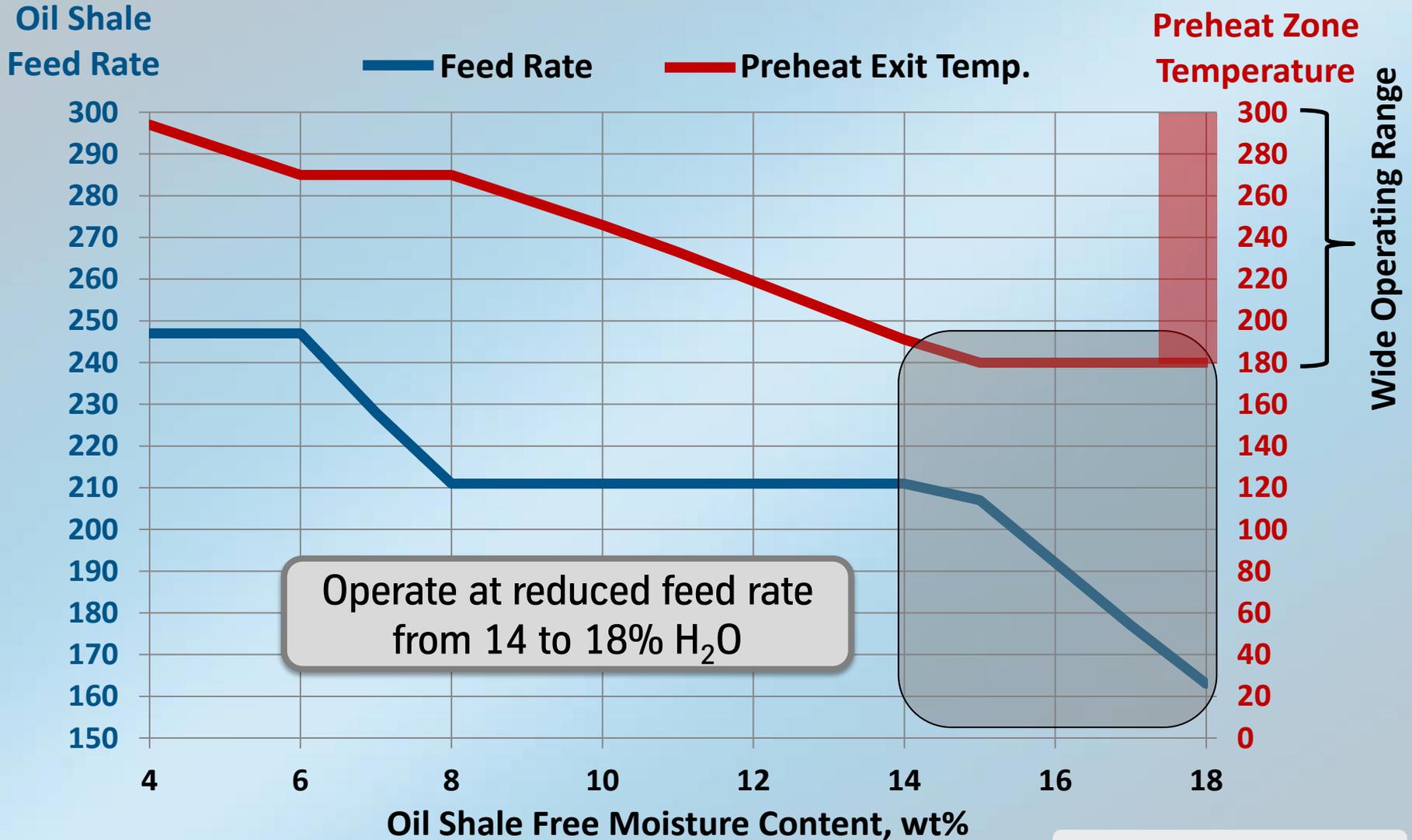
Additional flexibility: Retort temperature can be adjusted to shift gas make

Retort Temperature

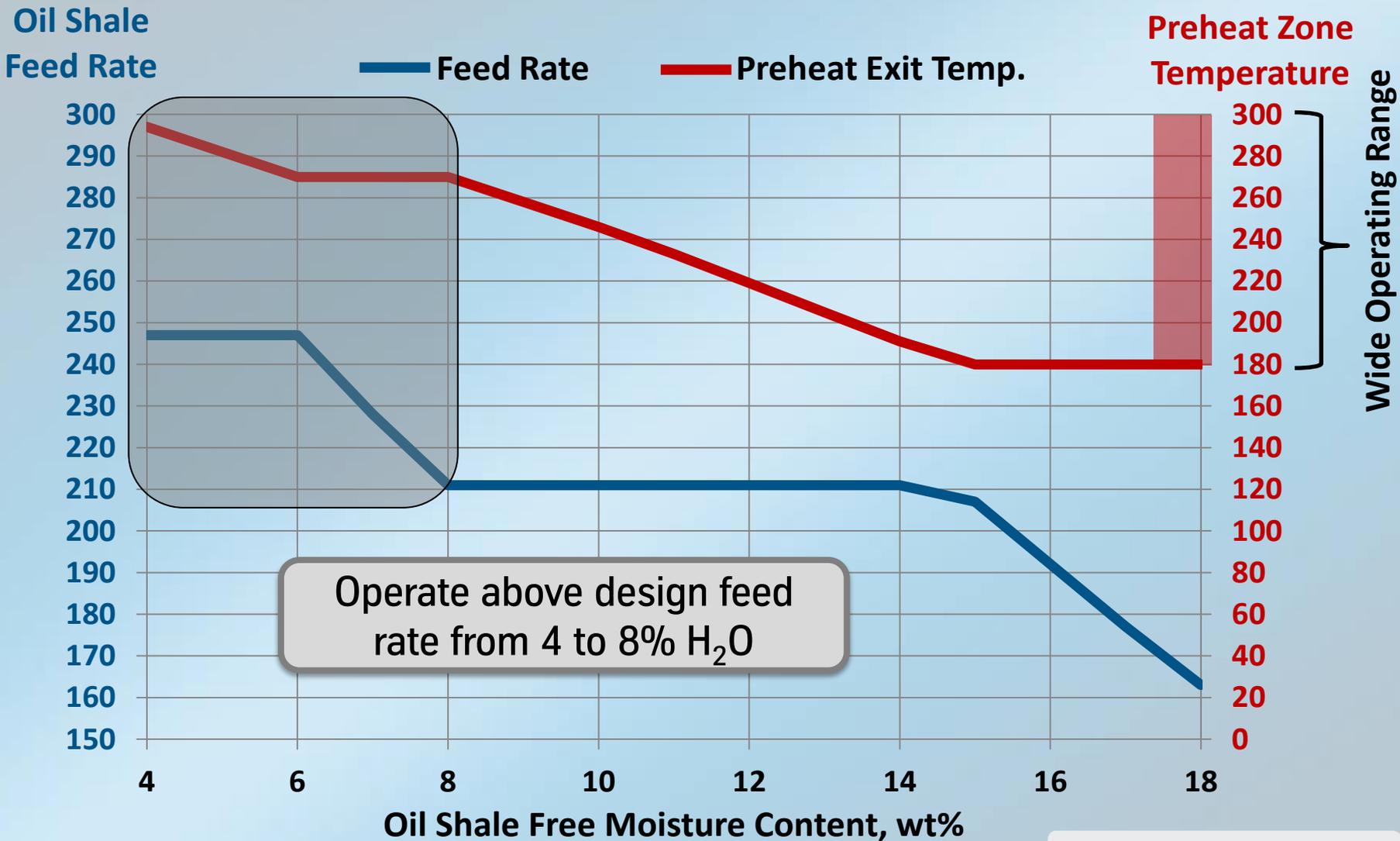
Example: Feed Moisture



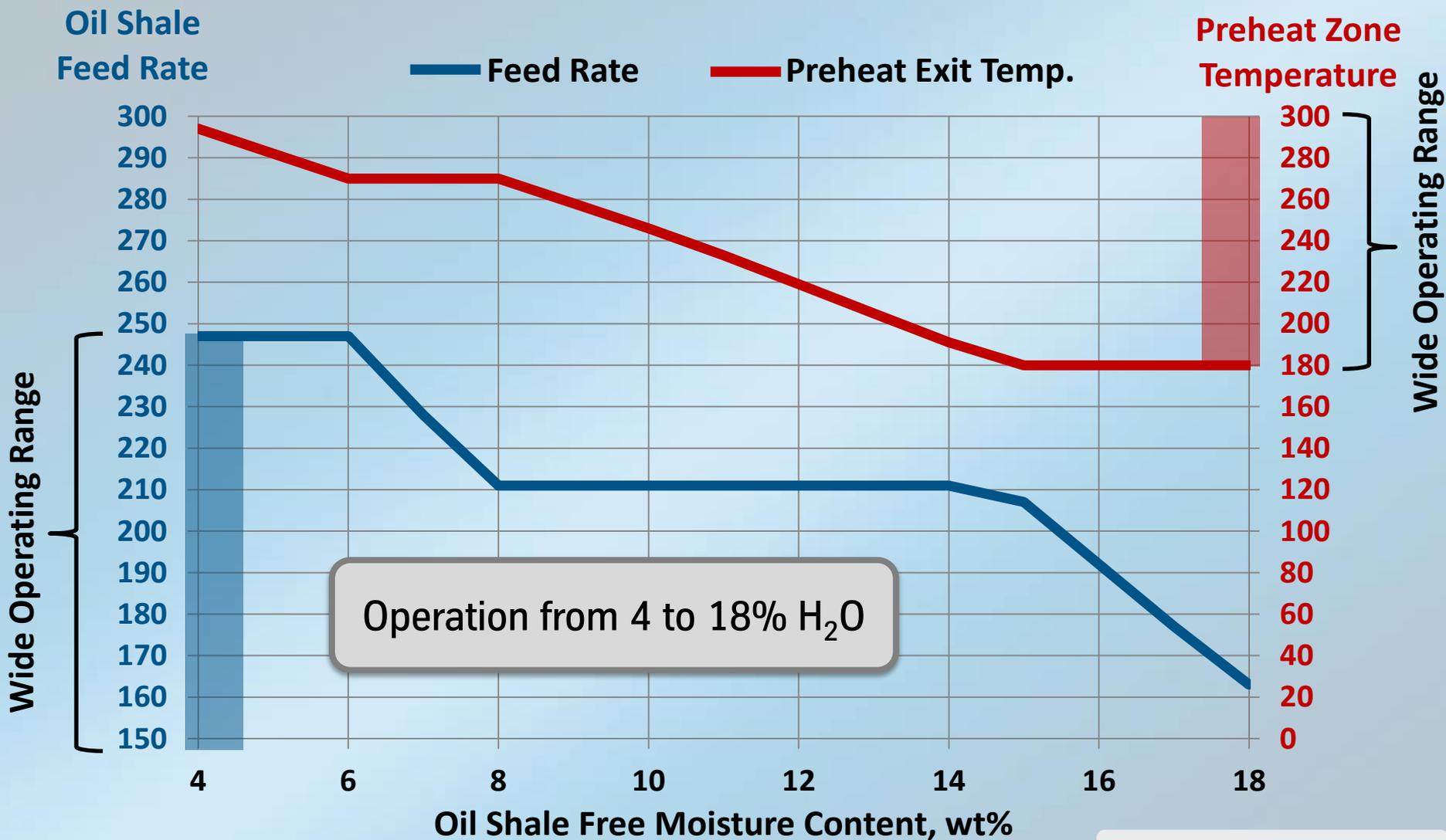
Example: Feed Moisture



Example: Feed Moisture



Example: Feed Moisture



Concluding Remarks

Know your ore

- Ore impacts the whole project
- Comprehensive (staged) analytical campaign required for shale ore and products



Choose the right partners

- UMATAC has extensive expertise
- ThyssenKrupp Industrial Solutions capable of complete project delivery



Design for specific ore BUT choose a technology with build-in flexibility

- ATP Systems are designed for specific oil shale, but are fully capable of handling a range of grade and moisture contents, and process conditions.



Questions?



谢谢 Thank You شكرا
Kiitos Vielen Dank Merci
Aitäh Obrigado Спасибо



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Definitions / Legend

OFM	Zero Free Moisture Basis
Arb	As Received Basis
ATP	Alberta Taciuk Process
bbbl	Barrel of Oil (~159 Litres)
°C	Degrees Celsius
FEED	Front-End Engineering Design
HC	Hydrocarbons
LTOM	Litres of Oil Per Tonne Of Zero Moisture Ore
PH	Preheat
t/h	Metric Tonnes per Hour
Temp.	Temperature
TKIS	ThyssenKrupp Industrial Solutions
TKRT	ThyssenKrupp Resources Technologies
wt%	Weight Percent
ZRM	Zero Moisture

