INTRODUCTION

Disclaimer, important notes and assumptions

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OVERVIEW

We are Woodside

• We are a global energy company, proudly Australian with a spirit of innovation and determination.
• We provide energy that the world needs to heat homes, keep lights on and support industry.
• We aim to thrive through the global energy transition with a low-cost, lower-carbon, profitable, resilient and diversified portfolio.

1. Targeted investment in new energy products and lower-carbon services by 2030. Individual investment decisions are subject to Woodside’s investment hurdles. Not guidance.
LONDON, August 20, 2019—"Schlumberger announced today an enterprise-wide deployment of the DELFI* cognitive E&P environment through a seven-year technology collaboration with Woodside Energy. Woodside will leverage this secure cloud-based software environment to increase consistency, reduce study cycle time and foster innovation in its subsurface characterization and development activities.”
NEST

New Energy Screening Tool
The objective

End-to-end right sizing
Of all components

Optimise
all components

Sensitivities
across all items

How do you plan, cost and design these $B systems?

What-if?
(scaling, concepts, cost evolution)
NEW ENERGY SCREENING TOOL

What are our system constraints?

- Customer location
- Delivery / electrolyser location for shipping
- Area of interest for wind
- Existing electricity network
- Land utilisation / availability in the Area of Interest
NEW ENERGY SCREENING TOOL

What data do we need to work with?

Wind data
- Needs to be enriched
- Interpolated
- Annualised
- Want high potential annual average wind speeds

From very high resolution spatial data

Streamed in data
- Wind models
  - MERRA (NASA)

Enrich the data

High resolution temporal data

ERRA5 (EU / ESA)

Find local wind power maxima

1000s of local maxima

High spatial resolution (low temporal) wind data
NEW ENERGY SCREENING TOOL

The solution: Optimise for power, time and distance from infrastructure

Optimise to:
- Maximise annualised wind power
- Minimise distance to nearest transmission line
- Minimise annualised grid power cost
- Minimise transport losses

Spatial Raster Ranking

Distance to nearest Transmission Line

Distance to Perth

Wind Variability
The solution: Optimise entire system for Levelized Cost Of Electricity (LCOE)

Optimise to find best performance of integrated electrolyser + grid + battery + wind farm sites

2020 Hourly Cost of Electricity

Optimise Power Mix / Storage
NEW ENERGY SCREENING TOOL

**Results – location and cost of supply**

### GENERATION

- **Wind Sites**: 1
- **Capacity**: 1.1 GW
- **Grid Usage**: 6%
- **Annual Generation**: 3.9 TWh

### ELECTROLYSER

- **LCOE**: $31.6/MWh
- **LCOH**: $2.47/kg
- **Capacity**: 630 MW

### DELIVERED

- **LCOH**: $3.7/kg
- **LCOA**: $644.2/ton

‘simulation and optimisation’ workflow

Example only – not indicative price/cost information
REAL CASES

Allowing the system to search for the lowest cost configuration
**NEW ENERGY SCREENING TOOL**

**Medium Ammonia / Year (30X)**

### GENERATION
- **Wind Sites**
  - Capacity: 250 MW
- **Grid Usage**: 4%
- **Annual Generation**: 1.1 TWh

### ELECTROLYSER
- **LCOE**: $28/MWh +50% $42
- **LCOH**: $1.95/kg
- **Capacity**: 137 MW

### DELIVERED
- **Japan / South Korea**
  - **LCOA**: $682/ton
  - **LCOH**: $3.9/kg

- **Economies of scale**
- **LCOE drops (-12.5%)**
- **Delivered costs falling (-19.5%)**

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**Electrolyser location**

- Storage (H2)
- Battery (electricity)
- Grid
- Wind farm

**Synthesis (H2->Ammonia)**

**Electrolysis (elec->H2)**

**Transmission by ship (Ammonia)**

**Customer**

- Demand (Ammonia)

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4% interest & wind @ 1.7% annual opex
NEW ENERGY SCREENING TOOL

Large Ammonia / Year (10X) – 1GW grid capacity constraint

- Transmission grid capacity limits scale up
- Forced to use battery storage to meet demand
- Huge spike in costs

**Optimiser added a battery to try and meet demand but it still ends up with some unmet demand**

### GENERATION
- Wind Sites: 2
- Capacity: 1.1 GW + 530 MW
- Battery size: 1 GW
- Annual Generation: 7 TWh

### ELECTROLYSER
- LCOE: $34/MWh + 50% S$3
- LCOH: $29.9/kg
- Capacity: 710 MW

### DELIVERED
- Japan / South Korea
- LCOH: $25.4/kg
- LCOA: $4440/ton

**Indicative Price/Cost Information**

*Example only – not indicative Price/Cost information*
NEW ENERGY SCREENING TOOL

Very large Ammonia Year – Pipeline cases

**GENERATION**
- Wind Sites: 2
- Capacity: 6 GW + 673 MW
- Annual Generation: 5.19 TWh

**ELECTROLYSER**
- LCOE: $46.2/MWh
- LCOH: $3.42/kg
- Capacity: 3 Gw

**DELIVERED**
- Japan / South Korea
  - LCOH: $4.5/kg
  - LCOA: $789/ton

Example only. Not indicative price/cost information.
• Small pilot scale projects are expensive.
• Lowest cost of Ammonia is achieved at 100s of kilotons per year.
• Once transmission grid limit is reached, producing ammonia at site and transporting via pipeline becomes preferrable.
How do you plan, cost and design these $Bn systems?

Flexible & powerful solution that can provide rapid insights

Economic sensitivity across the full end-to-end workflow

Extendable to all other main energy use cases (eg Solar)

Automate full analysis and update easily (in minutes)

Apply to any global location
NEW ENERGY SCREENING TOOL

The Team
ADDENDUM

H2Perth
NEW ENERGY SCREENING TOOL
H2Perth: making WA a hydrogen powerhouse

Proposal for a world-scale hydrogen and ammonia production facility

Phased development: First phase focused on lower-carbon, low-cost and early hydrogen: 65 TJ/day natural gas and up to 250 MW electrolysis

Project designed to abate, store and/or offset all emissions associated with the production of hydrogen and ammonia

Later expansion to be driven by additional renewable energy developments

More than hydrogen - provides stable demand to support grid stability as renewables increase

H2Perth schematic. Conceptual only, not to scale.
Thankyou for your attention