



# Overview of Coal Liquefaction

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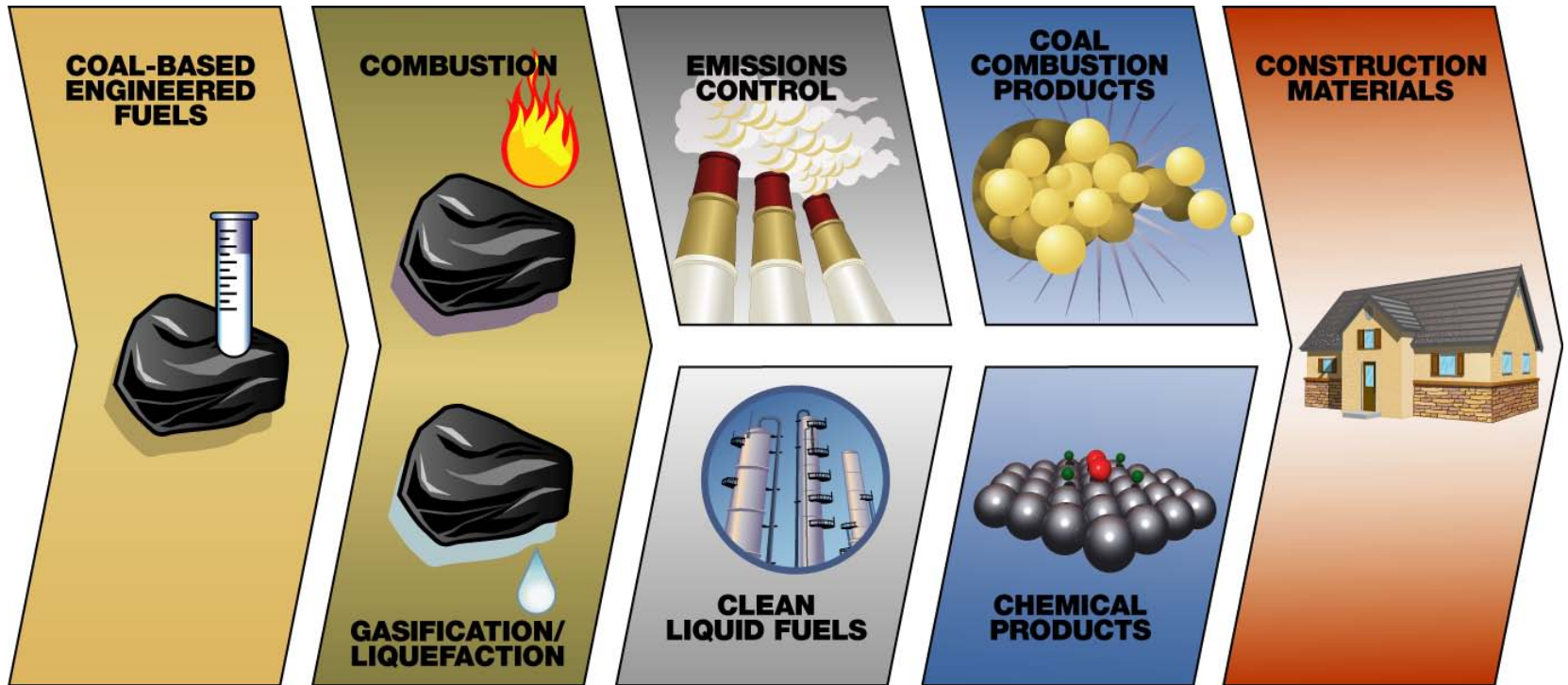
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# Headwaters at a Glance



## Coal Value Chain



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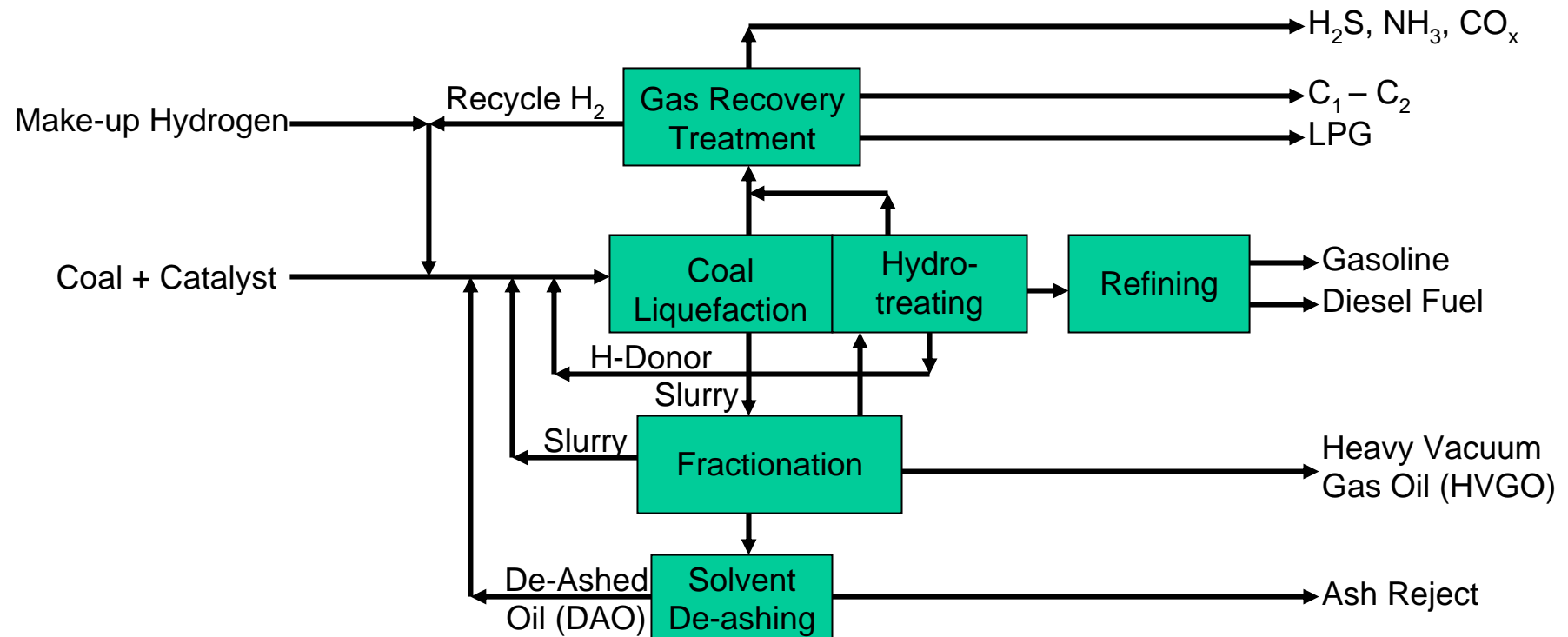
# Coal Liquefaction Technologies

- Direct Coal Liquefaction (DCL)
- Indirect Coal Liquefaction (ICL)
- Hybrid Coal Liquefaction (DCL/ICL)



# Direct Coal Liquefaction Process

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# Direct Coal Liquefaction Plants

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**Lawrenceville, NJ**  
**30 bpd**



**Catlettsburg, KY**  
**1800 bpd**

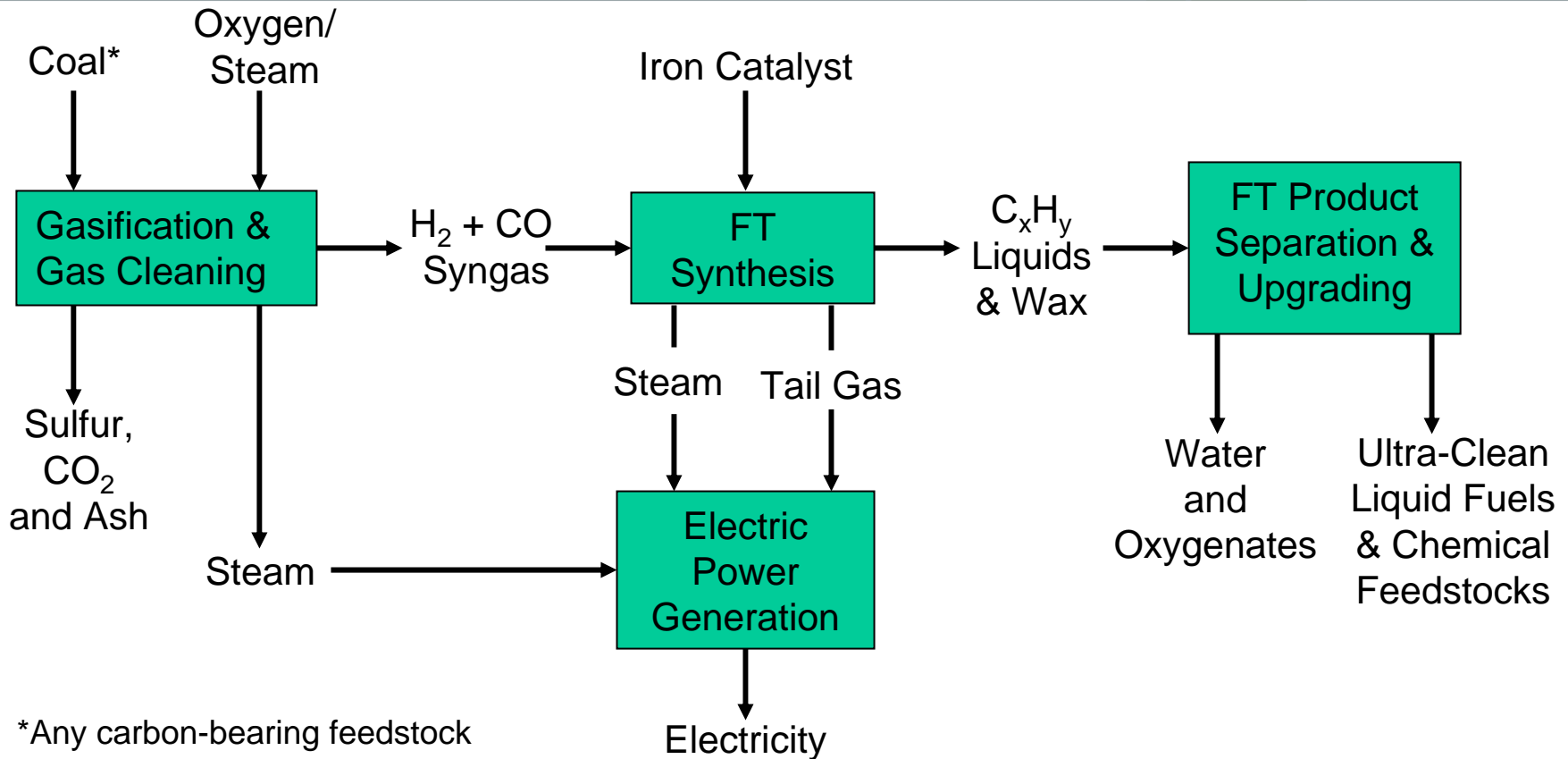


**Inner Mongolia, China**  
**17,000 bpd**

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# Indirect Coal Liquefaction Process



# Indirect Coal Liquefaction Plant



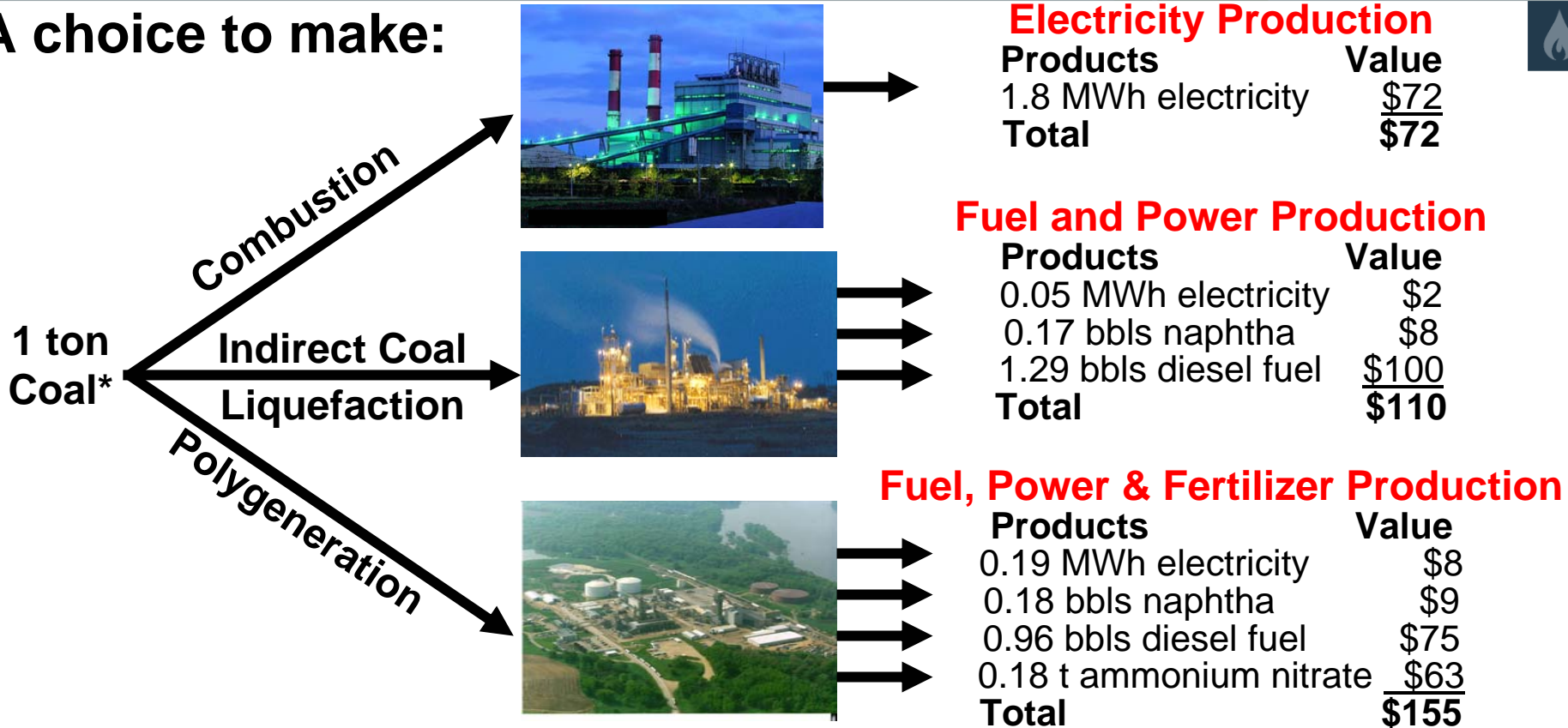
**Brownsville, TX**  
**7,000 bpd**  
**GTL Plant**



**Secunda, South Africa**  
**135,000 bpd**

# Maximizing the Value of Coal

A choice to make:



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\*Sub-bituminous coal as received basis



# Comparison of DCL and ICL Economics

(Based on Sub-bituminous Coal at \$1/mm BTU)

For discussion purposes only.

	<b>Direct</b>	<b>Indirect</b>
Capex for 50,000 bpd plant (\$billion)*	3.3	3.3
Coal required for 50,000 bpd (stpd as rcvd)	23,000	32,000
Coal feedstock cost (\$/bbl)	8	11
Opex excluding coal (\$/bbl)	17	12
Return on investment @ 15% (\$/bbl)**	30	30
Production cost including 15% ROI (\$/bbl)	55	53
Crude oil equivalent (\$/bbl)	41	40

\* U.S. location. \*\*100% equity basis

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# Comparison of DCL and ICL Final Products

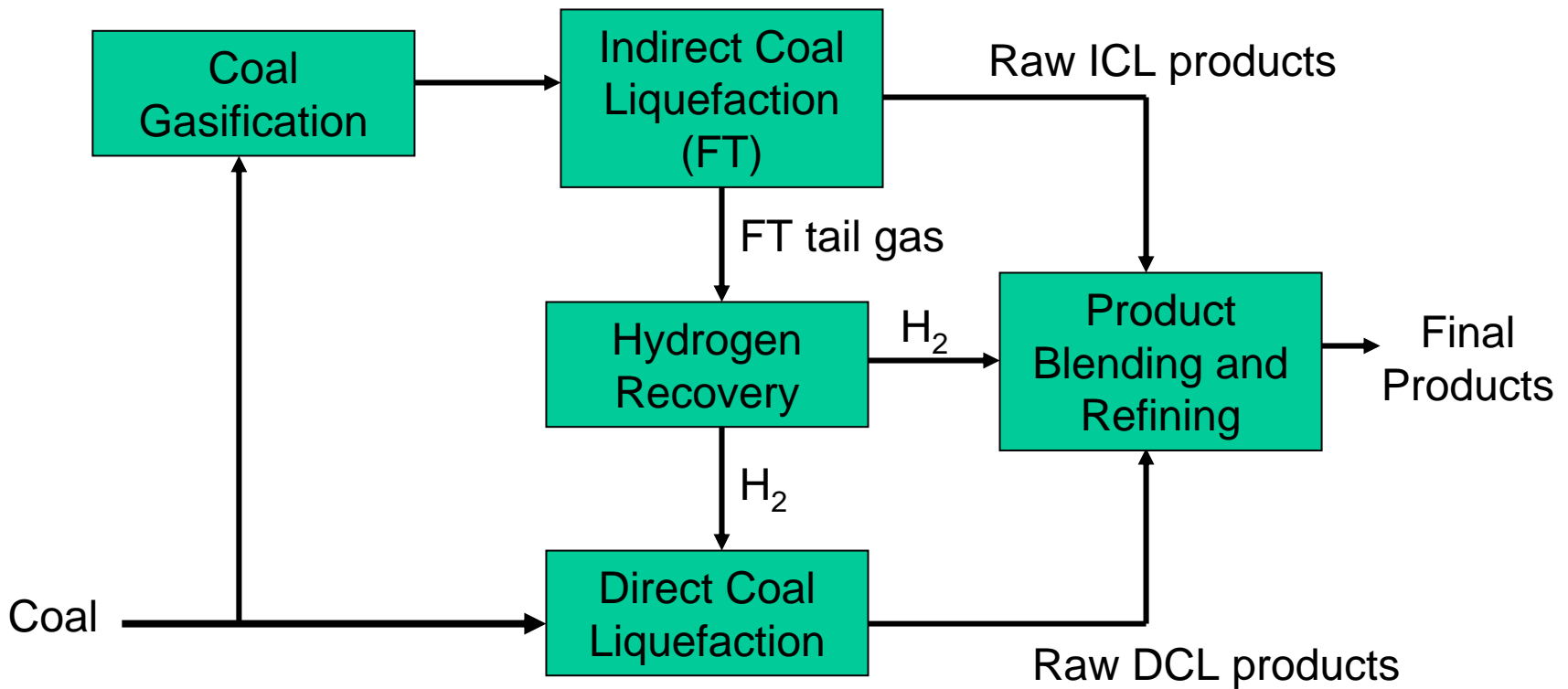
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	<b>Direct</b>	<b>Indirect</b>
Distillable product mix	65% diesel 35% naphtha	80% diesel 20% naphtha
Diesel cetane	42-47	70-75
Diesel sulfur	<5 ppm	<1 ppm
Diesel aromatics	4.8%	<4%
Diesel specific gravity	0.865	0.780
Naphtha octane (RON)	>100	45-75
Naphtha sulfur	<0.5 ppm	Nil
Naphtha aromatics	5%	2%
Naphtha specific gravity	0.764	0.673

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# Hybrid DCL/ICL Plant Concept





# HEADWATERS

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