9. Supplementary material

Table S1: Energy flow data used for constructing the Sankey diagrams. All values are normalized per tonne of diesel produced. Positive values indicate energy demand, while negative values represent recovered electricity returned to upstream units.

Source	**Target**	**Energy type**	**Value (MWh/t)**
Electricity	Direct Air Capture (DAC)	Power	1.13
Electricity	SOEC Energy & Heat Recovery	Power	30.45
Electricity	CO_2 Recovery	Power	0.26
Electricity	F–T Process	Power	0.19
Heat from Fuel	Direct Air Capture (DAC)	Heat	2.27
Heat from Fuel	SOEC Energy & Heat Recovery	Heat	1.25
Heat from Fuel	F–T Process	Heat	0.14
Heat Recovery from By Product	Direct Air Capture (DAC)	Heat	2.27
Heat Recovery from By Product	SOEC Energy & Heat Recovery	Heat	8.64
Heat Recovery	CO_2 Recovery	Heat	0.07
Heat Recovery	F–T Process	Heat	1.89
Direct Air Capture (DAC)	Air Contactor	Power	0.22
Direct Air Capture (DAC)	Liquid Transfer & Absorber Pumps	Power	0.50
Direct Air Capture (DAC)	Miscellaneous Equipment	Power	0.25
Direct Air Capture (DAC)	Air Separation Unit (ASU)	Power	0.52
Direct Air Capture (DAC)	Cooling Water Circulation (DAC)	Power	0.04
Direct Air Capture (DAC)	Rankine Cycle	Heat	2.27
Energy Recovery	Direct Air Capture (DAC)	Power	−0.40

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Source	**Target**	**Energy type**	**Value (MWh/t)**
SOEC Energy & Heat Recovery	Electrolyzer Stack	Power	28.39
SOEC Energy & Heat Recovery	Blowers & Syngas Compressors	Power	2.21
SOEC Energy & Heat Recovery	Cooling & Condensing Equipment	Power	0.13
SOEC Energy & Heat Recovery	Cooling Water Circulation (SOEC)	Power	0.20
SOEC Energy & Heat Recovery	RWGS Heating & Conditioning	Heat	7.30
SOEC Energy & Heat Recovery	Pre-Electrolysis Heating	Heat	2.59
CO_2 Recovery	CO_2 Compression	Power	0.10
CO_2 Recovery	Refrigeration Compressor	Power	0.15
CO_2 Recovery	Cooling Water Circulation (CO_2 Recovery)	Power	0.01
CO_2 Recovery	Syngas Heating	Heat	0.07
F–T Process	Hydrogen Compressor	Power	0.07
F–T Process	Distillation & Separation Equipment	Power	0.01
F–T Process	Product Pumps	Power	0.01
F–T Process	Cooling Water Circulation (F–T)	Power	0.10
F–T Process	F–T Reactor Heating	Heat	0.50
F–T Process	Product Separation & Gas Recycle	Heat	0.47
F–T Process	Hydrotreating & Reboiler Duty	Heat	0.93
F–T Process	Steam Turbine Generator (Energy Recovery)	Heat	0.61
Steam Turbine Generator (Energy Recovery)	Direct Air Capture (DAC)	Power	−0.61

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Source	**Target**	**Energy type**	**Value (MWh/t)**
Steam Turbine Generator (Energy Recovery)	Direct Air Capture (DAC)	Power	0.40
Steam Turbine Generator (Energy Recovery)	SOEC Energy & Heat Recovery	Power	0.47

Table S2: Regional unit prices used for the variable operating cost screening analysis (utilities and raw materials)

Process input	Unit	Japan	Canada	Reference / Basis
Electricity (grid)	USD/kWh	0.18	0.10	[124]
Electricity (renewable)	USD/kWh	0.06	0.04	Solar (JP), hydropower (CA); [125]
Methane (CH_4)	USD/t	1,294	203	[126]
Calcium carbonate ($CaCO_3$)	USD/t	198	299	[130, 131]
Potassium hydroxide (KOH)	USD/t	1,340	925	[132, 133]
Water (industrial)	USD/t	0.2	2.3	[134, 135]

Table S3: Available and recovered heat and temperature ranges used for heat integration (Plant capacity: Diesel 79.8 t/h)

Source (Hot Stream)	**Target (Cold Stream)**	**Heat (MW)**	**Temperature Range (°C)**
Direct Air Capture (DAC)			
Slaker output	Steam Rankine cycle evaporator	50.2	300–85 / 50.6–243.9
Slaker reactor	Steam Rankine cycle evaporator	106.3	300 / 243.9–263.7
Calciner output	Steam Rankine cycle evaporator	24.3	445–325 / 263.7–415.0
Subtotal DAC		*180.8*	

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Source (Hot Stream)	Target (Cold Stream)	Heat (MW)	Temperature Range (°C)
Solid Oxide Electrolysis Cell (SOEC)			
Burner outlet	Synthesis reactor output	34.2	809–642 / 230–375
2nd RWGSR	Water into 1st RWGSR	237.5	800–343 / 30–600
Burner outlet	Heated synthesis reactor + water	207.0	483–800 / 175.6–810
O_2 from SOEC	Compressed air	3.3	800–780 / 109–772
Burner outlet	Compressed air	0.15	809–642 / 772–800
1st RWGSR	SOEC inlet	206.7	800 / 483–800
Subtotal SOEC		*688.9*	
CO_2 Recovery Unit			
Compressed SOEC product	Absorber output to FT process	5.83	43–27 / 1–21
Subtotal CO_2 Recovery		*5.83*	
Fischer–Tropsch (FT) Unit			
Hydrotreater outlet	Bottom product of separator 2	11.25	320–273 / 45–250
Hydrotreater outlet	Recycle stream from FT	5.30	280–320 / 220–113
FT reactor outlet	FT reactor inlet	7.69	230–195 / 157–182
FT reactor outlet	Bottom product of separator 1	6.06	195–194 / 43–180
FT reactor outlet	Top product of separator 1	7.92	194–192 / 43–175
Burner 1 outlet	Hydroprocessing inlet	9.13	1554–320 / 275–320
Burner 2 outlet	Reboiler duty	64.78	1562–435 / 422

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Source (Hot Stream)	**Target (Cold Stream)**	**Heat (MW)**	**Temperature Range (°C)**
Diesel output	WGS reactor	2.49	292–262 / 210–250
WGS outlet	WGS inlet	2.15	250–225 / 175–210
FT reactor	FT reactor inlet	17.17	230 / 28–157
FT reactor	FT reactor inlet	0.83	230 / 157–182
FT reactor	PSA unit	0.38	230 / 45
FT reactor	Distillation column inlet	2.01	230 / 180–220
WGS reactor	FT reactor inlet	13.8	250 / 182–230
Subtotal FT Unit		*151.0*	

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