Supporting Information

Optimal Design of Sustainable Power-to-Fuels Supply Chains for Seasonal Energy Storage

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1. Modeling Parameters

Parameter $\rho_{i,j}$

Process	Resource	Yield (kW/kW or kg/kW)
PV	Solar production	-1
PV	Power	1
WT	Wind production	-1
WT	Power	1
EL	Water	-4.48263608e-5
EL	H_2	5.12612885e-6
EL	O_2	4.12998750e-5
EL	Power	-1
AS (Distillation)	Air	-1.21682195e-3
AS (Distillation)	N_2	9.06520023e-4
AS (Distillation)	O_2	2.94648710e-4
AS (Distillation)	Power	-1
AS (PSA)	Air	-3.80407220e-3
AS (PSA)	N_2	8.99459261e-4
AS (PSA)	Power	-1
AS (Membrane)	Air	-2.49476770e-3
AS (Membrane)	N_2	6.59397172e-4
AS (Membrane)	Power	-1
DM	H_2	-3.29085182e-3
DM	CO_2	-2.41201209e-2
DM	DME	1.26069367e-2
DM	Power	-1
CH	H_2	-1.26639437e-3
CH	CO_2	-6.96619528e-3
CH	CH_4	2.74830155e-3
CH	Power	1
ME	H_2	-2.68866125e-4
ME	CO_2	-1.97126317e-3
ME	MeOH	1.43374179e-3
ME	Power	-1
NH	H_2	-7.90036943e-5
NH	N_2	-8.52418111e-4
NH	NH_3	3.19096482e-4
NH	Power	-1
GT	Power	1
GT	CH_4	-3.0644e-5

Maximum process capacity $C_i^{\max}$

Process	$C_i^{\max}$ **(kW)**
PV	5% of total area of the sub-region
WT	5% of total area of the sub-region
EL	495110.46
ASU (distillation)	25250.41
ASU (PSA)	5541.84
ASU (Membrane)	4813.67
DM	625.37
CH	1461.63
ME	487.21
NH	32125.08
GT	200000.00

Maximum storage capacity $\bar{C}_j^{\max}$

Resource	$\bar{C}_j^{\max}$ **(kg)**
N_2	50000
H_2	50000
DME	5e6
CH_4	5e6
MeOH	5e6
NH_3	5e6

Transportation cost Γ_{jd}

Mode of transportation	Γ_{jd} **($/km t)**
Truck (liquids)	0.034
Truck (gases)	0.035
Train	0.025
CH_4 pipeline	0.021

Process capital cost δ_i, γ_i

Resource	δ_i (MM$)	γ_i (MM$/kW)
PV	0.01	1.69650602e-4
WT	0.01	5.33333333e-4
EL	18.61182898	0.00208263
ASU (distillation)	1.26183952e1	4.56887900e-3
ASU (PSA)	3.00697981e-1	6.06296004e-3
ASU (Membrane)	1.89366268e-1	8.33085712e-3
DM	2.09620435e1	7.03176498e-1
CH	3.06292520e-1	2.22428080e-2
ME	5.61429083	5.61666595e-3
NH	1.14249824e1	9.25374128e-3
GT	0	0.882e-3

Storage capital cost α_j, β_j

Resource	α_j (MM$)	β_j (MM$/kg)
N_2	0.079	9.036e-5
H_2	0.079	0.00125695
DME	0.079	1.6866e-7
CH_4	0.079	0.000172256
MeOH	0.079	1.427e-7
NH_3	0.079	1.856e-7

Piece-wise linear approximation $\widehat{P}_{iml}$, $\widehat{J}_{iml}$

Resource	$\widehat{P}_{iml}$ (kW)	$\widehat{J}_{iml}$ (MM$/year)
PV	0	0
PV	5e6	0
WT	0	0
WT	5e6	0
EL	0	0.320
EL	16503.68	-0.177
EL	990220.91	-25.321
ASU (distillation)	0	0.374
ASU (distillation)	1010.02	0.236
ASU (distillation)	4040.07	-0.187
ASU (distillation)	60600.98	-10.433
ASU (PSA)	0	0.218
ASU (PSA)	46.18	0.235
ASU (PSA)	277.09	0.328
ASU (PSA)	738.91	0.403
ASU (PSA)	2124.37	0.510
ASU (PSA)	11083.68	0.761
ASU (Membrane)	0	0.161
ASU (Membrane)	17.19	0.174
ASU (Membrane)	103.15	0.246
ASU (Membrane)	343.83	0.318
ASU (Membrane)	1375.33	0.431
ASU (Membrane)	8595.84	0.665
DM	0	0.395
DM	15.63	1.298
DM	1876.11	119.926
CH	0	0.236
CH	48.72	0.284
CH	194.88	0.390
CH	487.21	0.488
CH	3897.68	0.917
ME	0	1.577
ME	474.21	2.190
ME	33194.96	32.229
NH	0	0.163
NH	53.54	0.179
NH	1070.84	0.329
NH	5354.18	0.410
NH	10708.36	0.410
NH	85666.88	-0.567
GT	0	0
GT	200000	2.6

2. Validation of the Heuristic Decomposition: Case of Study Information

Raw materials availability

Location	H_2O (kg/s)	CO_2 (kg/s)
1	2.00	4.57
2	2.00	0.00
3	2.00	2.45

Power demand (only one month with a constant power demand)

Location	Power demand (kW)
1	412.9
2	381.3
3	307.8

Transportation alternatives

For truck

Location/Location	1	2	3
1	0	1	0
2	1	0	1
3	0	1	0

For train

Location/Location	1	2	3
1	0	0	0
2	0	0	0
3	0	0	0

For pipeline

Location/Location	1	2	3
1	0	0	0
2	0	0	0
3	0	0	0

Distances (km)

Location/Location	1	2	3
1	0	23.1	25.9
2	23.1	0	12.0
3	25.9	12.0	0