

Life Cycle Results from the NGCC LCI&C Study

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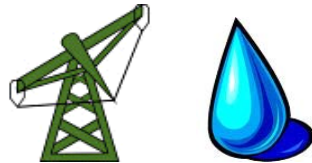
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Conceptual Study Boundary

Natural Gas Combined Cycle (NGCC)

Economic & Environmental Boundary



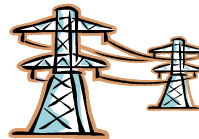
Natural Gas Acquisition



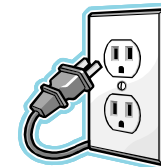
Natural Gas Transport



NGCC Facility



Electricity Grid



End User



CO₂ Pipeline

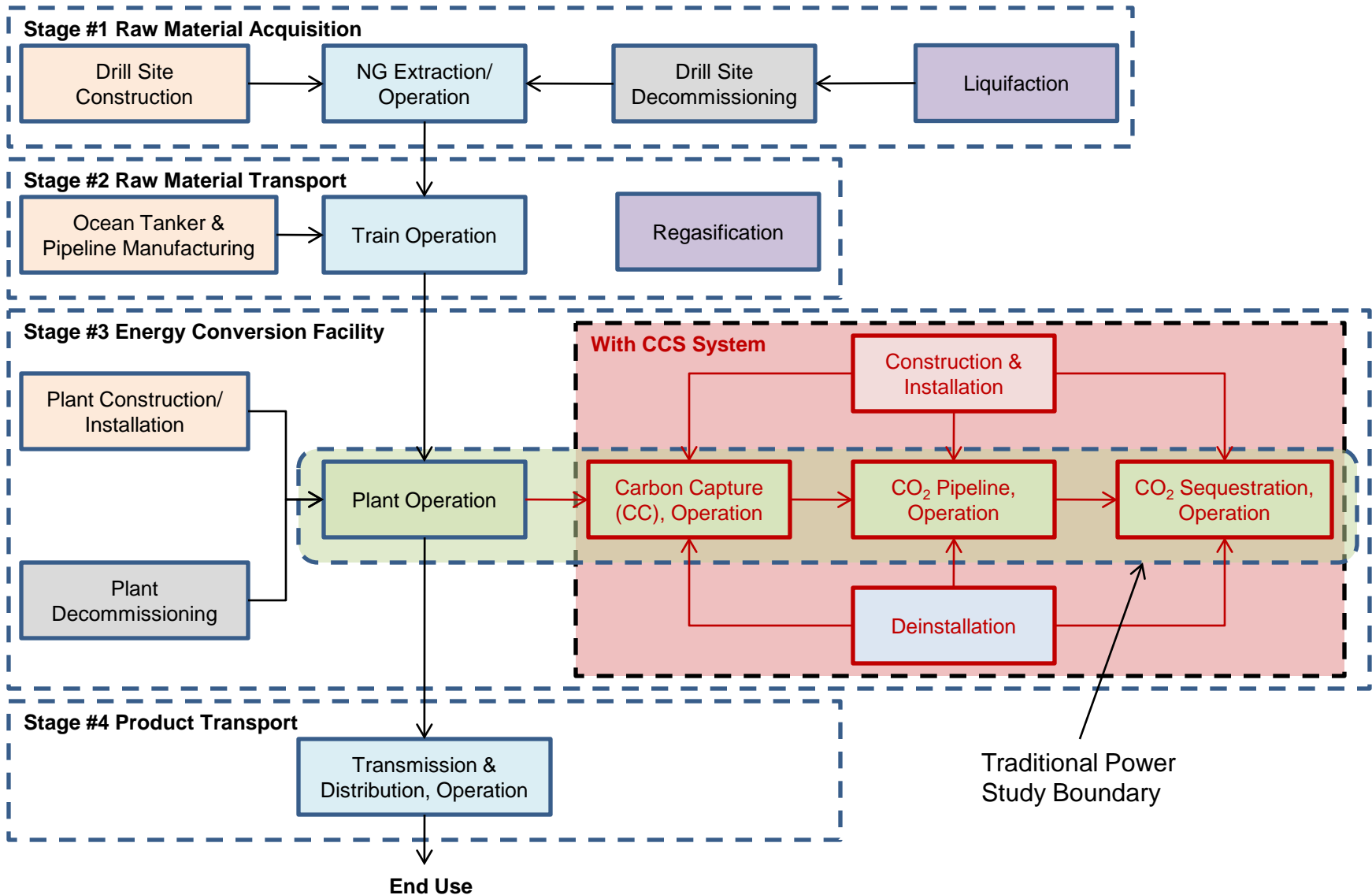


Geologic
Saline
Sequestration

KEY

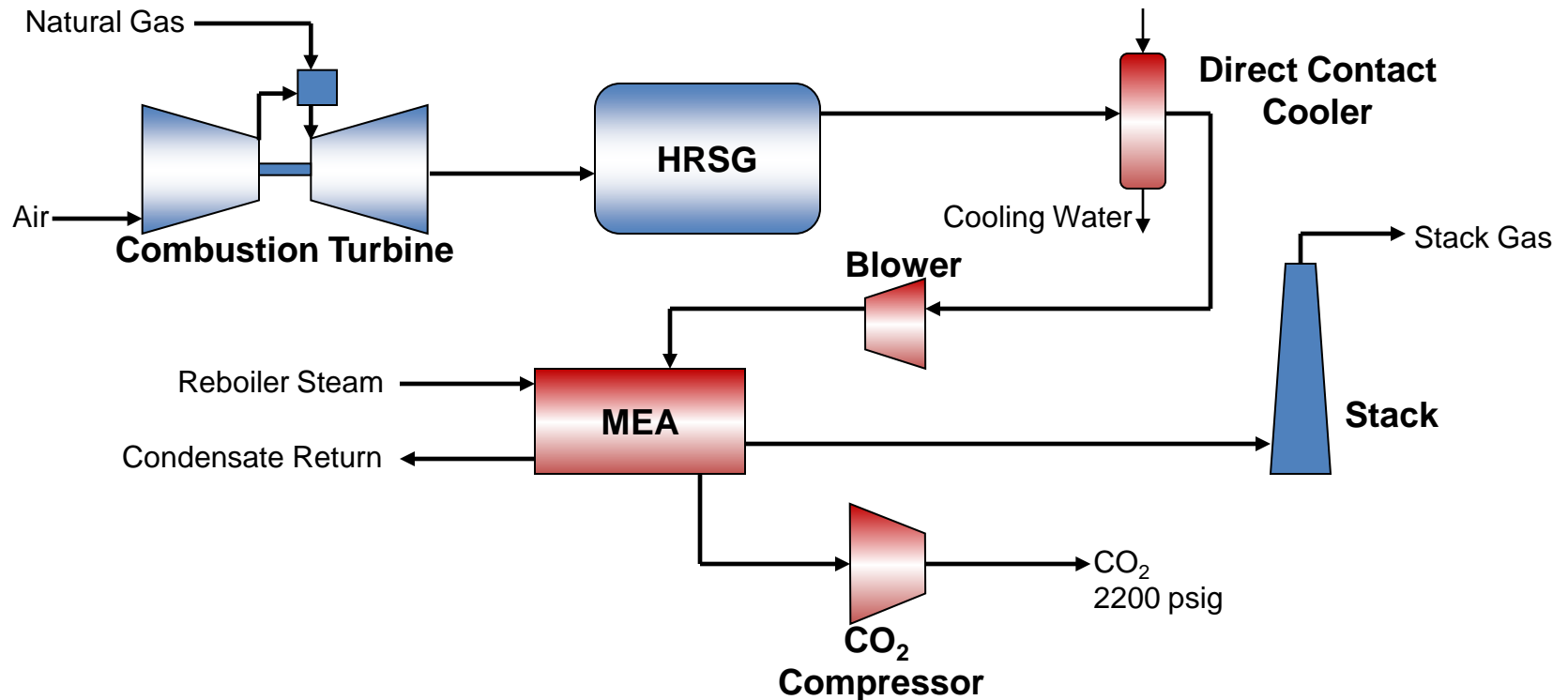
- Raw Material Path
- ... Electricity Path
- - - CO₂ Path

LCA's Expanded Boundary for NGCC



Current Technology

**Red Blocks Indicate Unit Operations Added for CO₂ Capture Case*



NO_x Control: LNB + SCR to maintain 2.5 ppmvd @ 15% O₂

Steam Conditions: 2400 psig/1050°F/950°F

Study Scenarios

Parameters	wo-CCS	w-CCS
Net Power Output (MW)	555	474
Emissions Normalizing Basis (MW)	555	474
Information Source	NGCC LCI&C	NGCC LCI&C

Key Modeling Assumptions

Parameters	NGCC w/Foreign NG	NGCC w/Domestic NG
Study Boundary Assumptions		
Temporal Boundary (Years)	30	
Cost Boundary	Overnight	
LC Stage #1: Raw Material Acquisition		
Extraction Location	Trinidad & Tobago	Domestic US
Feedstock	LNG	NG
Extraction Method	Off-Shore Drilling	Domestic Process
C&O Costs	In Delivery Price	
LC Stage #2: Raw Material Transport		
One-way transport Distance (Miles)	2260	NA
U.S. LNG Terminal Location	Lake Charles, LA	NA
Pipeline Length to ECF (Miles)	208	604
LNG Infrastructure C&O Costs	In Delivery Price	

Key Modeling Assumptions (Cont.)

Parameters	NGCC
LC Stage #3: Energy Conversion Facility	
Location	Southern Mississippi
Net Output (MW)	555
Net Output w/CCS (MW)	474
Trunk line Constructed Length (Miles)	50
Capacity Factor	85%
CO ₂ Capture Percentage	90%
CO ₂ Pipeline Pressure (psia)	2215
CO ₂ Pipeline Length (Miles)	100
CO ₂ Loss Rate	1% / 100 yrs
LC Stage #4: Product Transport	
Transmission Line Loss	7%
Transmission Grid Construction	Pre-Existing

Life Cycle Cost Parameters

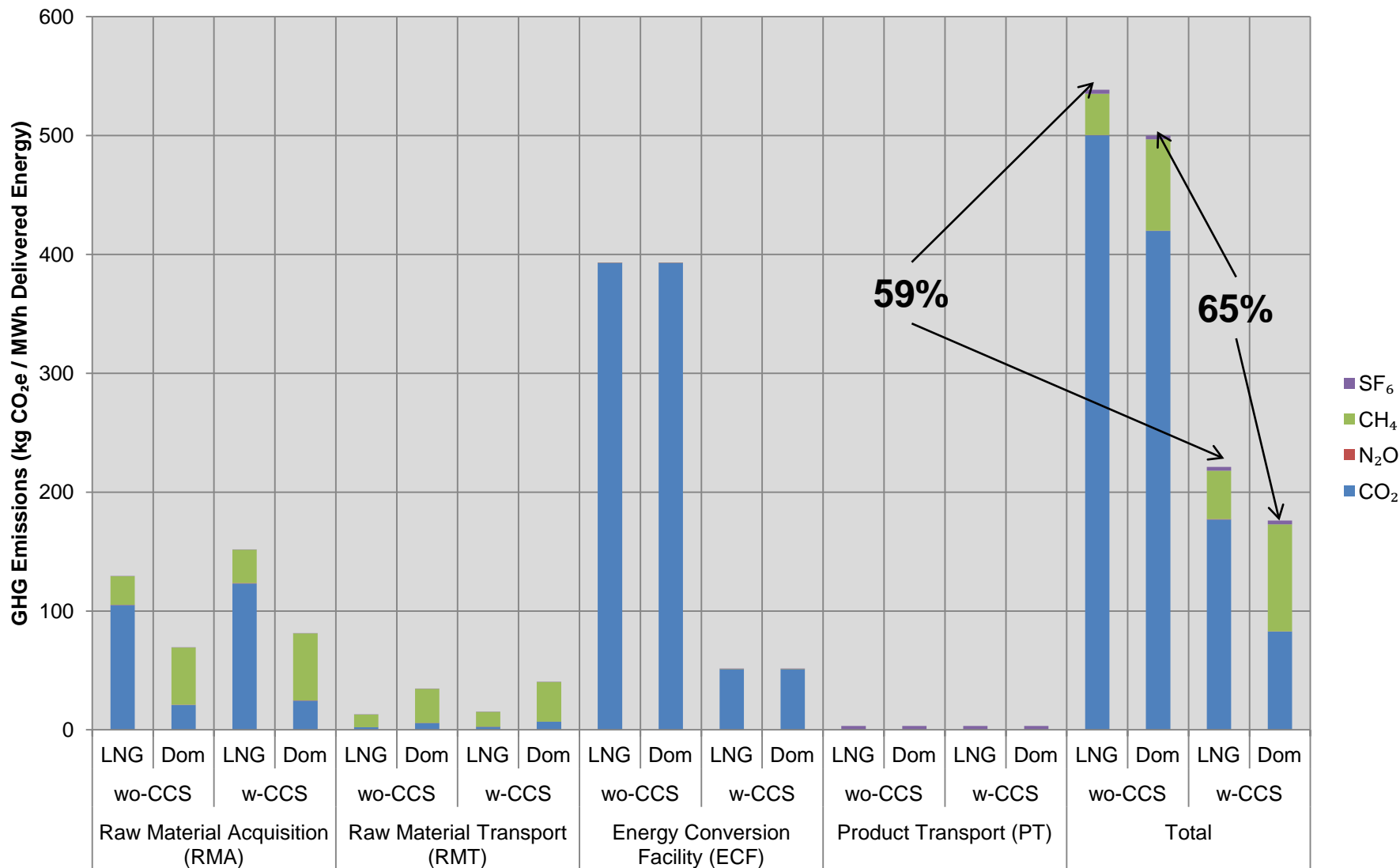
Property	Value	Units
Reference Year Dollars	December 2006/January 2007	Year
Assumed Start-Up Year	2010	Year
Real After-Tax Discount Rate	10.0	Percent
After-Tax Nominal Discount Rate	12.09	Percent
Assumed Study Period	30	Years
MACRS Depreciation Schedule Length	Variable	Years
Inflation Rate	1.87	Percent
State Taxes	6.0	Percent
Federal Taxes	34.0	Percent
Total Tax Rate	38.0	Percent
Fixed Charge Rate Calculation Factors		
Capital Charge Factor – wo-CCS	0.1502	--
Capital Charge Factor – w-CCS	0.1567	--
Levelization Factor – wo-CCS	1.432773	--
Levelization Factor – w-CCS	1.410939	--
Start Up Year (2010) Feedstock & Utility Prices	\$2006 Dollars	Units
Natural Gas	6.76	\$/MMBtu
Coal	1.51	\$/MMBtu
Process Water	0.00049 (0.0019)	\$/L (\$/gal)

Life Cycle Inventory Data Reported

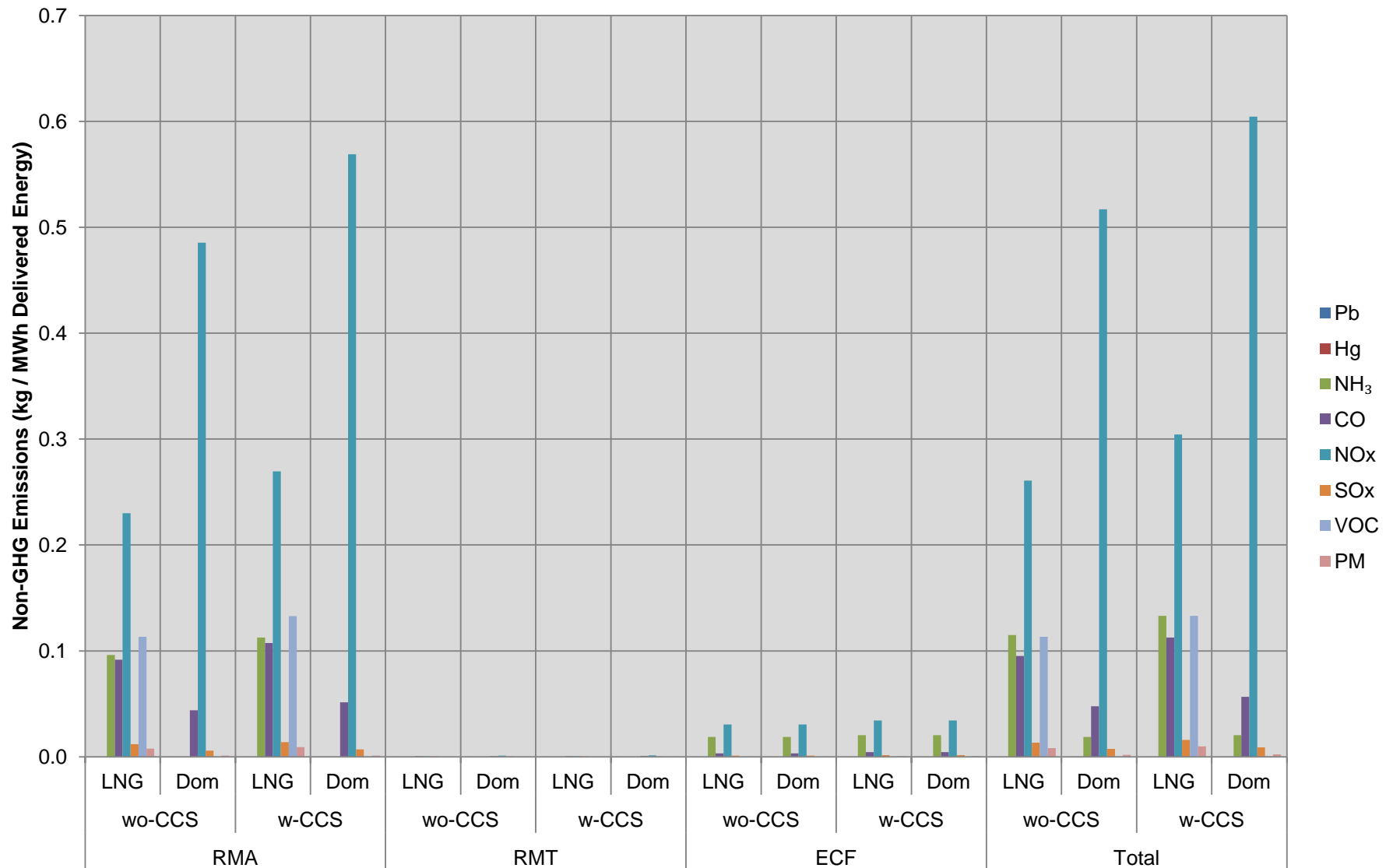
- **GHG Emissions** (2007 IPCC CO₂e Values, 100 Year basis)
 - Carbon Dioxide (CO₂)
 - Methane (CH₄)
 - Nitrous Oxide (N₂O)
 - Sulfur Hexafluoride (SF₆)
- **Water Usage**
 - Withdrawal
 - Consumption
- **Non-GHG Emissions**
 - Criteria Air Pollutants
 - Carbon Monoxide (CO)
 - Nitrogen Oxides (NOX)
 - Sulfur Oxides (SOX)
 - Volatile Organic Compounds (VOC)
 - Particulate Matter (PM)
 - Lead (Pb)
 - Species of Interest
 - Ammonia (NH₃)
 - Mercury (Hg)

GHG Emissions

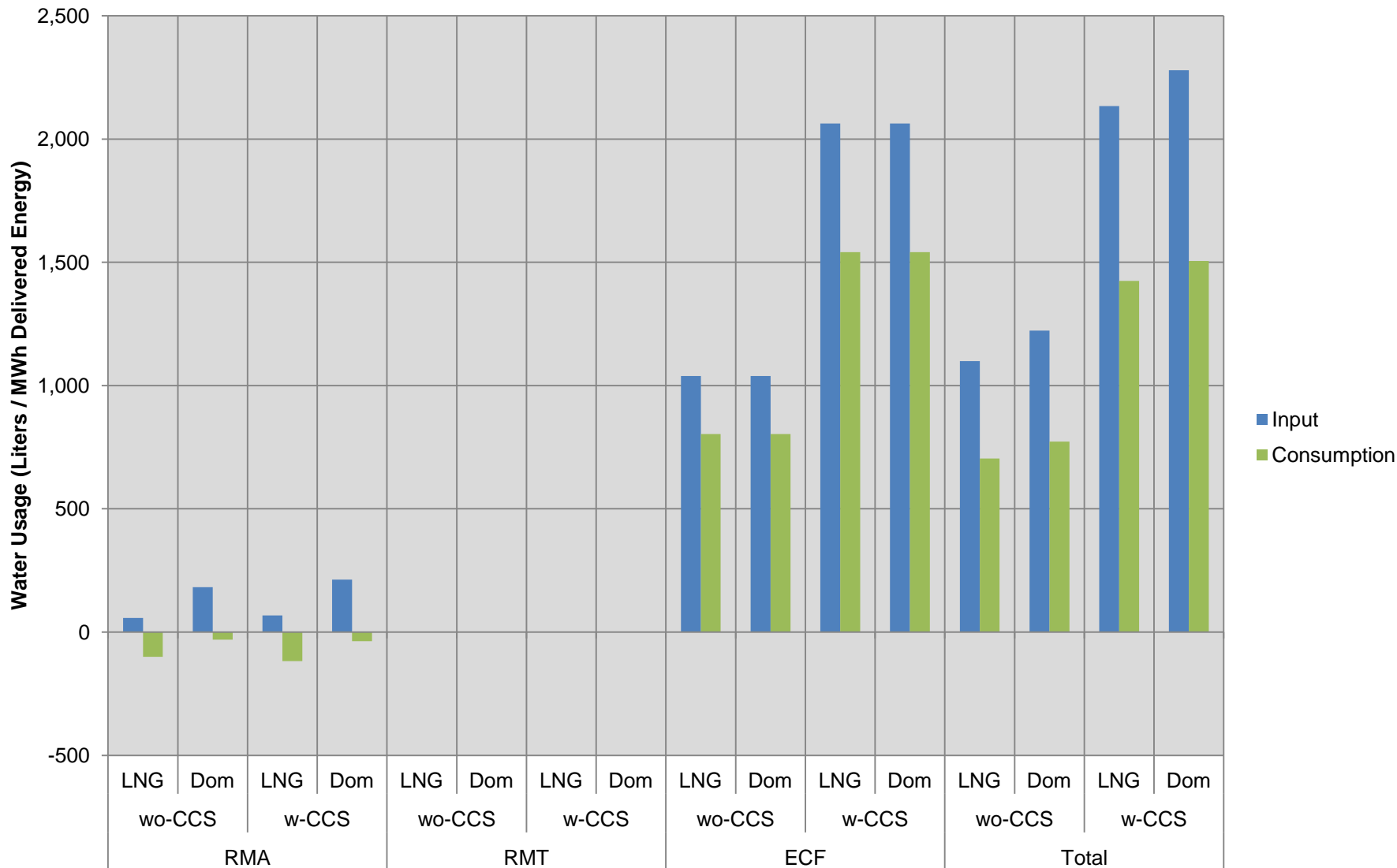
2007 GWP



Non-GHG Air Emissions



Water Usage



LCA Inventory Results Recap

Foreign LNG

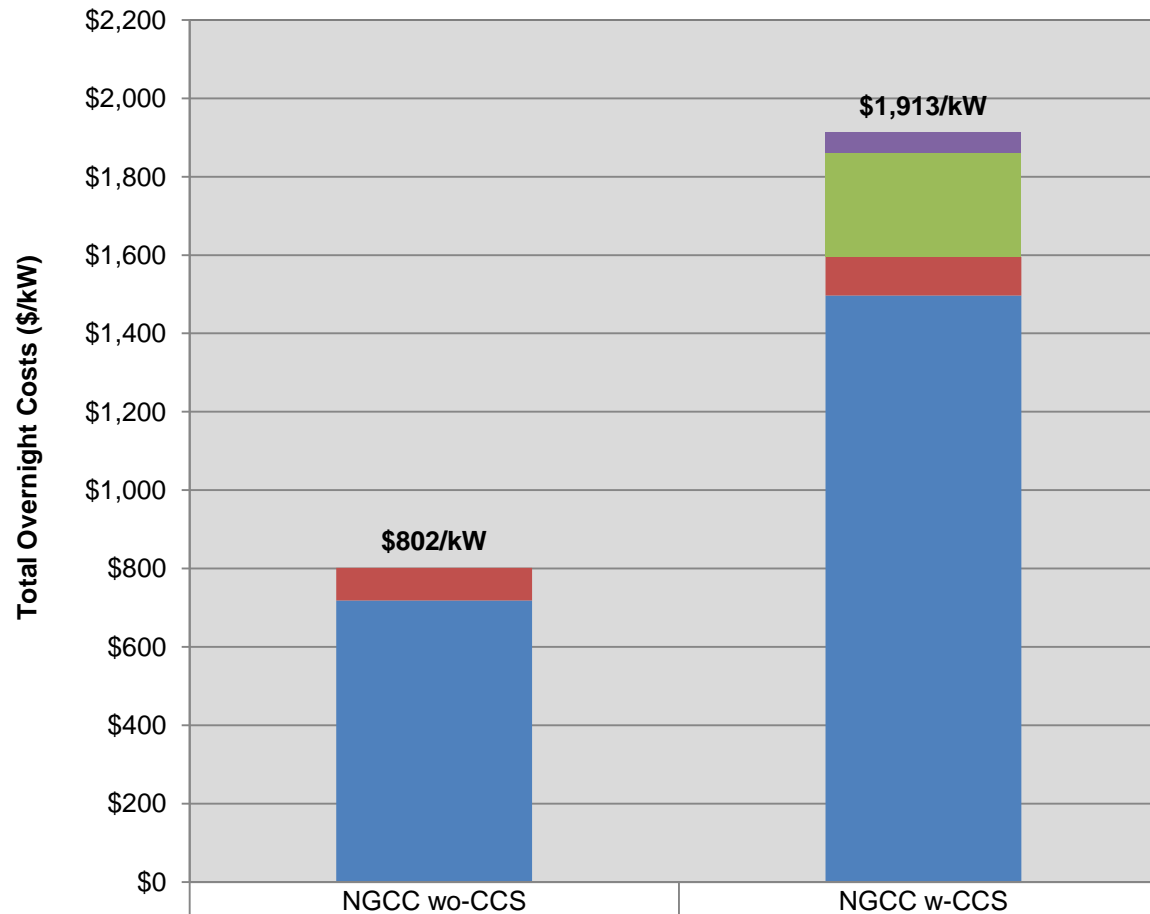
Emission Type	Species	RMA		RMT		ECF		PT		TOTAL	
		wo-CCS	w-CCS	wo-CCS	w-CCS	wo-CCS	w-CCS	wo-CCS	w-CCS	wo-CCS	w-CCS
GHG (kg CO ₂ e / MWh)	CO ₂	104.94	123.00	2.23	2.62	393.00	51.27	0.00	0.00	500.18	176.89
	N ₂ O	0.36	0.42	0.00	0.00	0.00	0.01	0.00	0.00	0.37	0.43
	CH ₄	23.98	28.11	10.67	12.50	0.01	0.02	0.00	0.00	34.66	40.63
	SF ₆	0.00	0.00	0.00	0.00	0.01	0.01	3.27	3.27	3.28	3.28
	Total	129.29	151.54	12.90	15.12	393.03	51.30	3.27	3.27	538.48	221.23
Non-GHG (kg / MWh)	Pb	6.6E-07	7.7E-07	1.7E-07	1.9E-07	2.7E-06	3.1E-06			3.5E-06	4.1E-06
	Hg	4.2E-08	4.9E-08	5.2E-09	6.1E-09	2.5E-08	3.5E-08			7.2E-08	9.0E-08
	NH ₃	9.6E-02	1.1E-01	1.1E-06	1.3E-06	1.9E-02	2.0E-02			1.1E-01	1.3E-01
	CO	9.2E-02	1.1E-01	5.3E-04	6.2E-04	3.1E-03	4.5E-03			9.5E-02	1.1E-01
	NOx	2.3E-01	2.7E-01	5.1E-04	5.9E-04	3.1E-02	3.4E-02			2.6E-01	3.0E-01
	SOx	1.2E-02	1.4E-02	3.1E-04	3.6E-04	1.2E-03	1.7E-03			1.3E-02	1.6E-02
	VOC	1.1E-01	1.3E-01	3.3E-05	3.8E-05	1.2E-04	1.9E-04			1.1E-01	1.3E-01
	PM	7.7E-03	9.0E-03	1.3E-04	1.6E-04	4.3E-04	7.0E-04			8.3E-03	9.9E-03
Water Usage (Liter / MWh)	Input	57.6	67.6	2.1	2.5	1038.9	2063.3			1098.7	2133.4
	Consumption	-100.2	-117.4	0.7	0.9	803.3	1541.4			703.9	1424.8

LCA Inventory Results Recap

Domestic NG

Emission Type	Species	RMA		RMT		ECF		PT		TOTAL	
		wo-CCS	w-CCS	wo-CCS	w-CCS	wo-CCS	w-CCS	wo-CCS	w-CCS	wo-CCS	w-CCS
GHG (kg CO ₂ e / MWh)	CO ₂	21.00	24.61	5.83	6.84	393.00	51.27	0.00	0.00	419.83	82.72
	N ₂ O	0.20	0.24	0.00	0.00	0.00	0.01	0.00	0.00	0.21	0.25
	CH ₄	48.05	56.32	28.65	33.58	0.01	0.02	0.00	0.00	76.72	89.92
	SF ₆	0.01	0.01	0.00	0.00	0.01	0.01	3.27	3.27	3.28	3.28
	Total	69.26	81.18	34.48	40.42	393.03	51.30	3.27	3.27	500.04	176.17
Non-GHG (kg / MWh)	Pb	2.0E-06	2.3E-06	1.7E-07	1.9E-07	2.7E-06	3.1E-06			4.8E-06	5.6E-06
	Hg	7.2E-08	8.5E-08	5.2E-09	6.1E-09	2.5E-08	3.5E-08			1.0E-07	1.3E-07
	NH ₃	1.1E-06	1.3E-06	2.9E-06	3.5E-06	1.9E-02	2.0E-02			1.9E-02	2.0E-02
	CO	4.4E-02	5.1E-02	7.3E-04	8.5E-04	3.1E-03	4.5E-03			4.8E-02	5.7E-02
	NOx	4.9E-01	5.7E-01	1.1E-03	1.3E-03	3.1E-02	3.4E-02			5.2E-01	6.0E-01
	SOx	5.9E-03	6.9E-03	3.2E-04	3.8E-04	1.2E-03	1.7E-03			7.4E-03	9.0E-03
	VOC	1.1E-04	1.2E-04	7.5E-05	8.8E-05	1.2E-04	1.9E-04			3.0E-04	4.0E-04
	PM	1.0E-03	1.2E-03	2.5E-04	2.9E-04	4.3E-04	7.0E-04			1.7E-03	2.2E-03
Water Usage (Liter / MWh)	Input	181.9	213.2	2.1	2.5	1038.9	2063.3			1222.9	2279.0
	Consumption	-31.0	-36.4	0.7	0.9	803.3	1541.4			773.1	1505.9

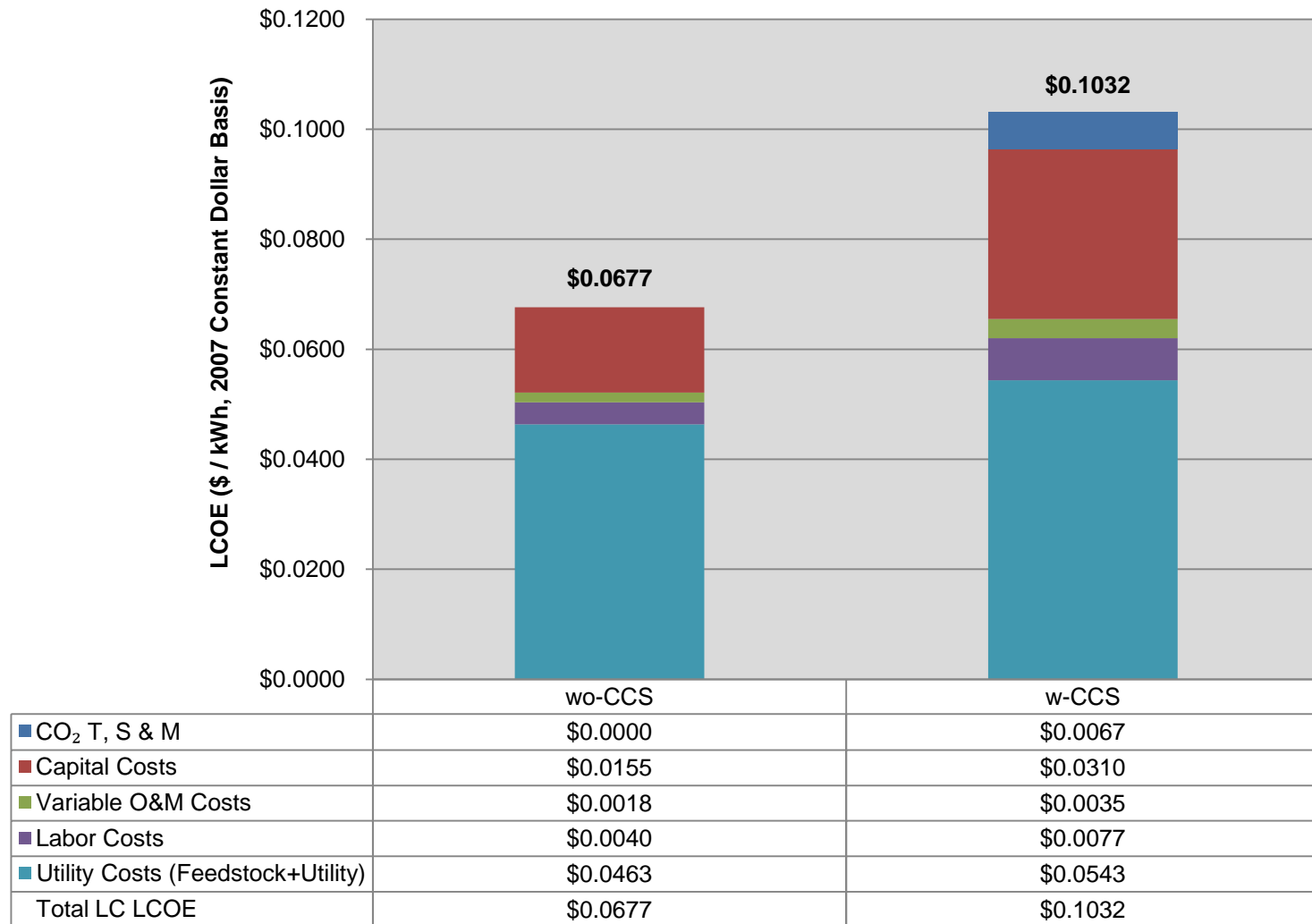
Capital Costs



	NGCC wo-CCS	NGCC w-CCS
Total Capital (\$/kW)	802.0	1912.6
CO ₂ Injection Well	0	52.2
CO ₂ Pipeline	0	265
Switchyard & Trunkline	83.96	98.4
Plant	718	1497

Levelized Cost of Electricity (LCOE)

2007 \$s



Key Findings

- **GHG Emissions**

- CO₂ is the dominant emission
 - Mostly from the NGCC ECF
 - wo-CCS – 79% on LNG, 92% on DNG
 - w-CCS – 30% on LNG, 55% on DNG
 - LNG - Large spike with Drilling operations – 17% wo-CCS, 56% w-CCS
- Methane emissions – Highest percentages from RMT
 - Regasification – 46.5% Overall GHG emissions
 - Pipeline operation – 26.4% on LNG, 81.8% on DNG
- Overall GHG Emissions of Domestic NG is less than LNG
 - wo-CCS
 - LNG 495 kg CO₂e/MWH,
 - DNG 428 kg CO₂e/MWH
 - W-CCS
 - LNG 171 kg CO₂e/MWH
 - DNG 92 kg CO₂e/MWH

Key Findings (Cont.)

- **Non-GHG Emissions**

- NOX is the primary effluent, followed closely by CO, SOX and VOC's.
 - Domestic NG – NOX is 30% higher than LNG cases – w- and wo-CCS
- Ammonia is measurable, but less than the above emissions
 - SCR ammonia slip at the ECF
 - 5 ppmv Average during NGCC Operation
 - Emissions from the Liquefaction plant for LNG
 - 99.9% of RMA NH₃ emissions(
 - 83% of overal NH₃ emissions

Key Findings (Cont.)

- **Water Usage**

- Primary vector of water consumption is the ECF
 - 88 - 97% of Consumption
- Domestic NG – Small Increase in water consumption
 - wo-CCS – 5% increase
 - w-CCS – 3% increase
- Addition of CCS
 - Water input
 - LNG – 94% increase
 - DNG – 90% increase
 - Water consumption
 - LNG – 90% increase
 - DNG – 81% increase

Key Findings (Cont.)

- **Capital Costs**

- Equipment Capital costs are the primary components
 - wo-CCS – 89% of CC
 - w-CCS – 78% of CC
- Addition of CCS
 - Additional costs for CO₂ pipeline & sequestration site – 17% of CC w-CCS
 - Increased Decommissioning costs (Extra equipment) – increases 115%

- **LCOE**

- Utility costs are the primary component
 - wo-CCS – 68% of LCOE
 - w-CCS – 53% of LCOE
- Capital Costs are second order
 - wo-CCS – 23% of CC
 - w-CCS – 30% of CC
- Lesser inputs from Variable O&M and Labor

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