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Post-Combustion Capture on NGCC Plants: Evaluation of Retrofit, New Build, and the Application of Exhaust Gas Recycle

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Californian Energy Commission

Workshop on Natural Gas Power Plants with CO_2 Capture

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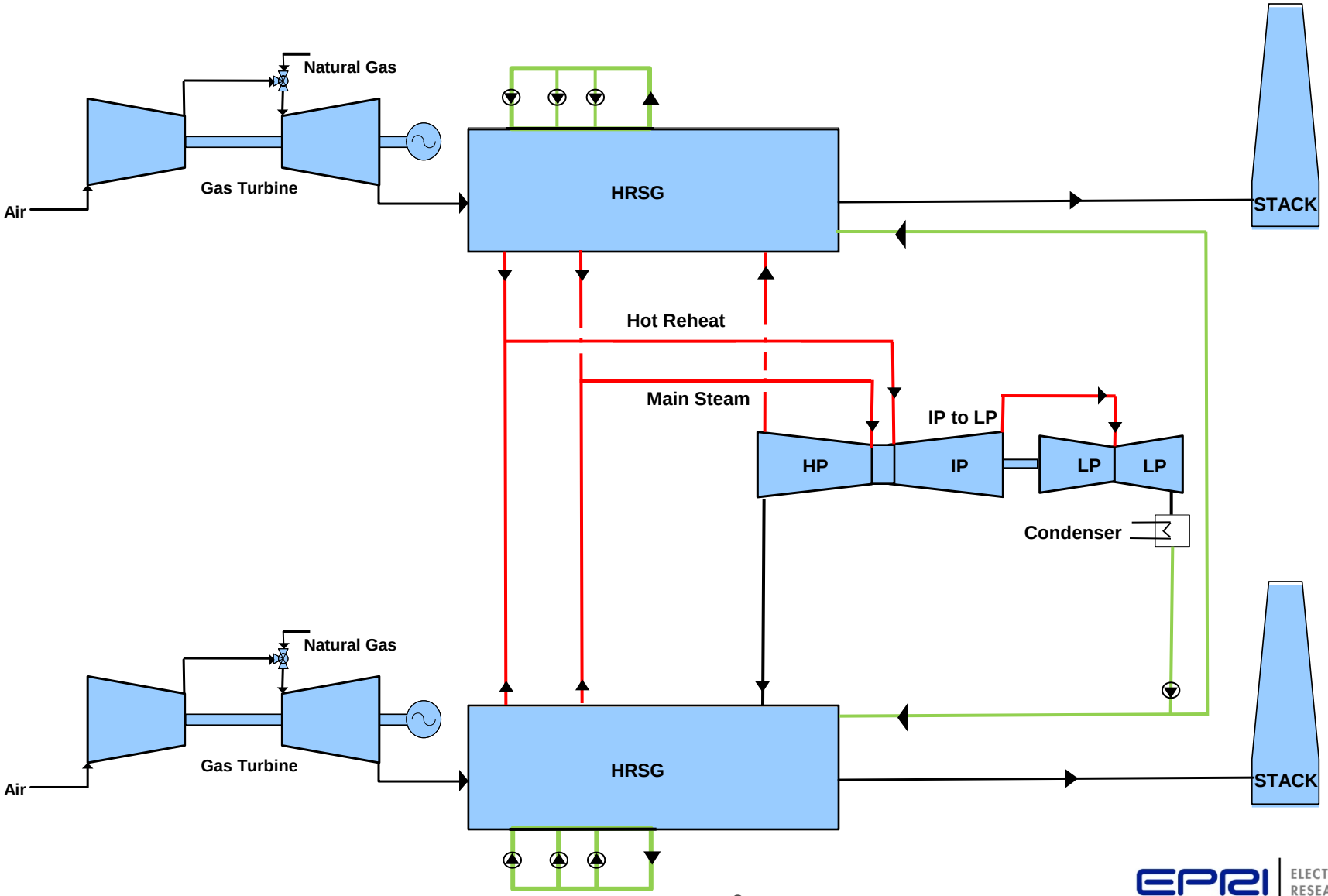
EPRI Objective and Scope

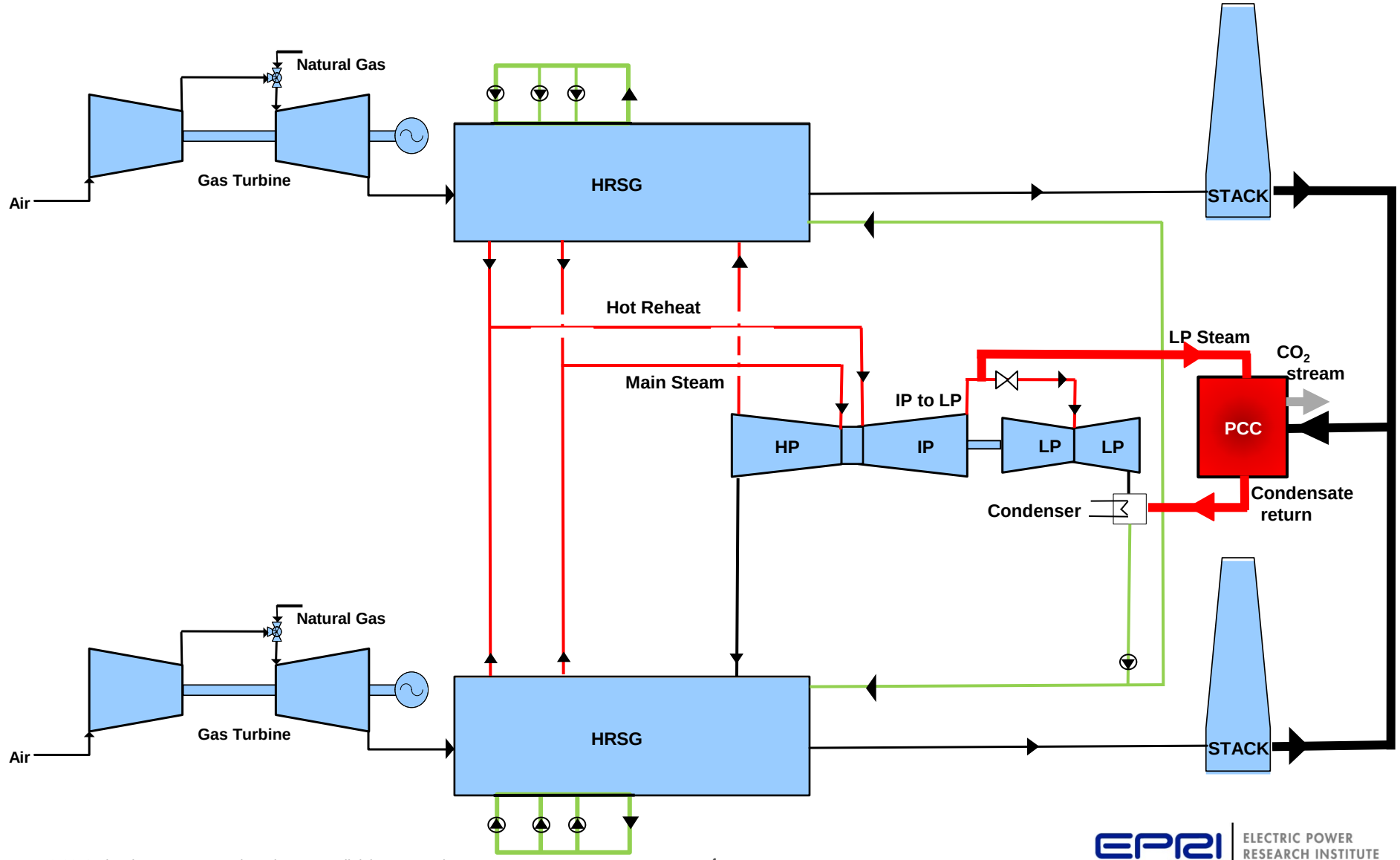
- Evaluate the performance and cost impact of applying post-combustion capture (PCC) to today's NGCC
- Cases considered:
  - **Reference** 556-MWe (Net) base NGCC plant
  - **Retrofit** post combustion plant to base plant
  - **New build** NGCC plant designed with capture
  - **New build** NGCC plant designed with capture and exhaust gas recycle **(EGR).**
- PCC technology utilized:
  - Aker Clean Carbon (ACC)

- Essentially 3 cases of advanced amine full-scale 90% capture considered for the same Kenosha, Wisconsin, USA site location

556-MWe (Net) NGCC Base Plant



556-MWe (Net) NGCC Base Plant with PCC



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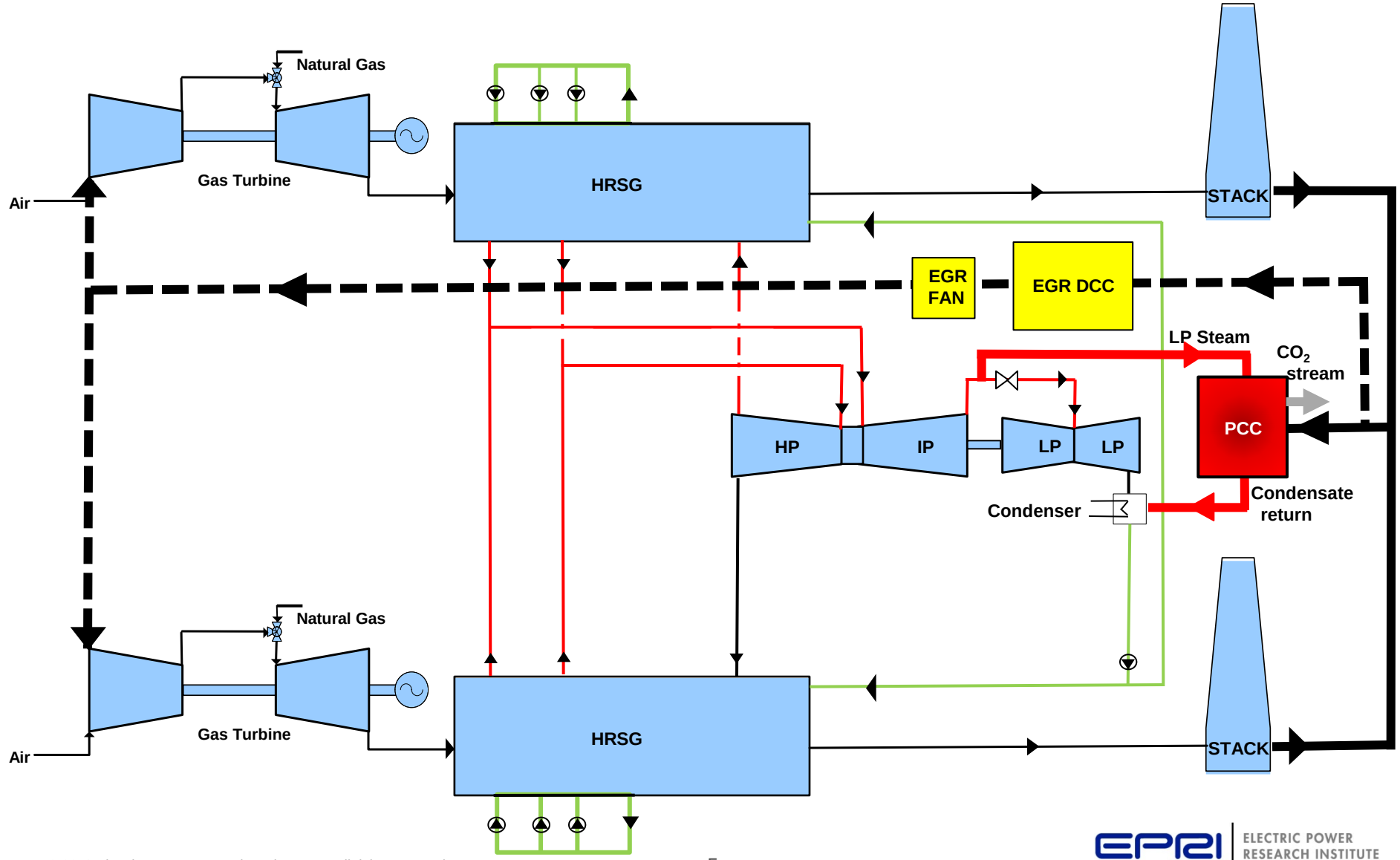
556-MWe (Net) NGCC Base Plant with PCC and Exhaust Gas Recycle



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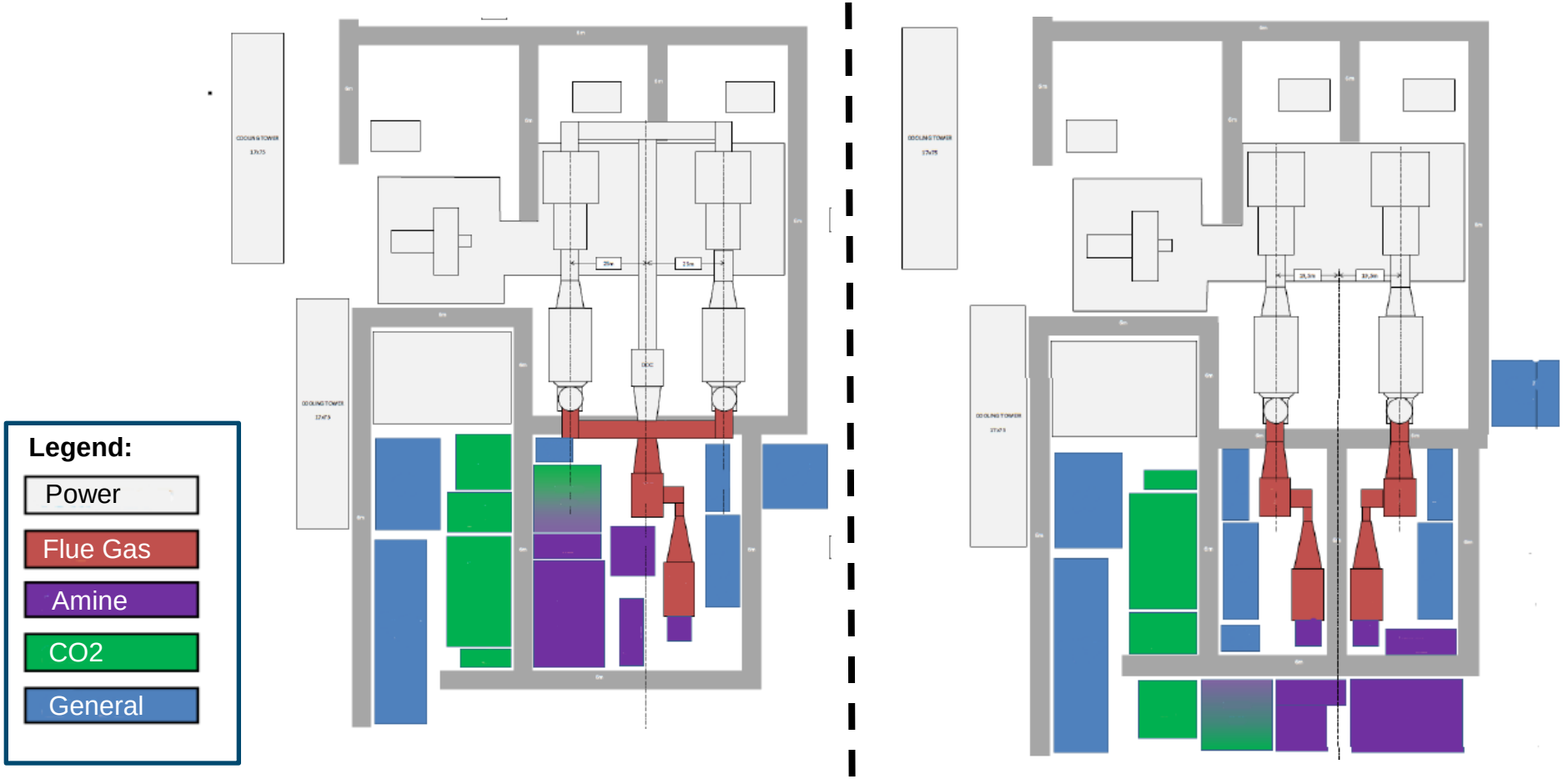
Plot Plan for NGCC Retrofit Before and After PCC Retrofit

- ACC designs presented for both the retrofit case and new build designed for capture case consist of the following key components

NGCC with PCC Retrofit No Consideration for Capture	New Build NGCC with Capture (Designed for Capture)	New Build NGCC with Capture and EGR (Designed for Capture)
2 Absorber Trains	2 Absorber Trains	1 Absorber Train
1 Desorber Train	1 Desorber Train	1 Desorber Train
4 Reboilers Per Desorber	4 Reboilers Per Desorber	4 Reboilers Per Desorber
2 Compression Trains	2 Compression Trains	2 Compression Trains

- When EGR is applied to the new build designed for capture case, one less absorber is envisaged
  - Less capital on PCC but gas turbine modifications required

Conceptual Layout



NGCC New Build with PCC & EGR

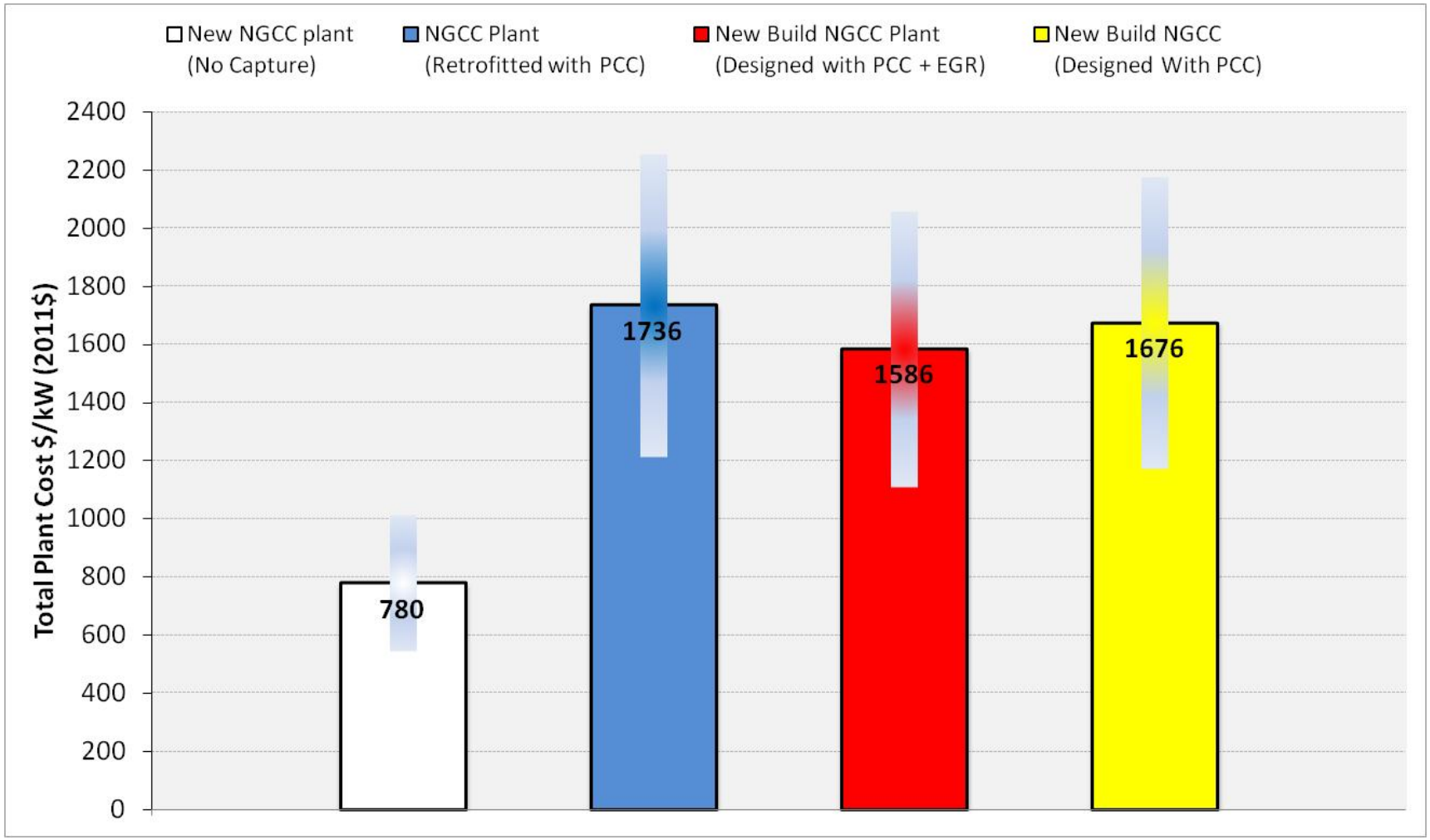
NGCC PCC Retrofit

Performance Results

	Reference NGCC Plant	NGCC plant RETROFITTED with PCC	NEW BUILD NGCC Plant Designed with PCC and Exhaust Gas Recycle	NEW BUILD NGCC plant Designed with PCC
Gross Power Output (MW)	**566**	**532.3**	**534.7**	**532.3**
Aux Load (MW)	**9.5**	**45.1**	**41.0**	**45.1**
Net Power Output (MW)	**556.5**	**487.2**	**493.7**	**487.2**
Net Plant Heat Rate (BTU/KWh) HHV	**6625**	**7560**	**7470**	**7560**
Net Plant Efficiency % LHV	56.9%	49.8%	50.5%	49.8%
Efficiency Reduction % points LHV	-	7.1%	6.4%	7.1%
Net Plant Efficiency % HHV	**51.5%**	**45.1%**	**45.7%**	**45.1%**
Efficiency Reduction % points HHV	**-**	**6.4%**	**5.8%**	**6.4%**

Shows ~0.6% point performance saving with EGR

Total Plant Costs: NGCC with and without CO_2 Capture



(Note: The key economic assumptions are listed at the end of presentation

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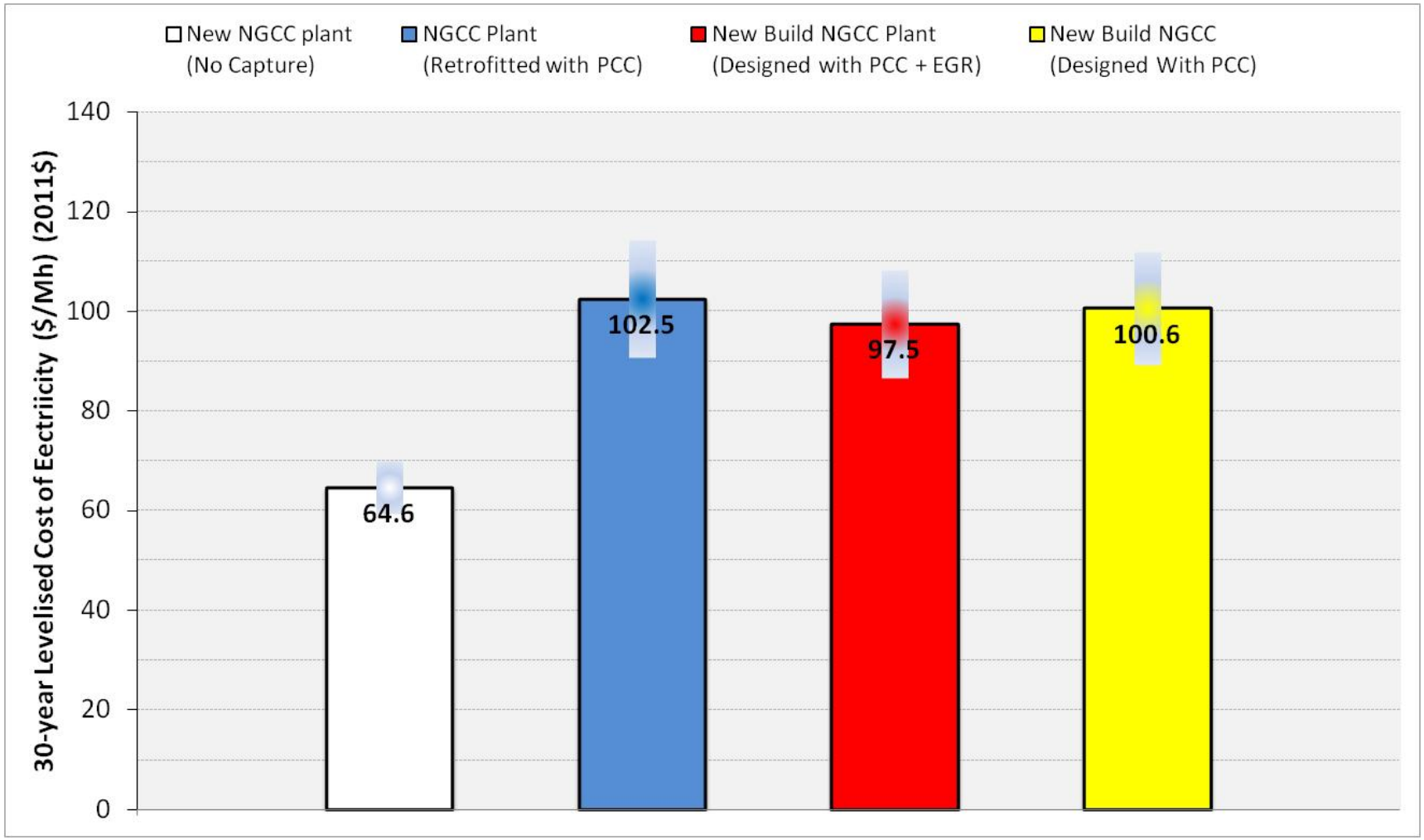
Levelized Cost Of Electricity: NGCC with and without CO_2 Capture



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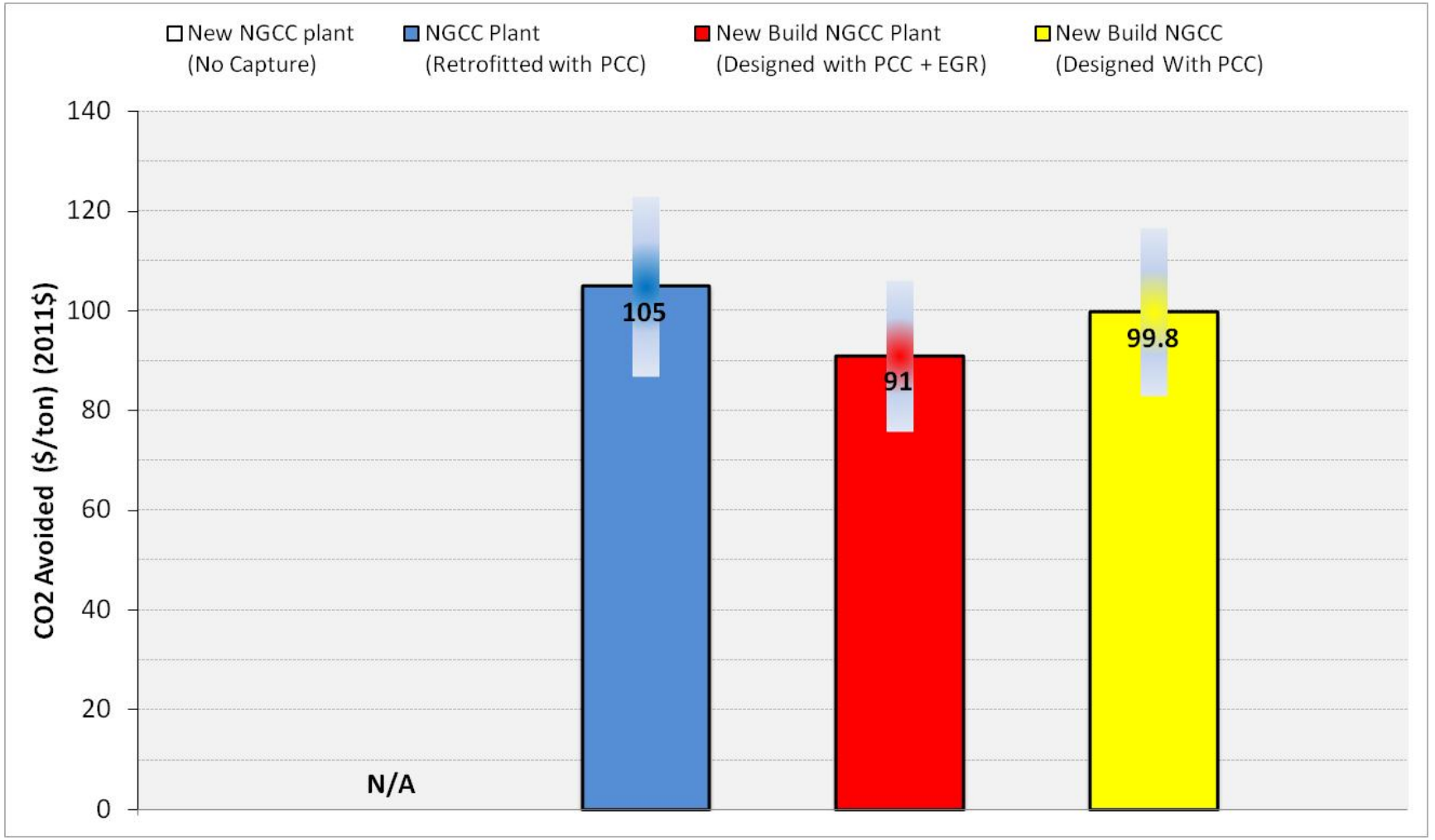
Cost of CO_2 Avoided: NGCC with Capture



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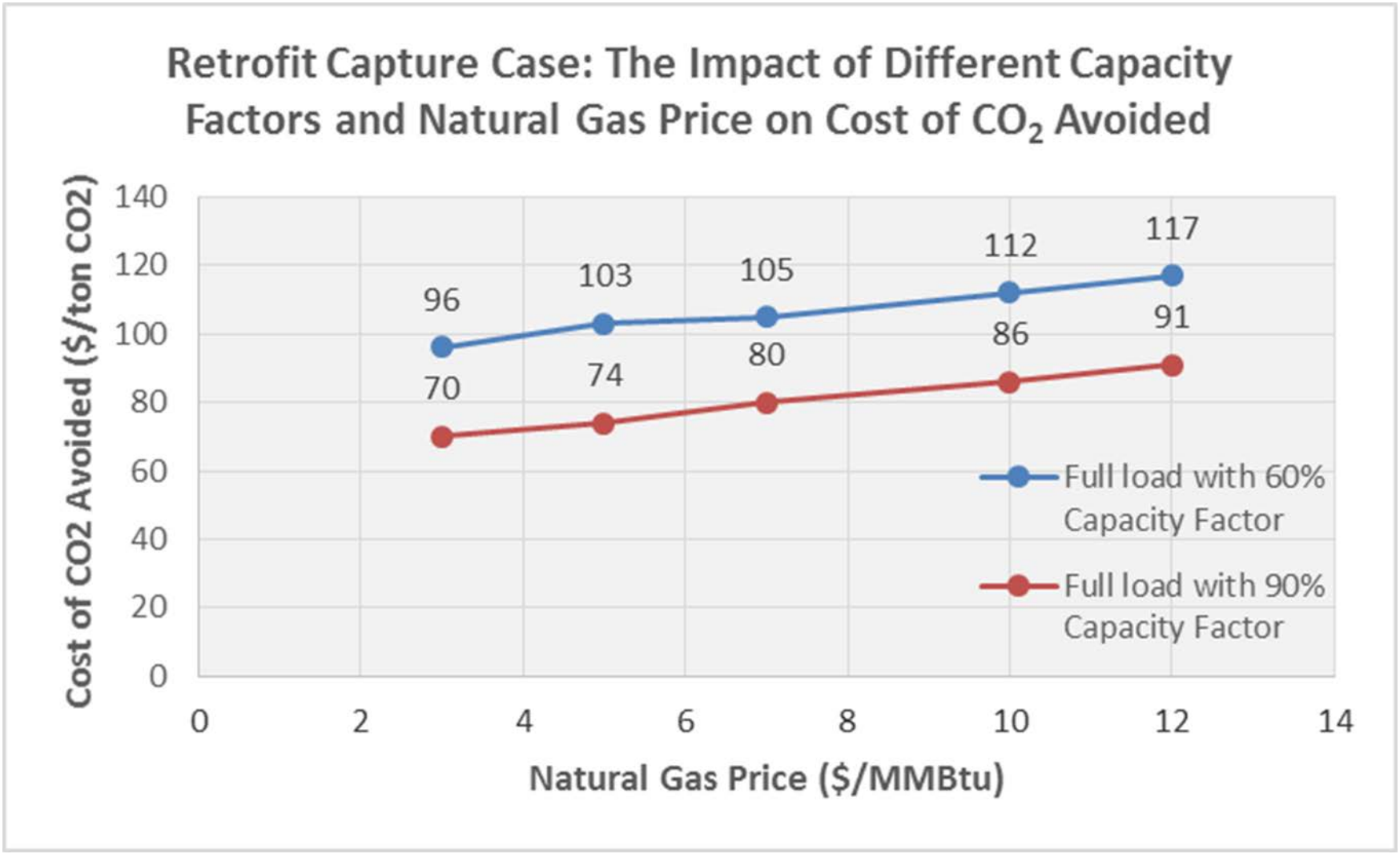
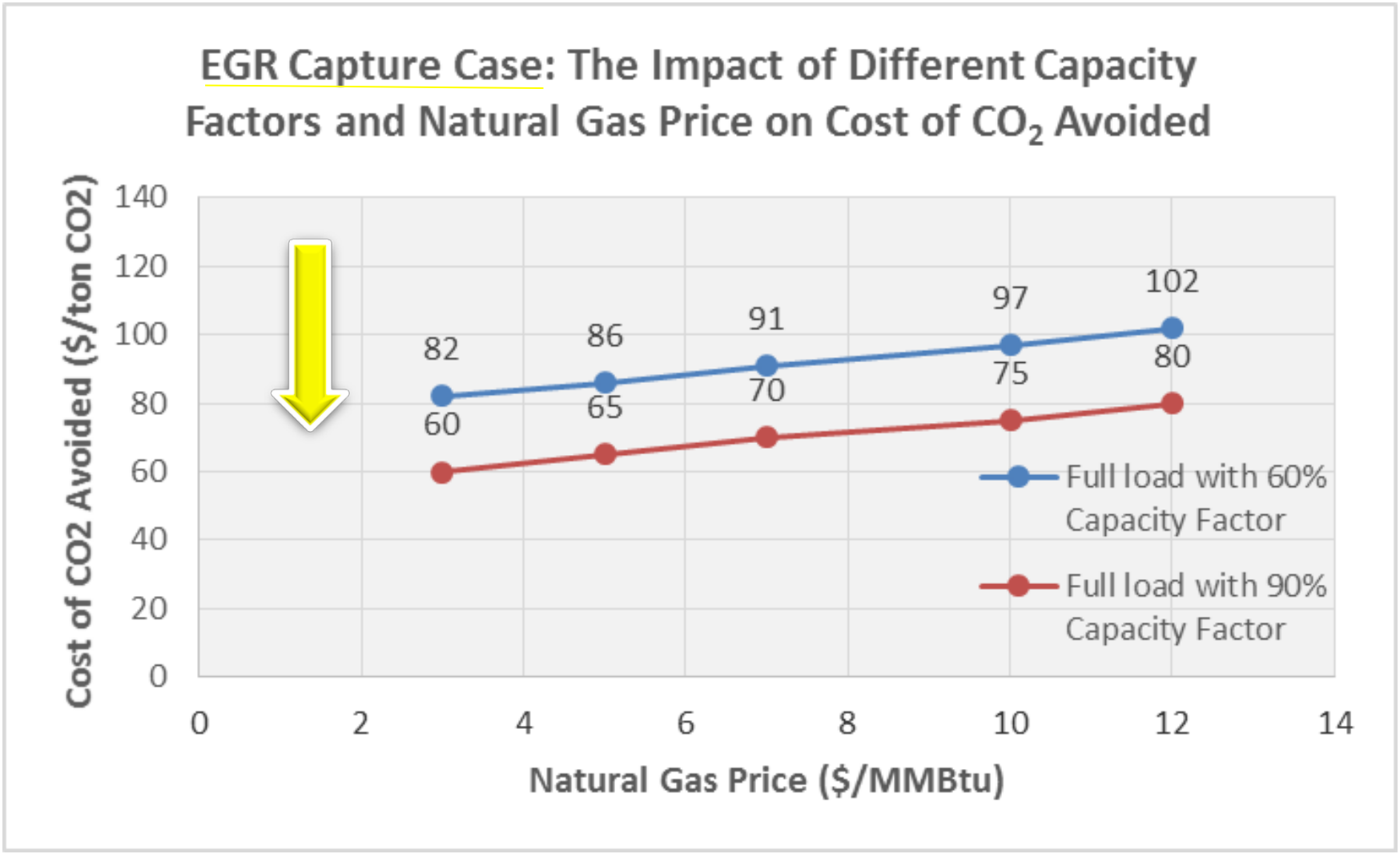
Conclusions

- Retrofitting PCC was more expensive than designing the PCC into the original NGCC plant.
- The NGCC retrofit of PCC technology has a higher avoided CO_2 cost when compared to designing the PCC into the original NGCC
- EGR lowered capital outlay, increased efficiency, and provided an incremental improvement to both LCOE and CO_2 avoided cost for the new build NGCC with PCC Case.
- In studies of this type, results are sensitive to original assumptions.
  - Further sensitivity studies showed:
    - Adding a 20% contingency to PCC capital equipment cost results in a 3.5% increase in the LCOE and a 10% increase in the cost of CO_2 avoided across all 3 capture cases
    - The larger the capacity factor, the smaller the increase in LCOE associated with adding capture and the lower the cost of avoided CO_2
    - An increase in the price of natural gas has more impact on the LCOE than the CO_2 avoided cost

Sensitivity Factors: Retrofit Case



Sensitivity Factors: EGR Case



Together…Shaping the Future of Electricity

EPRI would like to acknowledge the following contributors to this work:

Aker Clean Carbon and Norsk Energi

Contact: *ddillon@epri.com*

Study Assumptions:

Key economic assumptions included in this study:

- No contingency applied to PCC equipment
- Gas price used is $7.00/MBtu ($6.6/GJ) HHV
- Costs estimate were based on a +/- 30% accuracy from pre-front-end engineering and design studies
- LCOE based on investor-owned utility revenue requirement analysis
- The base plant for the avoided cost of CO_2 calc was the NGCC without capture (CASE 1)
- 60% capacity factor applied
- All capital costs have been adjusted to 4th quarter 2011 dollars
- All Kenosha, Wisconsin based site conditions
- 11.9 % annual capital carrying charge factor applied
- Captured CO_2 is compressed to 2205 psig (152 barg)
- Constant value of $9.1/ton ($10/tonne) was applied to account for transport and storage.
- The TPC used, is defined as the sum of the following: Capital cost (broken into materials and installation including labor, subcontracts, field indirect costs, no sales tax assumed) / Engineering and other Home Office Overhead, including Fee / Warranty costs / Any Contingencies applied.