An Integrated Tool for Rapid Assessment of Chemical Manufacture Emissions, Treatment, and Sustainability Performance

Shuyun Li[1], Selorme Agbleze[1], Gerardo J. Ruiz-Mercado[2] and Fernando V. Lima[1]

[1]West Virginia University, Morgantown, WV

[2]U.S. Environmental Protection Agency, Cincinnati, OH

Motivation

- Several industries rely directly or indirectly on the chemical industry
- Several metrics exist for evaluating efficiency for different applications in chemical industry
- Efficiency measures based on optimization are usually driven by cost

Figure 1: Industry dependence

- To assess plant wide performance :
  - (a) Raw material and energy usage (b) Plant productivity
    (c) Operating costs (d) Waste/Emission generation and treatment
- The methods available to answer the above involve using the proposed integrated GREENSCOPE and Pollution Control Unit (PCU) Analysis tools

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GREENSCOPE FRAMEWORK

- Input data: energy and mass flows, operating and equipment data, properties of addressed component
- GREENSCOPE translates process design and performance data into a set of dimensionless indicator scores
- GREENSCOPE can be used to assess new processes or compare different technologies
- Data availability in terms of quality and quantity is critical for the assessment of results
- Process simulators have the potential for providing required data, but have limitations in emission estimation and challenges in software data transfer

$$Indicator\ Score = \frac{|Actual - Worst|}{|Best - Worst|} \times 100\%$$

* 100% represents the most sustainable while 0% the least sustainable

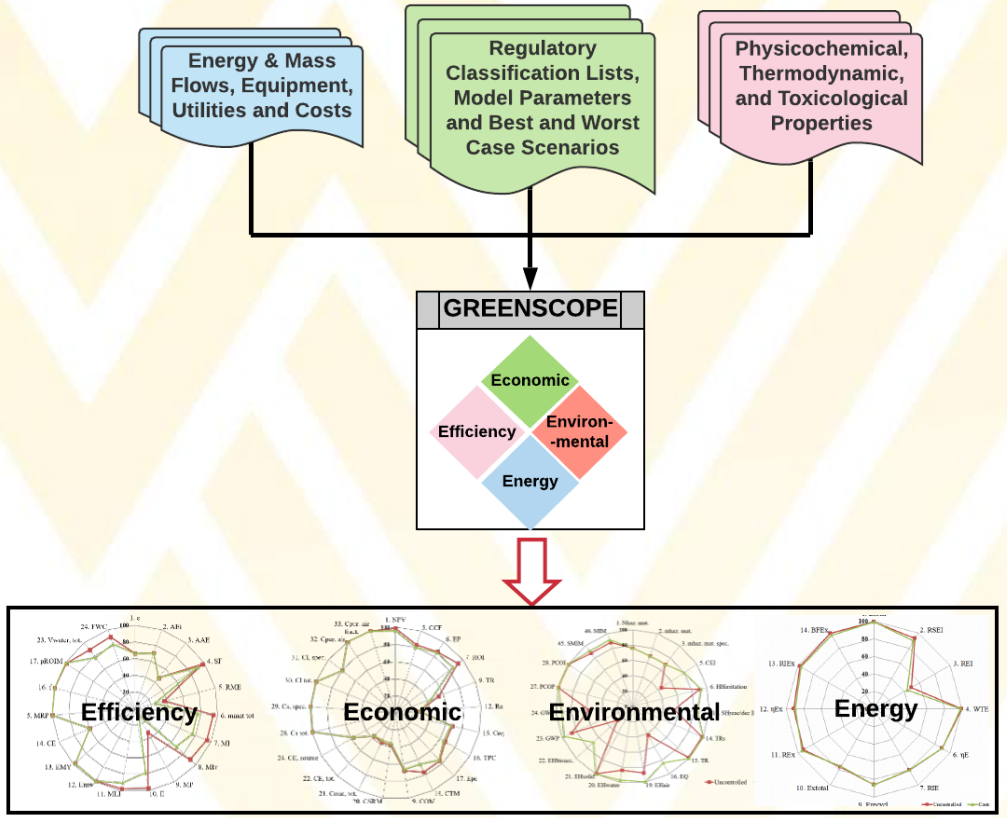

Figure 2: GREENSCOPE Framework

* Ruiz-Mercado GJ, Smith RL, Gonzalez MA. GREENSCOPE.xlsm User's Guide. Excel Version 1.1 2013

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GREENSCOPE APPLICATION

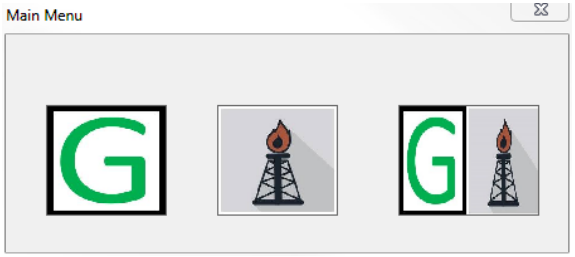

Figure 3: GREENSCOPE-PCU Main Menu

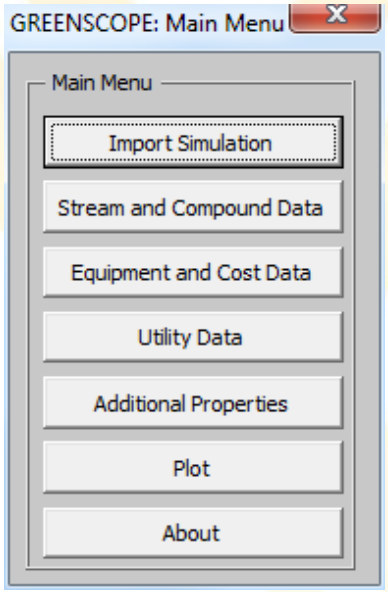

Figure 4: GREENSCOPE Main Menu

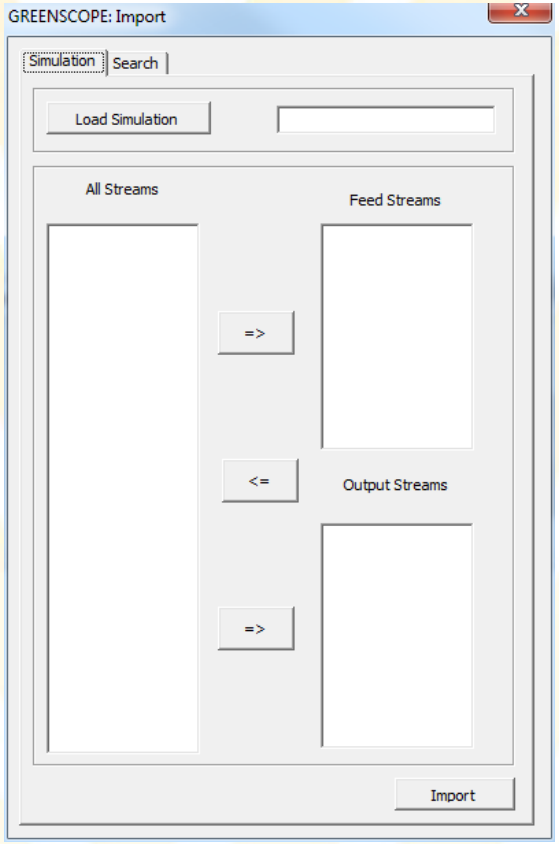

Figure 5: GREENSCOPE Import Menu

- Users have choices to perform, GREENSCOPE, PCU analysis, or both

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GREENSCOPE APPLICATION

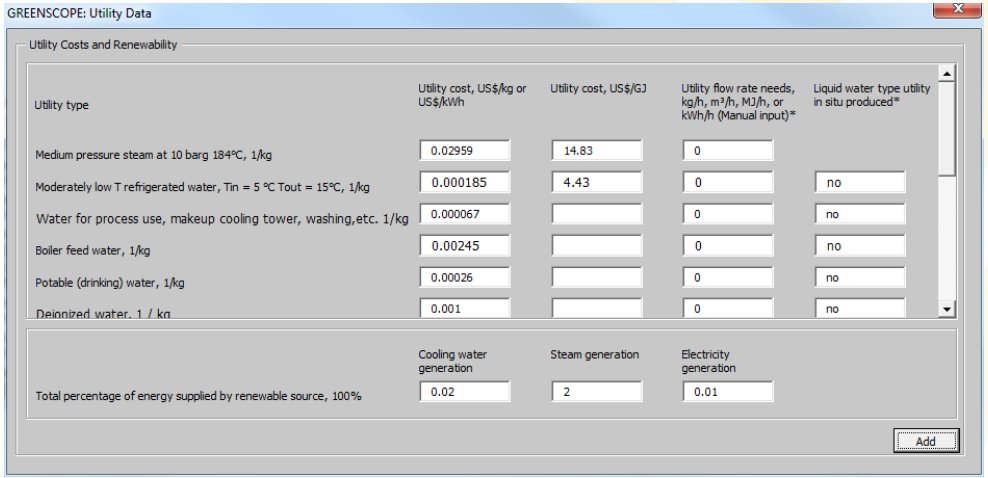

Figure 6: Utility Entry Window

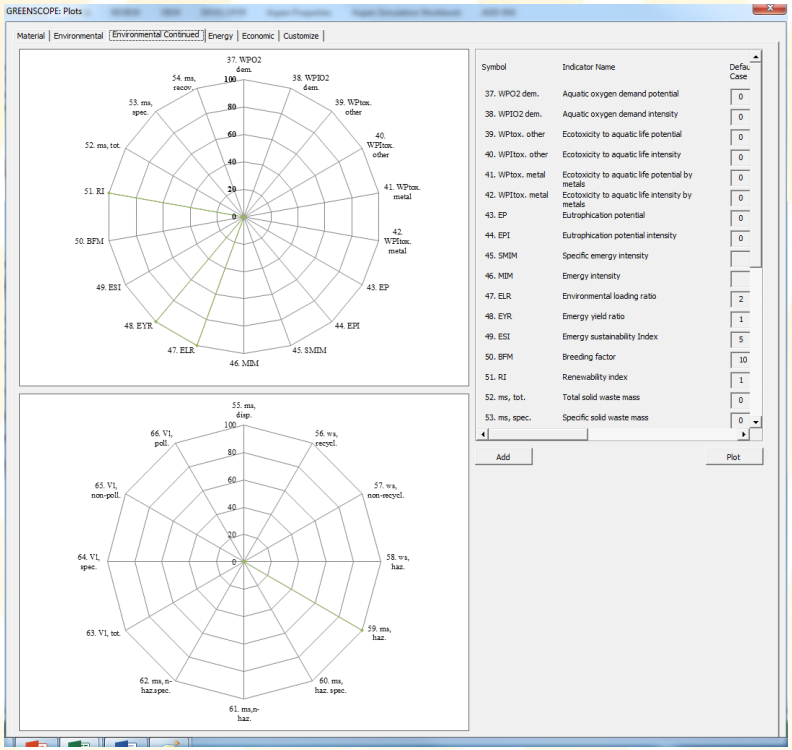

Figure 7: Indicator Plot Window

- Users are able to enter values for different process utilities
- Users can plot all indicators or customize

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PCU FRAMEWORK

- PCU Framework
  - Simulate gas flare calculations
  - Generate results on:
    - Stream composition
    - Equipment size
    - Utility usage

- The current framework has been tailored towards CHEMCAD but this can be extended to Aspen or other process simulators

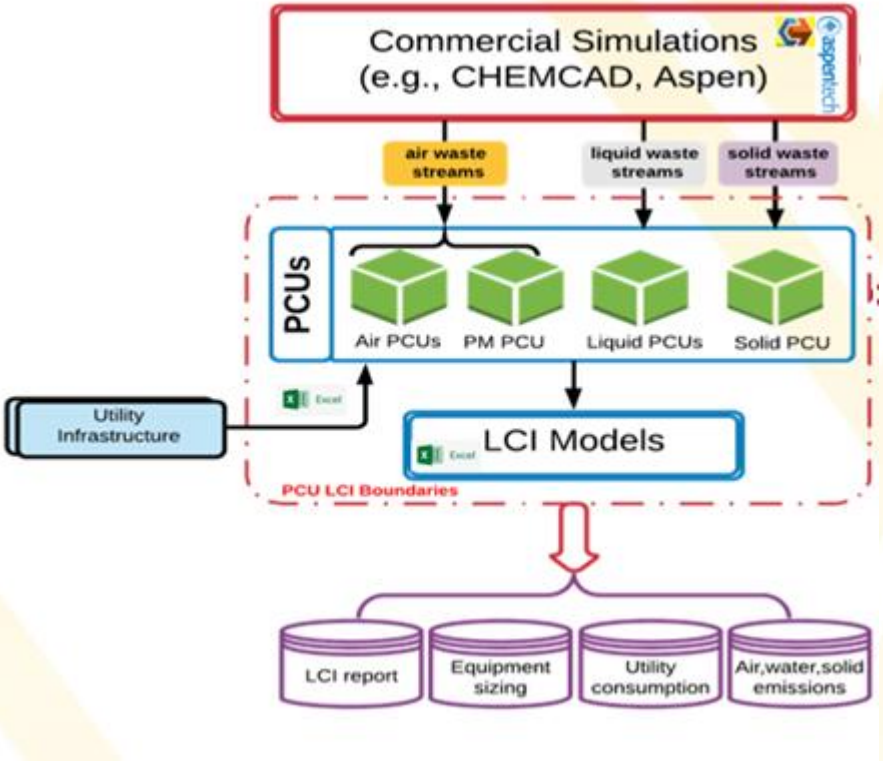

Figure 8: PCU Framework

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PCU APPLICATION

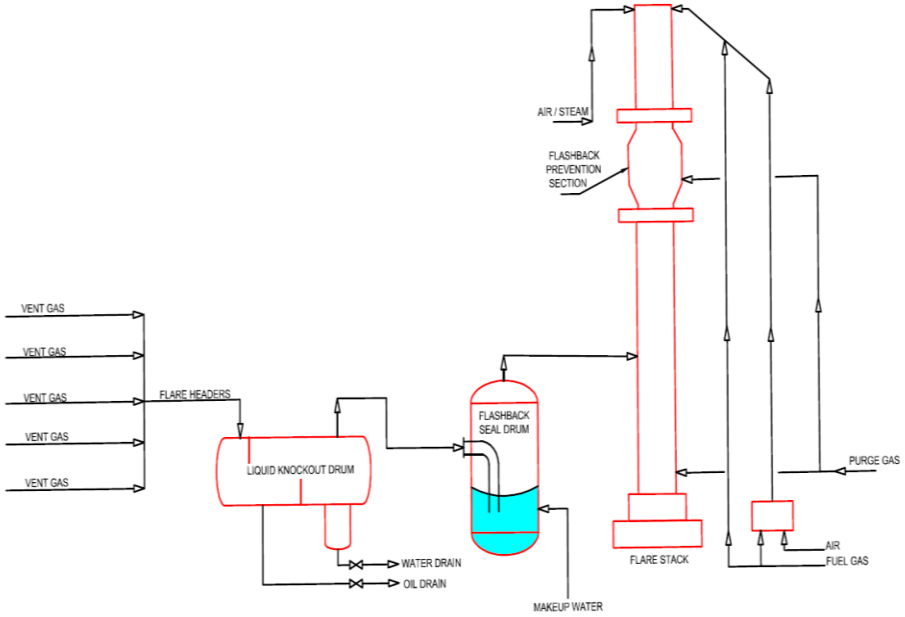

Figure 9: Flare System

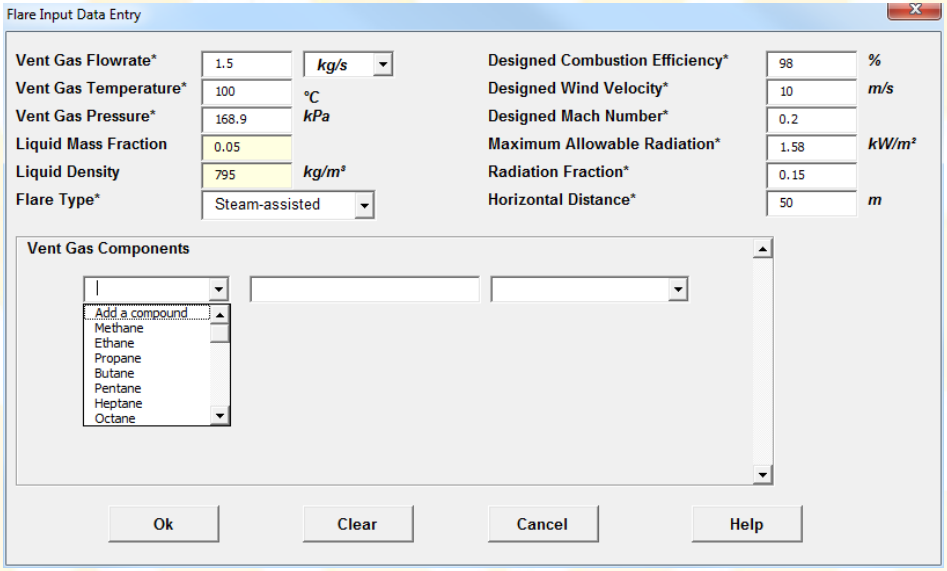

Figure 10: Flare Interface

- This interface allows the user to design a flare system based on maximum estimated flows

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GREENSCOPE-PCU FRAMEWORK

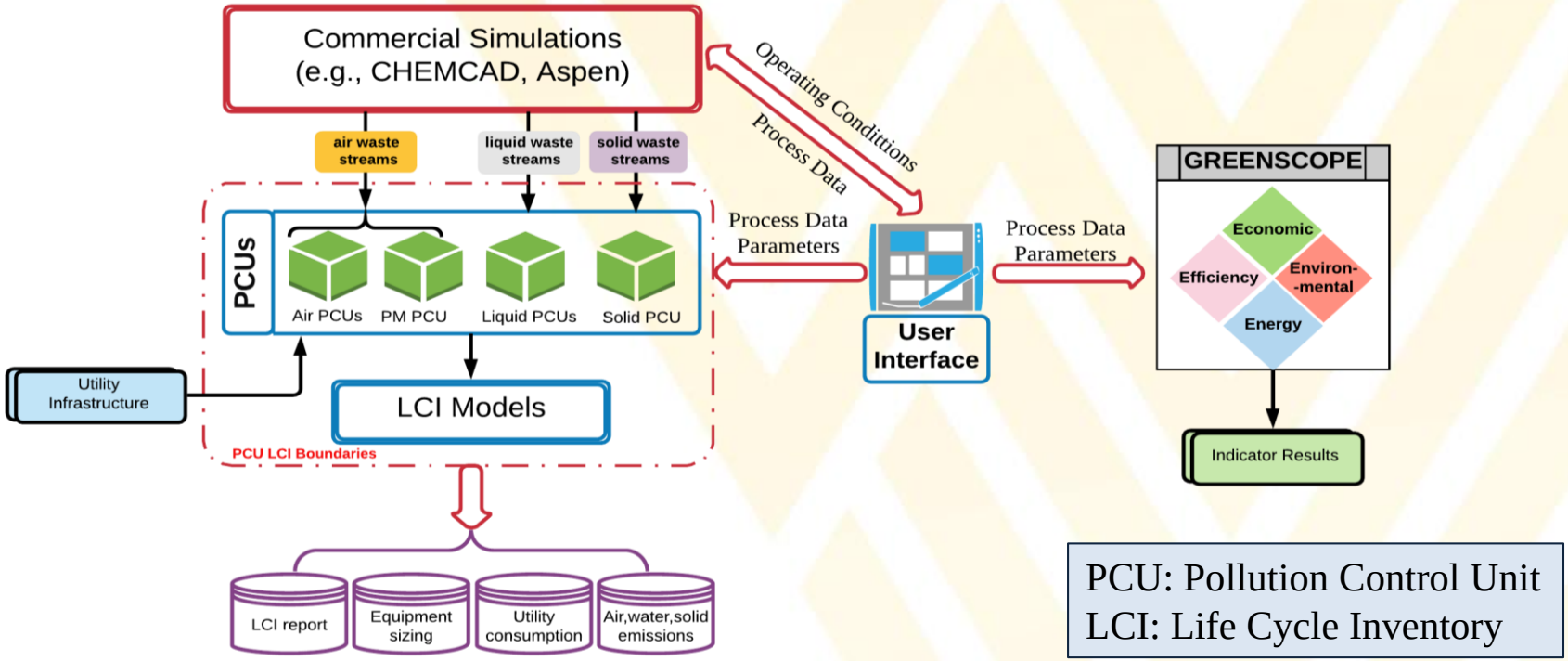

Figure 11: GREENSCOPE-PCU Framework

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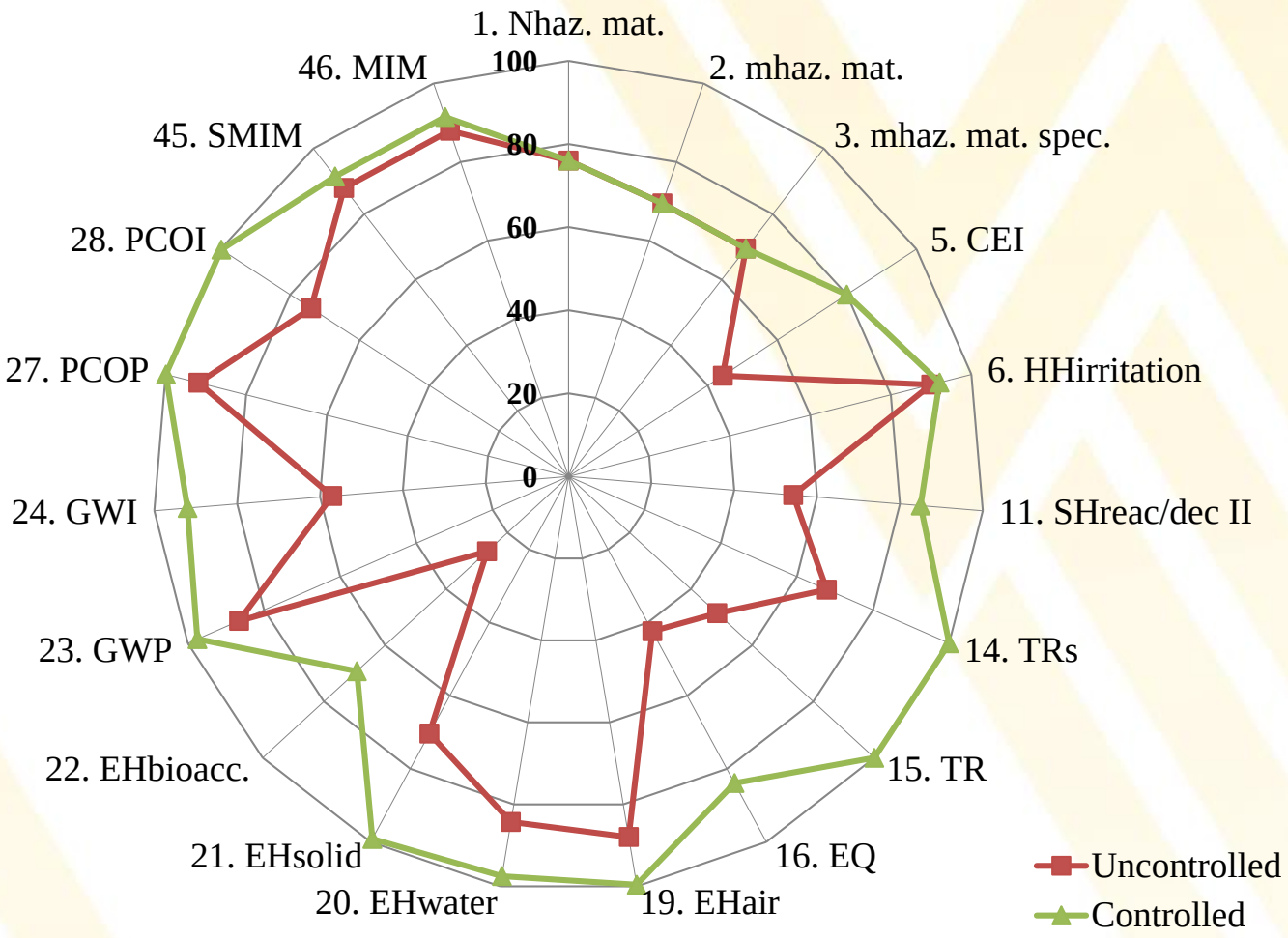
Results



- CEI (Chemical Exposure Index), EQ (Environmental Quotient), GWI (Global Warming Intensity) increased 35.65%, 41.56%, 34.93%, respectively, due to the controlled emissions by PCUs

Figure 12: GREENSCOPE-PCU Framework

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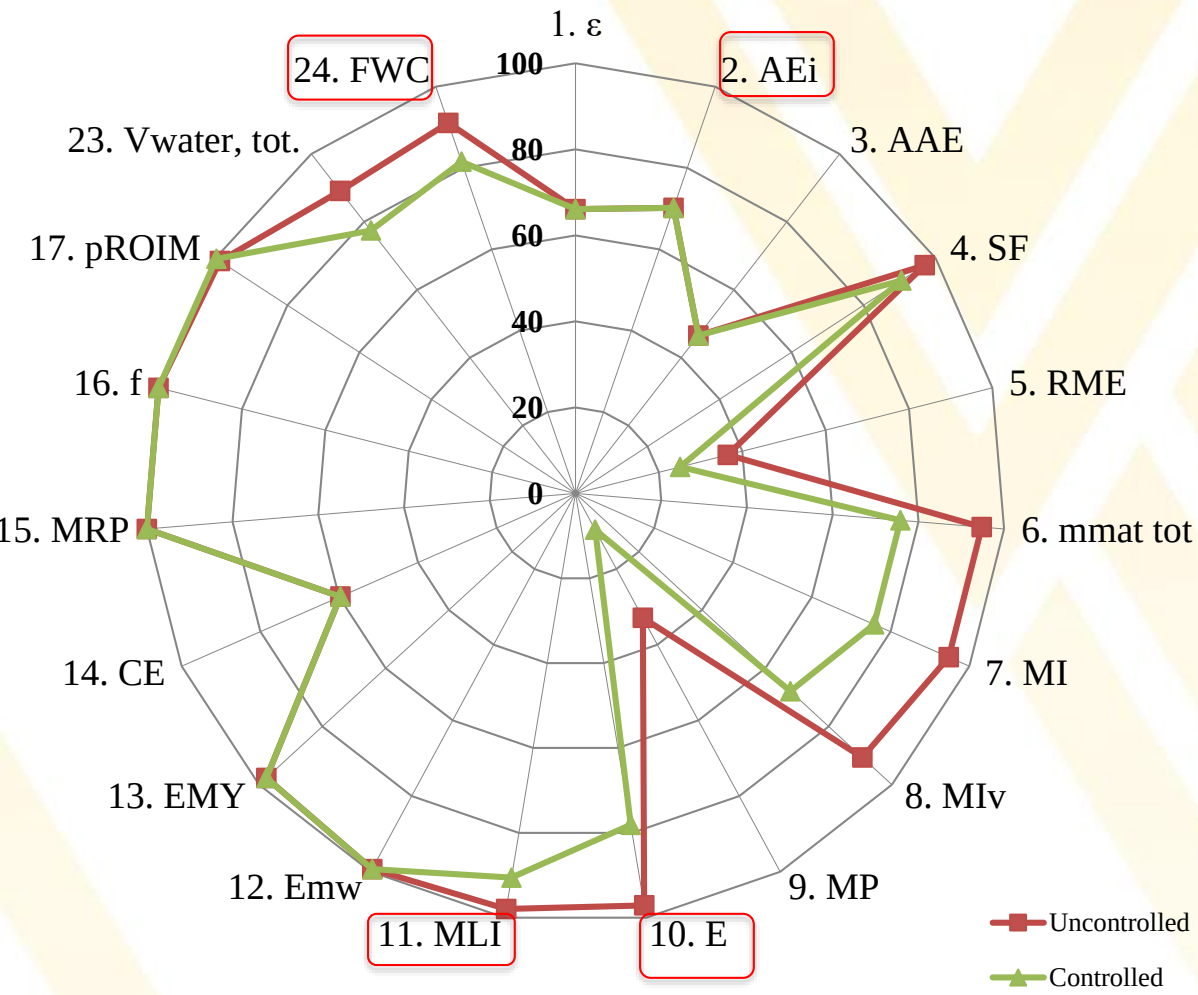
Results



- Radar plot shows that some efficiency indicator scores decrease when pollution treatment units are added to the process
- total material consumption ($m_{mat.,tot.}$), Mass Intensity (MI), dropped 18.94%, 19.98%, respectively

Figure 13: GREENSCOPE-PCU Framework

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CONCLUSIONS

- GREENSCOPE was used to estimate indicators and improve plant performance
- The PCU package is a great tool for estimating and simulating treatment operations and designs
- The motivation for the integration of these frameworks is to due to their reliance on the same dataset
- Proposed framework can bridge existing gaps between *sustainability assessment, pollution control,* and *process modeling* (commercial simulators)

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Thank you!

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