



August 30, 2011

Dear Catalyst SME,

Thanks very much for your willingness to share your expertise during the upcoming Catalyst Roadmap Subject Matter Workshop in Paris (September 7-8). We understand that your time is valuable so we really appreciate the time you'll take to join us. To make best use of that time and to make the workshop as useful as possible we've prepared this brief backgrounder and request for some prework on your end. The results presented are of course preliminary and as such should not be shared broadly.

**Workshop Objectives:** As noted in the introductory material sent with the invitation, the roadmap aims to describe the potential impact (historical, near term, future) of catalysis on energy and GHGs. In the past couple of months several routes of gauging the impact have been pursued (survey, open literature, proprietary database...) and we'd like to improve on that data with the following objectives for the workshop;

- Presentation of results, assumptions and potential/impact of catalysis on energy/GHG's
- Sanity check on assumptions and the estimated impact
- Check for missing processes with expected major impact
- Look on the horizon for new catalyst impact in emerging processes and gamechangers
- Fill data gaps where possible
- Understand hurdles and describe what's needed to address them

**Methodology:**

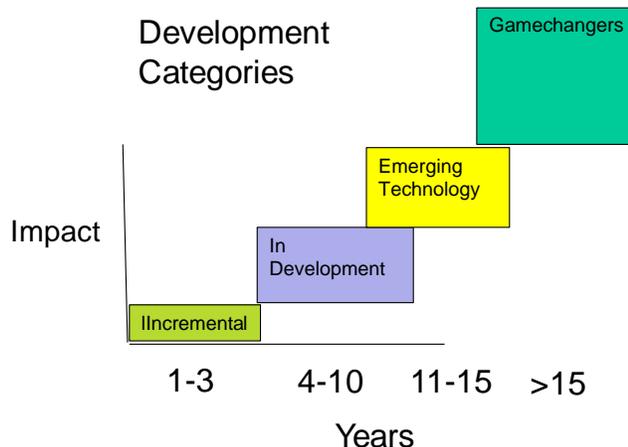
The rolled-up information by process from the questionnaire has been compared and placed in the context of other information to gauge the impact of potential catalyst improvements. The improvement rates from several sources were used along with the global capacity and the energy use (GJ/tonne) to estimate the impact. This was done for a selection of the 20 top energy consuming processes where catalysts have a significant impact, and in some cases processes were selected that had a good response rate in the questionnaire

## Stages of Development

The responses from the questionnaire cover a range of improvements with different timelines and development stages. The Incremental category is widely represented, but potential improvements are also noted in other categories.

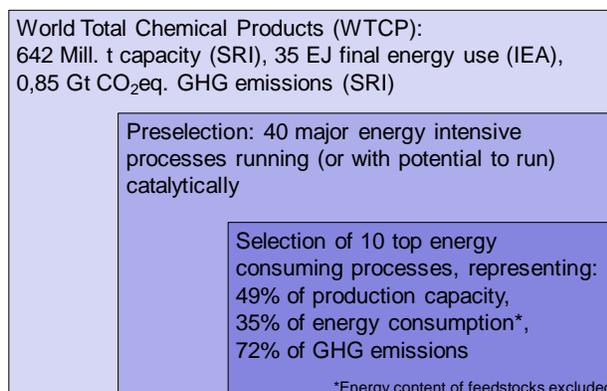
To describe the potential impact of catalysis on energy and GHGs **we would invite participants to think about the processes they are familiar with and consider improvements**

**in the later stages** (impact, resources needed, timing...) so the impact across all development stages can be summarized. If you're aware of prior categorization categories/methods that have worked well please bring this information so we can place improvements in the best context.

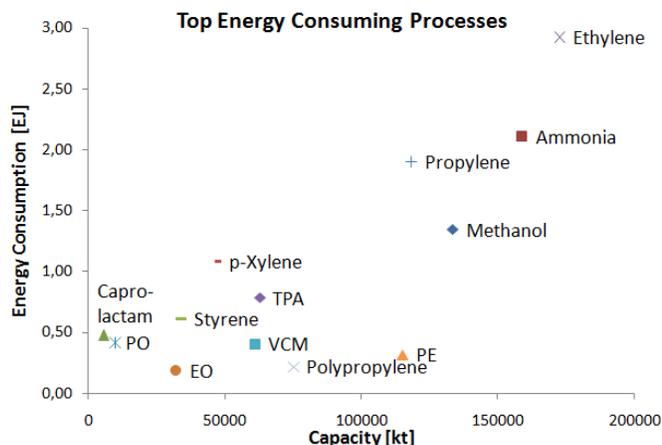


## Preliminary Data Views:

For this study the top energy consuming processes that presently use a catalyst have been studied. Also, several top energy consuming processes that don't presently use a catalyst but could in the future were included. These top 12 processes utilize about 14 EJ (exajoules, or  $10^{18}$  J) vs. the 35 EJ utilized by all chemical processes globally. It will be important at the workshop to clarify the basis for the 35EJ to be sure the numbers are on the same basis.



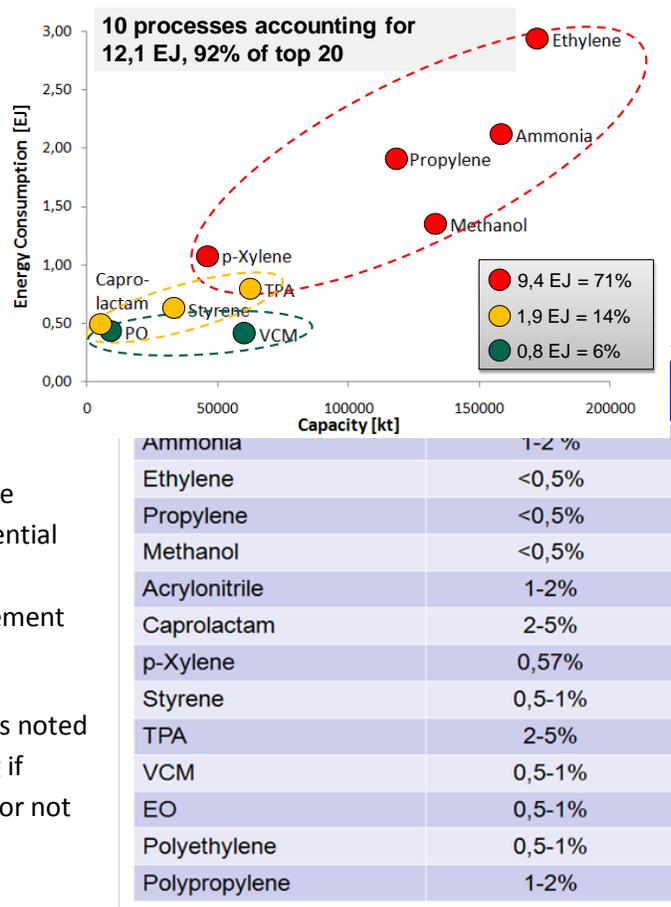
A summary of the 13 processes studied as part of this work to date shows the correlation between energy consumption and capacity. If there are catalyst improvements for those processes in the upper right of the figure, even if 1-2%, the impact could be substantial. A number of other catalytic processes can be found at even lower capacity, but their impact will be smaller.



An early treatment of the data shows several groupings of processes. The top 10 processes account for around 12 EJ, which is about 92% of the energy consumed by the top 20 processes. The first group (in Red) accounts for nearly 70% of that energy, and hence would be a prime target for catalyst improvements that would impact energy and GHGs.

The potential rates of improvement that could be made according to the questionnaire results, input from SRI, and expert opinion are listed in this table. With ethylene and other mature processes in the top group (red circles) having potential improvement rates around 1%/yr or less it's understandable that the composite yearly improvement rate is currently estimated around 0.6%.

As noted earlier a fair amount of the improvements noted in the survey reflected a near-term view. Verifying if additional improvements are likely in latter stages or not would be an important outcome of the workshop.



### PreWork

We'd ask that you consider the following questions in advance of the workshop. If you are aware of/ or can provide data that would be helpful in improving these estimates of impact so please bring that data to the workshop. We'd like to understand the potential impact for adoption of emerging technology, new processes, gamechangers, etc. so if you have info. here please also bring that info.

Area	Key Questions
General	Are you surprised that a major catalytic process is not included in the list of 12 analyzed by this ICCA study? If so, what's process? What data suggests it should be included?
	Do the improvement rates suggested so far seem about right to you? If not what data or other should be considered?
	What developments are on the horizon that would be considered "emerging technology" or "gamechangers" that should be included in the discussion of the processes below? What's the potential impact, timing, resources needed?

Process Specific	Key Questions, continued
Ammonia	In the survey it was noted that the reforming section was the most energy consuming. What's the potential for a catalyst improvement to significantly reduce energy in this section? What's the likelihood of new approaches (e.g. catalytic reduction of N <sub>2</sub> )?
Propylene	What would be the expected rate of steam craking replacement by catalytic once early demonstration plants line out? What would be the impact of bioethylene production?
Ethylene	Is an assumption of 3% annual replacement rate? Is a 20% adoption rate for catalytic processes for new facilities reasonable?

### Hurdles/ Resources

For improvements in the later development stages it would be useful to have you consider these questions;

- What are the most significant hurdles?
- What is the development timeline? Adoption timeline?
- What resources, focused research, etc. would be needed to lower those hurdles?

Again, thanks very much for your participation in the upcoming workshop. We look forward to discussing this topic with you.

The Catalysis Roadmap Core Team