Background -- ICEF CO$_2$ Utilization Roadmap 1.0 (November 2016)

• Analyzed CO2 utilization technologies and market potential in wide range of areas.

• Found significant market and CO$_2$ mitigation potential
ICCF CO\textsubscript{2} Utilization Roadmap 2.0
(Project launched May 2017)

Deeper analysis of:

- Cement and aggregates (near-term)
- Chemicals (medium-term)
- Durable carbon materials (long-term)
- Policy options
- Life cycle analysis
ICEF CO2 Utilization Roadmap 2.0
(released today)

Key Messages

• R&D required to bring most products to market
• Market development will require policy support
• Life cycle assessment is key
We analyzed three CO₂ utilization opportunities:

Near-term: Cement & Aggregates

Mid-term: Chemicals

Long-term: Durable Carbon Materials
Concrete & Aggregates

- Near-term opportunity
- Energetically favored but slow reactions
- Direct use of CO$_2$ in concrete could have large climate benefits
- Raw materials are a challenge for aggregates
Key Messages

Commodity Chemicals

- Near-to-mid term opportunity
- Many products and technology pathways
- Low-carbon electricity and hydrogen need for climate benefit
- R&D to advance new pathways needed
Key Messages

Durable Carbon Materials

• Long-term opportunity
• Potentially high value, large future market
• High leverage on energy-saving applications
• R&D to advance basic understanding needed
Cross-cutting R&D needs

- Improved catalysis
- Reactor design that takes advantage of advanced manufacturing technology
- Integration of CCU with CCS
- Identification of barriers to scale-up
Lifecycle assessment is essential

- The LCA and energy modeling communities should collaborate to improve consequential LCA for CO$_2$-based products.
- The CO$_2$U community should be cognizant of the lessons learnt from LCA of biofuels and CCS.
- Point answers are inadequate: ideally, use probabilistic uncertainly analysis and, at a minimum, parametric sensitivity analyses.

Climate is important, but so are other environmental impacts.
Policy support is essential

• Significant R&D needs
• Climate mitigation benefits not captured by markets
• Market barriers (e.g., incomplete standards) need identification and work to change
Policy Tools

1. Government support for R&D
2. Carbon Price
3. Mandates
4. Pipeline development
5. Government procurement
6. Lifecycle assessments
7. Certification and testing
8. Product labeling
Conclusion: CO$_2$ utilization is feasible and can be beneficial

• Our report identifies pathways to achieve it in:
  • Cements
  • Chemicals
  • Durable Carbon Materials

• R&D extent, development of lifecycle methods that are widely agreed upon, and policy support will determine timing for climate impact.