MIT Research Update
MIT Roosevelt Project and MIT CEEPR

CIBO Energy/Sustainability Meeting

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The Roosevelt Project

- **The Roosevelt Project derives its name from three prominent figures in American history:**
  - Theodore Roosevelt for his stewardship of the environment during his presidency, protecting over 230 million acres of public land.
  - Franklin Roosevelt for embodying a commitment to expanding the middle class in response to the Great Depression.
  - Eleanor Roosevelt for her staunch support of social justice issues.
- The project is headed by former Secretary of Energy and former Assistant Secretary of Energy for Nuclear, Ernie Moniz
- The program is supported by the MIT CEEPR and over 24 companies and organizations.

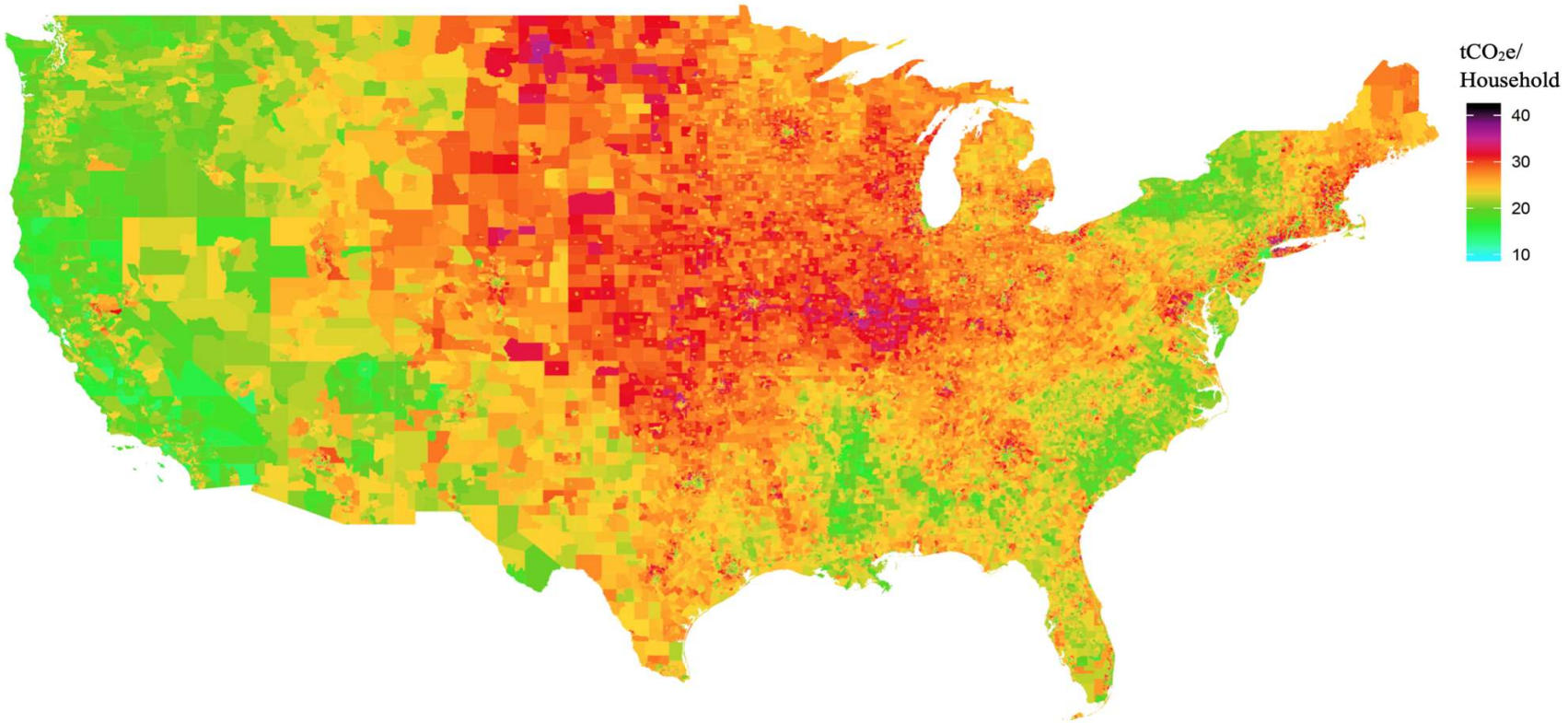
MIT Roosevelt Project

- A deep decarbonization transition in the United States will have unequally distributed effects across socio-economic groups, geographies, and economic sectors.
- The goal of the Roosevelt Project is to provide an analytical basis for charting a path to a low carbon economy in a way that promotes high quality job growth, minimizes worker and community dislocation, and harnesses the benefits of energy technologies for regional economic development.
- The current project has 2 phases:
  - The first phase looked at the overall transition issues and prepared a series of papers.
  - The second phase looked at 4 specific regions for deeper analysis:
    - Southwestern PA, Industrial Midwest, Gulf Coast, and New Mexico

Industrial Transitions

- There are four general areas (or domains) that encompass markers of community health:
  - human capital,
  - business landscape,
  - policy environment,
  - and social fabric.
- Each domain includes multiple societal attributes that affect community outcomes and each may drive success in a way that is distinct from the others.

Regional Carbon Footprints



A Typical Example

- Consider the experience of Adams County, Ohio.
- Adams County, 70 miles from Cincinnati, experienced an economic boom in the 1970s and 1980s following the commissioning of two coal-fired power plants. At the time, coal-fired power plants delivered 80 percent of Ohio's electric power.
- Along with the plants came jobs, from handling heavy machinery in the yard, to operating boilers and turbines, to ensuring water quality and regulatory compliance.
- In recent years the availability of inexpensive natural gas and increased emissions reduction policies have combined to make traditional coal-fired power plants less economically viable.
- In 2017, AES, the owner of the Adams County coal plants, announced that they would close, leaving the roughly 500 employees at the two plants jobless. In addition to worker displacement, the plant closures created an acute budget crisis for Adams County – tax revenues from the plants made up 10 percent of the county budget – already under great stress as the criminal justice system was overwhelmed by the on-going opioid epidemic. In response to budgetary woes, the county was forced to cut spending on education, among other public services

Retraining Programs

- In every case, in every geography, and every community size, retraining and career support is placed in the hands of the corporations, which makes the process opaque at best.
- There is very little evidence concerning what, if anything, these programs have added for displaced workers.
- Facilities with proximity to strong research hubs can lessen corporate reliance by partnering with universities to develop a more highly-skilled manufacturing line.

Some Key Points

- Policy packages are strongest when they acknowledge distinct regional social fabric and human capital, carefully structure policy to encourage cross-community collaboration, and design policy with the particular business landscape in mind, while avoiding overreliance on private firms.
- Knowledge of a community's specific skillsets and an understanding of the importance of geography is paramount to managing a transition. Each community has its own characteristics, and policymakers should be fully aware of these.
- Build ties between core institutions. Nearly every example of industrial transition investigated benefitted from a robust structure of communication and trust between local players.
- Leverage economic development corporations and public-private partnerships with caution.

Phase 1 Economic Results

- A baseline case was done to look at costs, jobs, industries, and social conditions. Current regulations and policies were assumed.
  - There was some decarbonization.
  - The goals for 2030 and 2050 were not achieved.
- A second case was undertaken as a kind of “unplanned” decarbonization.
  - Rules and limits were assumed, but no real planning for the impacts.
  - All regions will see a lower GDP as a result of decarbonization.
- The third case simulated “recommended” policies to help offset these losses.
  - Revenues from a carbon tax could be recycled to those areas identified in the footprint.
  - Job training and infrastructure will be necessary.
  - Border adjustment tariffs will be needed.
  - Coordinated policy interventions across jurisdictional scales and “siloed” policy domains will be required.

Phase 2: Case Studies

- The first region was southwest Pennsylvania
- This region went through a major transition with the steel industry.
  - There was a definite decline in the region.
  - There was relatively strong social cohesion.
- The region recovered to a reasonable extent by rethinking and reinventing the region. Healthcare was identified as an area of focus.
- For decarbonization, another focus will be needed (broader perspective).
  - One possibility is environmental reclamation and remediation.
    - There are thousands of abandoned gas wells from before the fracking era
    - There are waste coal piles, etc.
  - Carbon management is another possibility.
    - CCS will be needed to continue to utilize the Marcellus and Utica gas resources.
    - Regional CCS hubs should be developed, particularly to produce hydrogen from natural gas.
  - Small nuclear power plants could be a technology for the future of the region.
    - DOE development program

Phase 2: Case Studies

- The next region was the industrial heartland, including Michigan, Ohio, and Indiana. The main focus was on the auto industry.
  - The study looked at the impacts of converting the industry over to EVs.
  - At one time, 1 in 6 jobs was related to the auto industry in the US.
- Manufacturing is still the largest source of jobs in the region.
  - The auto industry is still the largest sector for manufacturing in the region.
- Historically, the region has experienced over 180 plant closures since 1980.
- Workers feel as though conversion to EVs is probably better than nothing, but there is still a lot of uncertainty and concern that this conversion will be just as "bad" as the past declines.
- In particular, parts manufacturing will likely suffer the most (ie fuel pumps, spark plugs, fuel injectors, exhaust manifolds, etc.)

Phase 2: Case Studies

- There is also uncertainty over the actual "success" of EVs in the market.
  - There are well over 1 billion vehicles in the world using IC engines, not counting trains, planes, and ships. That number is still growing.
  - China leads the world in EV sales, followed by the EU. The US has seen only 2 – 3% of vehicle sales for EVs and half of that is in California. EV sales are near zero in Japan, Asia Pacific (ex-China), and the rest of the world.
- The percentage of African Americans at work in the industry has fallen from 30% in 1980 to about 10% today.
- The pay scale at plants in the region is 40% higher than foreign based plants in other parts of the US (primarily due to union contracts).
  - This leads to suggestions that what is really needed are high paying union jobs and, thus, subsidies for such jobs (think trade restrictions, US content requirements, tariffs, etc.)
  - One suggestion is to set up a Federal Transportation Electrification Commission to coordinate needed actions while accounting for displaced workers.

Phase 2: Case Studies

- Utility companies in the region have been more forward looking and could serve as a model for other industries to follow.
- The auto industry is not the only industry to suffer.
  - Incandescent light bulb plants have been closing.
  - Appliance manufacturing has been closing.
  - Coal fired power plants are closing.
- Potentially 100,000 jobs are at risk.
- The economic impacts are effecting the R&D being pursued to the point where the US is losing its technology base in these areas.
- CCS will be needed due to the coal base in the region (around 300 coal plants)
- Solutions can be identified, but implementation is very difficult due to the different perceptions of all of the parties involved.

Phase 2: Case Studies

- The third case study was the Gulf Coast region, particularly with respect to the oil and gas industry. The energy transition will have a major sociological impact on this region. Success will be more likely with socially equitable approaches.
- The community strongly identifies with the energy industry and infrastructure of the region, particularly with regard to problem solving.
  - Everybody is related to or knows someone that works in the industry. They understand that these people are not willfully destroying the environment.
  - Opportunities include industrial facilities, energy infrastructure, trained workforce, and port facilities. Many of the potential solutions (ie blue or green hydrogen) involve the same kinds of technologies and skills as the current industry.
  - Challenges can be converted to opportunities through proper dialogue.
  - Recognition of the problem without finger pointing can help to establish a path forward for remediation.

Phase 2: Case Studies

- Interviews were done with 75 leaders and stakeholders in the region.
  - Care needs to be taken to identify “trigger words” (like fossil fuels instead of oil and gas) and avoid using them.
  - Communities vary in the social resources that they can bring to bear on the problem.
  - Collective efficacy in communities looks at how these communities can represent themselves with regard to these issues.
  - Houston is the major player in the region.
  - New social processes will be needed to help bring people together.
- The region would be ideal for a CCS hub and a hydrogen hub.
- A Gulf Coast skills consortium has been suggested.
- The DOE needs to demonstrate more technology that is applicable to this transition.

Phase 2: Case Studies

- The 4th case study was New Mexico. The state is a producer of both traditional and renewable energy. The energy transition is already underway there. Fossil energy supplies roughly half of the GDP for the state.
- Roughly half the population is Mexican or Latino. Another 9% is Native American.
- The state has espoused at 45% reduction in GHG emissions by 2030. Most of this is planned for the utility industry.
- Transportation accounts for 34% of the state's CO2 emissions.
- The oil and gas industry, transportation, other industry, commercial, and residential emissions will all have to be reduced.
- Rural and low income households spend a disproportionate share of their income on transportation.

Phase 2: Case Studies

- Due to the low population density, charging infrastructure is difficult to implement. There are often 50 – 60 miles between towns with not much in between.
- CCS and hydrogen hubs can be implemented due to the amount of co-located assets. Natural gas processing removes CO2 before the pipeline. This can be collected and piped to storage or for use in EOR. Gas can be converted to hydrogen (blue or green).
- Mining is another opportunity in that many metals and materials will be needed in a low carbon future. A new Lithium mine has already been opened.
- Biogas and renewable gas can become net negative with the use of CCS.
- Geothermal resources are also available.

Phase 2: Case Studies

- There is a need for base load power to be combined with renewables. Biogas, RNG, and hydrogen can all power combined cycle plants to provide the power.
  - The integration of such plants with renewable sources could potentially be more valuable than battery storage.
  - Sufficient renewable capacity would be needed to power the production of these fuels.
- Distributed energy on public, private, and tribal lands can help renewables.
- Unabated coal units need to be phased out (ie those without CCS).
- Hydrogen and BECCS represent an opportunity for the future.
- Fugitive methane emission need to be reduced.
- New legislation and executive actions will be needed to support decarbonization beyond the utility sector.
- There are 2 national labs that can be used to help develop the technologies.
- Inclusive communications are needed to involve all stakeholders.

Phase 2: Case Studies

- Note that CCS was clearly identified in these case studies. Several presenters mentioned the funding that has been earmarked in the infrastructure bill. The studies were completed before the bill was passed.
- For reference, the bill includes:
  - $ 2.5 billion for CCS demonstration projects
  - $ 1.0 billion for CCS pilot plant projects
  - $ 3.5 billion for Direct Air Capture hubs
  - $ 5.0 billion for the development and financing of CO2 transportation and storage infrastructure.
- According to the Global Carbon Capture and Storage Institute there are currently 24 CCS facilities operating in the US and another 50 projects that are scheduled for startup by 2025.

Phase 2: Case Studies

- Also referenced were ideas that show up in the “Build Back Better” proposal.
  - Some $ 550 billion has been earmarked for climate and environmental justice.
    - $ 160 billion to address legacy pollution issues for impacted communities.
    - $ 30 billion for a Civilian Climate Corps.
    - $ 29 billion for a GHG reduction fund.
    - Clean Energy tax credits tied to core labor standards.
    - Transmission investment tax credits to upgrade the power grid.
    - Point of sale tax credits for EVs (new and used).
    - Investments in manufacturing.
    - Investments for “hard to decarbonize” industries (steel, cement, and aluminum).
    - $ 6 billion to establish a consumer rebate program for the purchase and installation of heat pumps.
    - $ 26 billion for conservation and restoration of forests.
    - $ 23 billion for agricultural conservation.
    - $ 6 billion for coastal restoration.
    - $ 1 billion for a Rural Partnership Program.

Next Steps

- Meetings will be held in Washington, DC to present the results and various recommendations of these studies.
  - The policy issues will be highlighted.
  - Of course, more R&D funding is needed.
- A lot of hard work and effort will be needed to ease the transition to net zero emissions by 2050, especially for displaced workers.
- Additional studies need to be done on the regions that were not included in phase 2, as well as developing a means to estimate the impacts of these regional actions on the overall economy.
  - While overall simulations exist, there needs to be a means to sum up the impacts on the individual regions to come up with a better picture of the overall result.
    - For example, a carbon tax (or price) is deemed necessary. However, recycling the tax receipts to individual households can be done in many ways. Accounting for regional differences will change the overall impact on the economy.

MIT CEEPR Industrial Decarbonization

- Industrial decarbonization is at the heart of the overall goal of net zero GHG emissions by 2050. Industrial applications often involve the need for high temperature heat energy. This will drive the need for alternative energy approaches to the problem.
- In a recent webinar, some results related to the steel industry were presented.
- Cement, iron and steel, chemicals, non-ferrous metals, and refineries are being studied to try to identify some of these approaches.
- Power, industry, transportation, and buildings all intersect at some point relative to energy requirements and use.
- If industrial processes could be made more flexible, integration with the other sectors could help reduce overall costs of decarbonization.

Steel Industry Processes

- Both blast furnace technology and direct reduced iron technology utilize coal to provide the energy for steel making, as well as the carbon for carbon steel.
- Pathways to lower carbon intensity include CCS, hydrogen, biomass, and natural gas. Increased utilization of scrap steel can also help to reduce overall emissions (electric arc furnaces).
- A full life cycle analysis must be done to evaluate the net result of each of these pathways, including scope 3 emissions.
- MIT CEEPR has carried out such studies for blast furnace and DRI technologies on a global basis.
- The results of these studies indicate that CCS is the most effective way for reducing GHG emissions for both systems.
- The use of hydrogen in the DRI process can become more competitive as the power grid progresses towards decarbonization.

Steel Industry Processes

- For natural gas processing, ammonia production, and ethanol production, CCS costs are lower at about $50/ton based on today's MEA technology.
- For other industries, CCS costs are closer to $100/ton.
- Refineries and ammonia production are major users of hydrogen.
- The use of blue and green hydrogen in these industries can reduce GHG emissions.
  - Questions remain about the production of large quantities of hydrogen, the storage of hydrogen as an energy carrier, the transportation of hydrogen, and the cost of hydrogen.
  - Today, most hydrogen is produced from steam methane reformation of natural gas that is done locally at the refinery and used on site.
  - For some regions, coal gasification can be used to produce the hydrogen provided CCS is used to capture the CO2.

Steel Industry Processes

- Ceres is a Boston based NGO. It was founded by a family grant after the Exxon Valdez incident. It is primarily funded by foundations, particularly those with an ESG lens. There are over 200 institutional investors with over $ 47 trillion of assets under management. There are 647 member companies.
- Ceres works with companies to improve their ESG commitments. Tools include meetings with companies and shareholder proposals.
- Resources include the IPCC work, the Task Force on Climate Related Financial Disclosure, standardized ESG reporting, GHG targets (The Science Based Target Initiatives), and the Responsible Steel Platform.
- There are additional investor driven alliances and platforms. In particular, there is the Climate Action 100+ group. This group is aimed at the top 100 emitting companies in the world, reportedly responsible for 80% of the GHG emissions.

Steel Industry Processes

- The US steel industry is already the most carbon efficient steel industry in the world. This is primarily due to the electric arc furnace and scrap steel.
- There are only 17 coke ovens left in the US and 33 blast furnaces.
- As the power grid becomes more driven by renewable energy, the US steel industry will automatically reduce its GHG emissions.
- At this time, most US steel producers have 2030 and 2050 reduction targets.
- There are two green hydrogen projects for steel underway in the US.
- The Ceres Clean Steel program is pushing the industry to adopt medium term Science Based targets (ie those from the Science Based Target Initiatives).
- They are also pushing the industry to go for net zero by 2040 on the grounds that the US steel industry is already in the lead and can, therefore, be the world leader ahead of the overall target of 2050 (somebody has to be first).

The Discussion Period

- It was pointed out that the EU will be adopting product GHG emission requirements. There are no real standards for claiming and verifying the carbon footprint of a particular individual product. Nevertheless, companies will have to respond to these policies.
- Without a carbon price, it will be difficult to make cost comparisons for the various pathways. Nearly all of these pathways cost money (with the possible exception of some efficiency gains). These costs will have a difficult time being justified without a carbon price.
- Prof. Emeritus John Deutch (former Under Secretary of Energy, head of CIA, Deputy Secretary of Defense, Director of Energy Research, President's Committee on Science and Technology, etc., etc.) pointed out that regardless of whether or not there is a carbon price, costs for decarbonization are going to cause increases in energy costs. These cost increases will hit consumer pocketbooks and cause distress (ie backlash). Increased costs will cause a headwind in the push for "net zero". Impacts will be different for different regions.

Key Takeaways

- Regional differences matter.
- Worker dislocations and community disruptions will need to be addressed in order to be successful in achieving climate goals.
- Decarbonzation is going to cost money.
- CCS and hydrogen appear to be the current technology approaches to something like near and medium term applications.
- There are going to be a lot more commissions and councils appearing in the next few years.
- It looks like “hubs” is going to be the new buzzword (ie CCS hubs, hydrogen hubs, etc.)
- Only one of the 4 case studies mentioned small nuclear reactors (SW PA). More on this from another MIT webinar.

Small Modular Reactors

- Present day, conventional nuclear power plants are 1100 – 1300 Mwe.
- The DOE small reactor program is looking at a 100 Mwe size. By contrast, submarine and aircraft carrier nuclear systems are 25 – 30 Mwe in size.
- There are 70 advanced nuclear power projects in North America.
- Further scale down to 10 Mwe or less is being considered for what is being called a nuclear battery.
  - The system is self contained.
  - The nuclear fuel for the system is expected to last 10 years. After that, the module is removed and a new one put in its placed (like plug and play).
  - The module would be transportable and use dry cooling.
  - Such modules could be used in desalination, flood protection, hydrogen production, data centers, EV charging stations, indoor aquaculture, ship propulsion, CHP, district heating, microgrids, military bases, and space installations.