Concurrent Session Part 2 “CO2 Utilization”
(Minutes Summary)

[Opening Remarks]
David Sandalow (Chair), Inaugural Fellow, Center on Global Energy Policy, Columbia University

In his welcome talk, Mr. Sandalow briefly emphasized the need for every tool to tackle challenges in mitigating climate change, and he talked about the enormous marketable potential of captured CO2 utilization in products in addition to CO2 capture and storage in the decarbonization strategy. He denoted that with comments from the session, final version of the roadmap will be presented on COP22.

[Presentation]
“CO2 Utilization Roadmap”
Issam Dairanieh, CEO, CO2 Sciences

Dr. Dairanieh started by introducing key points in developing CO2 utilization roadmap; identify technology, market opportunities, and incentivized to accelerate deployment; in his presentation of the draft roadmap for comments. He first presented potential products that can be created using CO2, and its impact on decarbonization and market opportunity. He explained the potential of CO2 consumption by the products from CO2 utilization as to 4 giga tons per year at 2030, and its implication on achieving net zero and even net negative emissions later this century.

Following the introduction, Dr. Dairanieh showed technological landscape of the CO2 utilization, including mineralization, catalytic conversion, and fermentation for CO2 conversions. Over the 200 global developers are identified in the database, and these technologies are categorized by technological readiness, conversion technology, and targeted end products. This identified that wide range of conversion processes exist, of which catalytic conversion, mineralization and electrochemical conversion are the most widely studied based on number density of developers. Development of catalysts is a prime research area to make the conversion processes more efficient; this research builds upon decades of work in catalysis in general. Some conversion processes focus directly on using sunlight as a low cost energy source for conversion (photocatalytic, photosynthesis, algae production). For the product side, six major sectors were
categorized as follows; algae for biofuels and food additives, fuels (mainly methane and ethanol), chemical intermediates, polymers, building materials, and novel materials.

In the market assessment, building materials (e.g. concrete, carbonates aggregates), chemical intermediates (e.g. methanol, syn-gas), fuels, and polymers are prioritized in terms of environmental impact and commercial opportunity. He exemplified building materials with concrete, and explained the technological maturity in CO2 utilization and importance of policy and business “intervention” to accelerate market deployment. Tremendous market opportunities of CO2 utilization were estimated that the markets for a selected sub-sectors could exceed $500 billion in annual revenue by 2030.

At the end of his presentation, five key strategic actions were shown to accelerate the deployment of CO2 utilization. They are: 1) implement carbon price and increase mandates for renewable products and fuels, 2) decrease cost of utilization of CO2 by funding research to improve catalysis for CO2 reduction and to improve electrolysis to produce hydrogen, 3) scaling up production by collaborations between research institutes, start-ups, governments and corporation, 4) steady supply of CO2 by development of a CO2 infrastructure, and 5) fund applied research on long-shot technologies that have high CO2 abatement potential.

[Comments on draft roadmap]
“Sustainable Pathways to CO2 Utilization”
A.-H. Alissa Park, Director, Lenfest Center for Sustainable Energy, The Earth Institute, Columbia University

Alissa Park outlined the diversity of CO2 utilization schemes, and started from currently utilized EOR option in US. She extended the utilization scheme to fuels and chemical conversion, and pointed out the challenge in improving efficiency of the slow process and reduction of footprint to make these higher energy materials. She then presented the mineralization process to produce carbonate using CO2. The process mimics natural chemical transformation in weathering, and provides appropriateness for long-term environmentally benign and unmonitored storage. An important conclusion of her presentation was that industrial waste could result in safe materials and for long-term carbon storage in the CO2 utilization schemes.

“Can CCU show the enough impact to mitigate climate change?”
Tohru Setoyama, Fellow, Executive officer, Mitsubishi Chemical Corporation

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Toru Setoyama presented an innovative technology to have drastic potential of CO2 mitigation and economic co-benefit. Solar to Hydrogen (STH) system was proposed in the evaluation and its high abatement potential was shown with anticipated improvement of efficiency in the system. Then he discussed the economic advantage for value-added chemicals compared to fuels in the CO2 utilization even with its high requirement of investment, also suggested importance of the policy incentive to actualize of future CCS using the economic benefit from the deployment of CO2 utilization in value-added chemicals in the long-term decarbonization scheme.

“It’s Comments on Draft of ICEF CO2 Utilization Roadmap”
Etsuko Fujita, Senior Chemist, Leader of the Artificial Photosynthesis Group, Chemistry Division, Brookhaven National Laboratory

Etsuko Fujita outlined two fundamentally different CO2 utilization, uphill and downhill reactions. She explained that uphill reactions which need energy input, and catalysts can lower the activation barriers. As a strategy for CO2 reduction which requires energy in the reaction, three processes were shown; photons as energy source, PV electricity as energy source, and CO2 hydrogenation using solar generated H2. She also denoted critical importance in catalyst developments. She outlined successes and challenges in these CO2 reduction processes in the current progress of researches. In the following discussion, possible new technology and opportunities for an on-board or on-site H2 generation system from formic acid fuel cell were mentioned. Finally, progress of development and its promising potential of solar fuels generation from CO2 were discussed with long-term need for basic research fund in the future commercialization path of solar fuels generation from CO2.

“Carbon Dioxide Utilization”
Colin McCormick, Chief Technologist, Valence Strategic LLC

Collin McCormick presented market opportunity of carbon fiber in the CO2 utilization, however, their constraint by high cost of the material was pointed out and the requirement for R&D was emphasized. For the demand side, key markets of carbon fiber consist from wind blades, aerospace, automotive, storage tanks (natural gas,
hydrogen), sporting goods, molding compounds, and tooling, showing growing demand projection to 2018, could yield significant emissions reductions.

In the latter half of his talk, McCormick discussed the topic of how to understand emissions impact of CO2 utilization, and the use of Life-cycle analysis (LCA) to fully accounting for net CO2-eq emissions and its challenges were shown. The challenges include variation of Global Warming Potential (GWP) among feedstock, allocation of emissions, and end-of-life treatment of CO2 based products. He also proposed extension of current credit for CO2 sequestration to CO2 utilization and its requirement for LCA.

[Discussion]

- At first, it was discussed on how 4 Gt of CO2 utilization in 2030 was generated in the roadmap, and its potential beyond 2030. It was answered that the potential was expected to continue beyond 2030, and it was reasonable to consider the technical development would be promoted in this time scale. Also it was stated that potential figure was based on different scenarios which assume with and without strategic actions.

- Best strategy in the different CO2 utilization pathways were then discussed in terms of sustainability and potential. The importance of CO2 utilization in industrial solid waste treatment was emphasized in the discussion.

- It was then brought up that how we think about permanence of products by CO2 utilization like fuels. In terms of avoided CO2 and absorbed CO2, favor on mineralization was mentioned. Also CO2 utilization by direct air capture in the production of fuels, which could bring negative emissions, was discussed with emphasis on certain potential of liquid fuels on transportation sectors, for example, jet fuels.

- One of the issues on economic value of the fuels produced by CO2 utilization was then questioned, and importance of value added chemicals and materials, and its profitable potential was mentioned.

- The question was raised on how to subsidize the products and problems in standardization of LCA in its process by governments. It was pointed out that the difference of local and global parameters is very important and challenging issue.
on development of public LCA databases due to the difficulties in sharing databases through detailed conversion processes.

- From the floor, question was raised on strategy in basic research and development and what governments can do in dedicated program and/or in the general progress in science and technology. It was highlighted that importance of connecting basic researches to technology and application side as shown in DOE reports, and also pointed out the past successes in R&D on PV and hydrogen system could also help in the development strategy of CO2 utilization technology.

- Then the pathway of CO2 feedstock use in chemical and fuels products with hydrogen was questioned. The question includes whether it is effective in energy use of hydrogen itself or generating products from CO2 combined with hydrogen in the point of thermodynamics. It was stated that the importance of production cost, particularly in hydrogen price. Also, benefit of chemical production path like methane and methanol from CO2 and hydrogen was discussed.

- For the final question, role of R&D funding by governments and their balance in the market were discussed. It was replied with the important role of government funding such as “Mission innovation”, and their possible help in CO2 utilization pathway connecting to the future large-scale CCS deployment, by use of learning rate of capture technology in CO2 utilization, and its big transitional play which could lead to carbon negative technology.