

International Institute for Carbon-Neutral Energy Research



CO₂ Capture & Utilization Revised Roadmap

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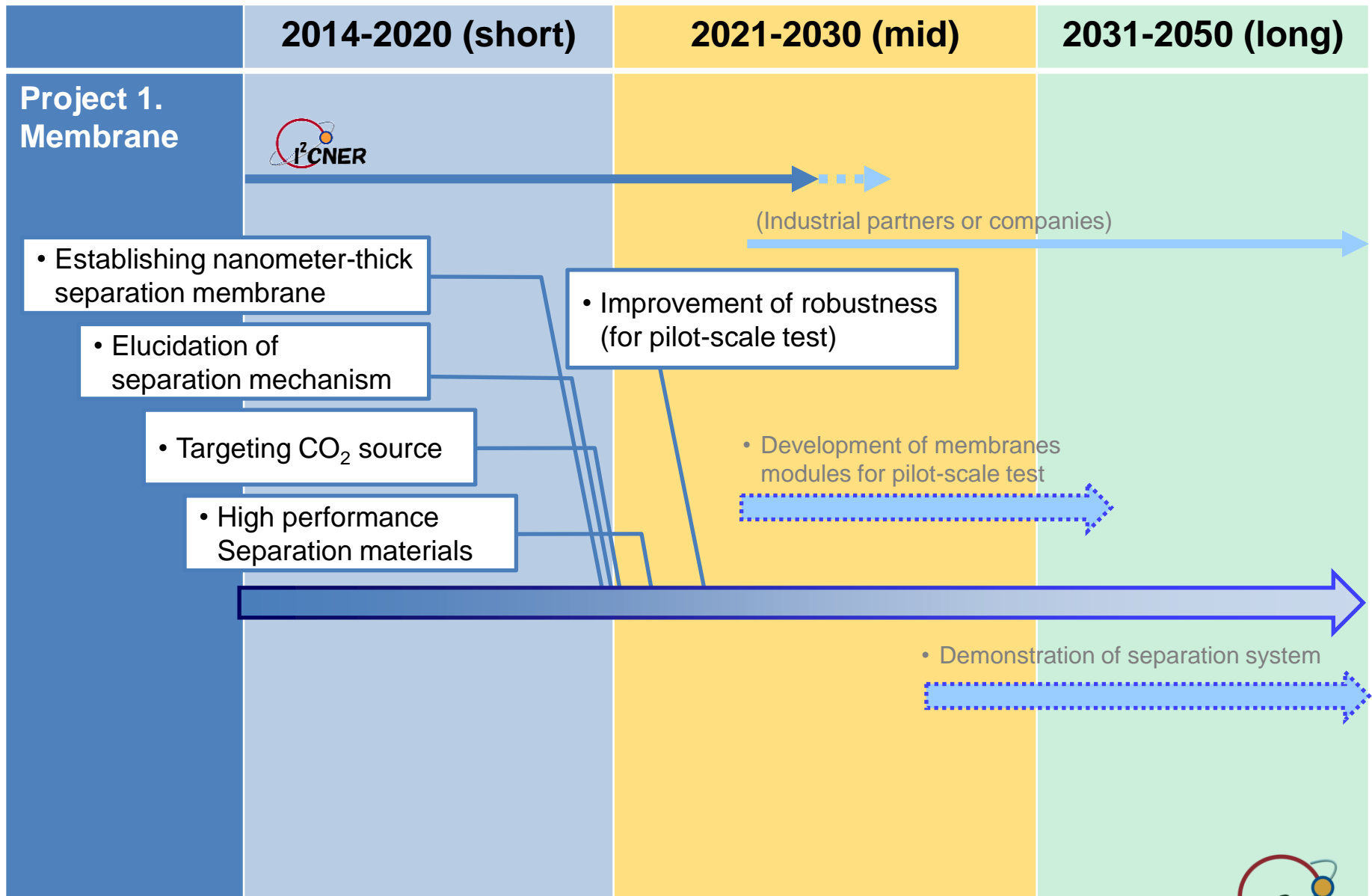
Division Objective

- **The development of highly efficient materials for CO₂ separation in power generation and industrial processes.**
- **The creation of energy efficient and cost effective CO₂ conversion systems for (i) production of value-added chemicals, such as a liquid fuel or their intermediates, or (ii) storage for renewable energy**

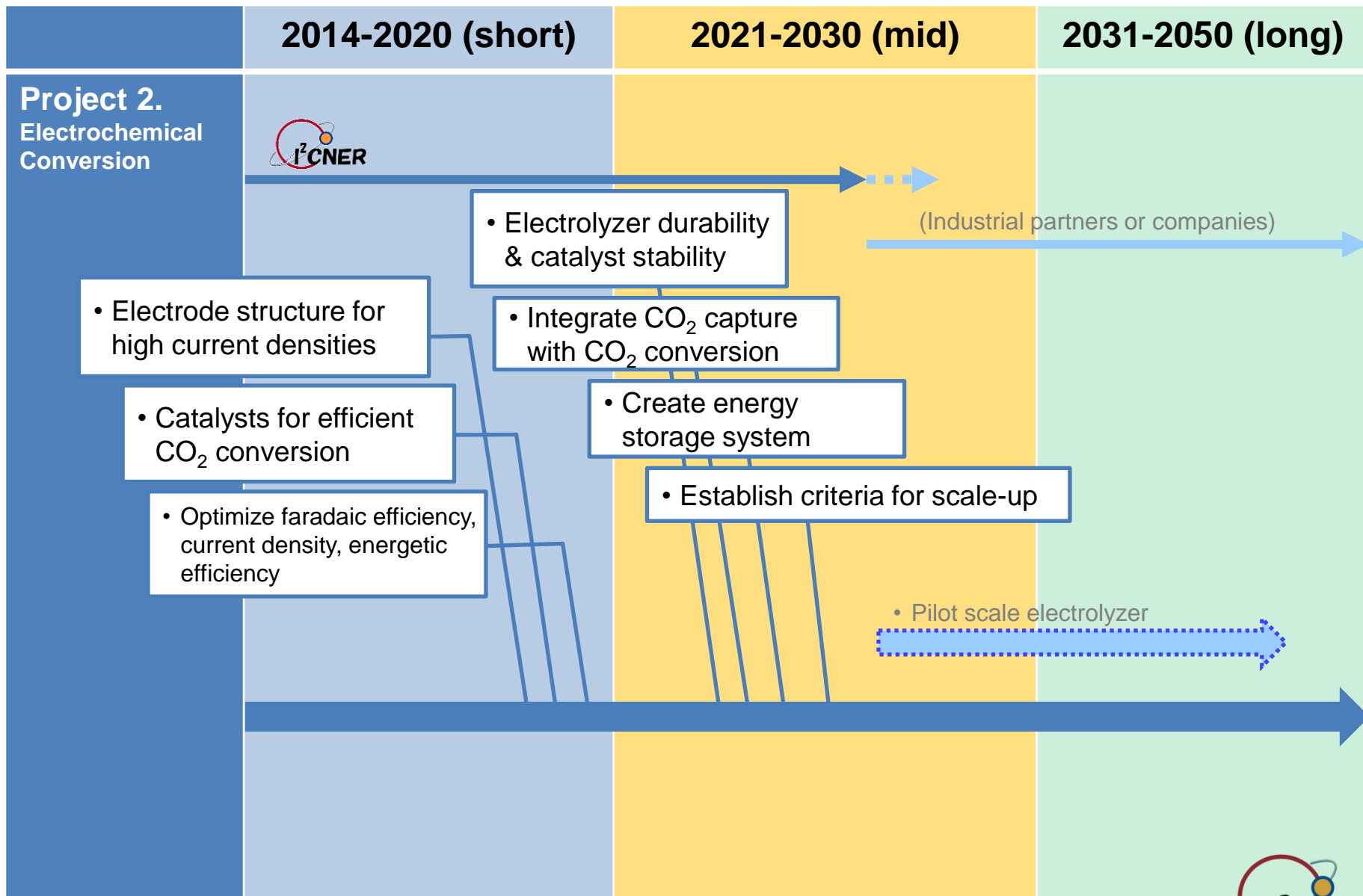
Division Projects, Objectives, and Research Efforts

Projects		Objectives	Research Efforts	Researchers
Capture	Project 1. Membrane	Develop novel membrane technology to separate CO ₂ from the mixture or (a) CO₂/H₂ (Pre-combustion) <ul style="list-style-type: none"> • IGCC/IGFC/NGTCC (b) CO₂/N₂ (Post-combustion) <ul style="list-style-type: none"> • Fossil-fired plant (c) CO₂/CH₄ <ul style="list-style-type: none"> • NG purification (d) Other industries <ul style="list-style-type: none"> • Cement (CO₂/N₂) • C-free H₂ production (CO₂/H₂) 	<ul style="list-style-type: none"> • Develop ultra-thin membranes with high CO₂ permeation • Development of high-performance ceramic and polymeric membrane materials • Improvement of a membrane durability • Elucidation of molecular mechanism in a gas separation 	S. Fujikawa I. Taniguchi B. Freeman
	Project 2. Electrochemical conversion	Develop novel catalysts and electrodes for the conversion of CO ₂ into value-added fuels or their intermediates (e.g. CO, Methanol and hydrocarbon)	<ul style="list-style-type: none"> • Improve performance of precious-metal catalysts though use of different supports (C, CNT, TiO₂) • Explore metal-free catalysts • Develop high performance, durable electrodes • Study performance with a diluted CO₂ feed (flue gas, 15% CO₂) 	P. Kenis Aided by N. Nakashima T. Fujigaya S. Lyth A. Gewirth
Conversion				

Milestones (1)



Milestones (2)



Ultimate Targets

	Ultimate targets	Current Benchmark	Technology/ Application
Project 1. Membrane	<p>Demonstration of a highly efficient separation system to remove CO₂ from pressured gas containing CO₂</p> <ul style="list-style-type: none"> ➤ CO₂/H₂ (Pre-combustion)* CO₂ permeance: 100GPU Selectivity: 30 (single cascade) CO₂ permeance: 30 GPU Selectivity: 125 (tandem cascade) @p(CO₂) 10 atm ➤ CO₂/N₂ (Post-combustion)* CO₂ permeance: 4000 GPU Selectivity: 40 <p>(*But these numbers are still under investigation, since they depend on separation processes.)</p>	<ul style="list-style-type: none"> ➤ CO₂/H₂ (Pre-combustion) CO₂ permeance: 41GPU Selectivity: 87 @p(CO₂) 3 atm (Ohio state Univ., USA) ➤ CO₂/N₂ (Post-combustion) CO₂ permeance: 1000 GPU Selectivity: 40 (MTR, USA) <p>(1 GPU = 7.5 x 10⁻¹² m³(STP)/(m² s Pa))</p>	<ul style="list-style-type: none"> • CO₂ capture from flue gas of coal / natural gas power generation for CCS / CCUS system
Project 2. Electrochemical Conversion	<p>Demonstration of a highly efficient electrochemical CO₂ conversion system (electrolyzer), driven by renewable energy, and able to produce value-added chemicals (i.e., fuels or their intermediates)</p> <ul style="list-style-type: none"> ➤ CO production Faradaic Efficiency: >90% Energy Efficiency: >60% Current Density: > 500 mA/cm² ➤ Production of other chemicals MeOH Hydrocarbons 	<ul style="list-style-type: none"> ➤ CO production Faradaic Efficiency: 80~85% Energy Efficiency: >70% Current Density: 250mA/cm² ➤ Energy storage Overall efficiency >35% (otherwise wasted intermittent renewable energy → chemical for storage → electrical energy) <p><i>*Benchmarks for other chemical are necessary</i></p>	<ul style="list-style-type: none"> • Fuel production using CO₂

Role & Contribution through Technology

- The role of this division toward CNS is to create:
 1. low energy penalty and low cost CO₂ capture system from flue gas of coal / natural gas power generation for CCU&S system by the development of novel membranes, contributing to CCS deployment through energy and cost savings in the CO₂ capture stage, **providing low carbon electricity**
 2. energy efficient and cost effective CO₂ conversion systems for the production of liquid fuels or their intermediates to **substitute for fossil fuel**

Technology/Application

