EXAMPLES OF PRAXAIR SOLUTIONS THAT HELP TO MITIGATE THE EFFECTS OF CLIMATE CHANGE (2009)

The Intergovernmental Panel on Climate Change (IPCC) identified several key technologies & practices, by sector, which could play a significant role in mitigating the effects of climate change. This table shows examples of how Praxair applications present many of the climate mitigation solutions the IPCC has identified for now & the future.[1]

Key Climate Change Mitigation Applications – Examples of Praxair Solutions			
Sector	**Currently commercially available**	**Projected to be commercialized before 2030**	**Examples of Praxair applications, existing & under development**
Energy supply	Improved supply & distribution efficiency; fuel switching from coal to gas; nuclear power; renewable heat & power (hydro-power, solar, wind, geothermal & bio-energy); combined heat & power; early applications of carbon capture & storage (CCS) - e.g. storage of removed CO2 from natural gas.	CCS for gas, biomass & coal-fired electricity generating facilities; advanced nuclear power; advanced renewable energy, including tidal & waves energy, concentrating solar, & solar PV.	**EXISTING** • **In Texas, with the U.S. Department of Energy (DOE), demonstrated Praxair's *Seeper Trace*™ technology as an effective CO2 sequestration monitoring technique** • **Liquid nitrogen & liquid CO2 are used throughout north America to fracture natural gas-bearing rock formations** • **Efficient supply of gases & sputtering targets for the production of photovoltaic cells & modules for solar power production** **UNDER DEVELOPMENT** • **Participating with multi-stakeholder partnerships to demonstrate CCS at coal-fired power plants in U.S., Spain & Germany** • **Comprehensive solution for carbon capture & sequestration (CCS) from coal-fired power plants** • **Combustion technology; air separation units for oxygen production; carbon dioxide recycling & oxygen mixing; carbon dioxide processing** • **Up to 99% carbon dioxide capture using proprietary partial condensation/VPSA process** • **Development of CCS ready hydrogen plants** • **Carbon-dioxide-ready for enhanced oil recovery (EOR) or underground storage** • **Cooling systems for superconducting power transmission cables for increased electricity distribution efficiency** • **Efficient activated carbon production method to remove mercury from power plant exhaust**

[1] IPCC, 2007: Summary for Policymakers. In: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom & New York, NY, USA. Fig SPM3, page 10: Key mitigation technologies & practices by sector. The column with Praxair examples has been added. This table was revised in 2009.

Key Climate Change Mitigation Applications – Examples of Praxair Solutions			
Sector	**Currently commercially available**	**Projected to be commercialized before 2030**	**Examples of Praxair applications, existing & under development**
Transport	**More fuel efficient vehicles; hybrid vehicles; cleaner diesel vehicles; biofuels; modal shifts from road transport to rail & public transport systems; non-motorised transport (cycling, walking); land-use & transport planning.**	**Second generation biofuels; higher efficiency aircraft; advanced electric & hybrid vehicles with more powerful & reliable batteries.**	**EXISTING** • **In Brazil, work with the government to increase consumer access to natural gas for cleaner transportation & other uses** **EXISTING** • **Proprietary technology to improve efficiency of biodiesel production** • **Technologies to improve ethanol production rates** • **Participating in commercial demonstrations & research programs to develop emissions-free hydrogen fuel cells for transportation** **UNDER DEVELOPMENT** • **Hydrogenation for advanced cellulosic biofuels, which will create clean transportation fuels from non-food sources** • **Optimization of trip planning to maximize product sold per mile traveled of internal distribution division**
Buildings	**Efficient lighting & day-lighting; more efficient electrical appliances & heating & cooling devices; improved cook stoves, improved insulation; passive & active solar design for heating & cooling; alternative refrigeration fluids, recovery & recycle of fluorinated gases.**	**Integrated design of commercial buildings including technologies, such as intelligent meters that provide feedback & control; solar PV integrated in buildings.**	**EXISTING** • **Nitrogen & carbon dioxide in cryo-mechanical integration technology which improves the efficiency of mechanical freezers** • **Technology to recover & recycle carbon dioxide in cryogenic food freezers** • **Argon-filled energy efficient insulated windows**

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Industry	**More efficient end-use electrical equipment; heat & power recovery; material recycling & substitution; control of non-CO2 gas emissions; & a wide array of process-specific technologies.**	**Advanced energy efficiency; CCS for cement, ammonia, & iron manufacture; inert electrodes for aluminium manufacture.**	**EXISTING** • **Helium to enhance fiber-optic manufacturing rates & product quality. Patented technology recovers up to 80% helium for reuse** • **Oxy-fuel combustion technology for the steel, glass & cement industries that increases fuel & electric power efficiency & production throughput & while reducing emissions** • **Heat recovery technology for glass production that reduces energy consumption by up to 30%** • **Ongoing equipment & control-systems upgrades that reduce the energy consumption of hydrogen and air separation units such as advanced turbo-machinery, improved heat recovery integration, real time optimization & model predictive control** • **New materials like high-k precursors & tantalum sputtering targets that enable production of semiconductors with lower power consumption** • **Rare gases used in liquid-crystal-display (LCD) flat panels lower unit power consumption in televisions, computers, cell phones** • **In the steel industry:** o **Stove oxygen technology that replaces the use of natural gas & reduces carbon dioxide emissions** o **Oxygen & oxy-fuel combustion technology that reduces the amount of natural gas required as fuel, increases production throughput & reduces NOx emissions by 80%-90%** • **Carbon dioxide replaces acids in: mining in hydrometallurgy; textiles for fabric neutralization; pulp & paper for pH control. These processes all serve as a carbon dioxide sink since a chemical reaction permanently removes carbon dioxide from the atmosphere** **UNDER DEVELOPMENT** • **Working with industry consortium to develop CCS for cement kilns** • **On-site fluorine generation for electronics industry which reduces the greenhouse gas impact compared to traditional use of more environmentally harmful agents** • **Participating in an industry/university consortium funding early-stage research in low-carbon-emission steel processing** • **Addition of hydrogen in flares to reduce the quantity of natural gas required to meet government emissions regulations**

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Agriculture	**Improved crop & grazing l& management to increase soil carbon storage; restoration of cultivated peaty soils & degraded lands; improved rice management to increase soil carbon storage; restoration of cultivated peaty soils & degraded lands; improved rice cultivation techniques & livestock & manure management to reduce CH4 emissions; improved nitrogen fertilizer application techniques to reduce N2O emissions; dedicated energy crops to replace fossil fuel use; improved energy efficiency.**	**Improvements of crop yields.**	**EXISTING** • **Carbon dioxide to enhance plant growth in large-scale greenhouses** • **Oxygen-delivery technology to optimize sustainable fish farming**
Forestry/ forests	**Afforestation; reforestation; forest management; reduced deforestation; harvested wood product management; use of forestry products for bio-energy to replace fossil fuel use.**	**Tree species improvement to increase biomass productivity & carbon sequestration. Improved remote sensing technologies for analysis of vegetation/ soil carbon sequestration potential & mapping l& use change.**	**UNDER DEVELOPMENT** • **In Italy, oxygen to improve the efficiency of a biomass gasifier fed with agricultural & tree-trimming waste for municipal heat & power**

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Waste Management	**Landfill methane recovery; waste incineration with energy recovery; composting of organic waste; controlled waste water treatment; recycling & waste minimization.**	**Biocovers & biofilters to optimize CH4 oxidation.**	**EXISTING** • **Carbon dioxide to neutralize alkaline wastewater streams, replacing the use of acids, creating a carbon dioxide sink by chemically changing the carbon dioxide & preventing its release into the atmosphere** • **Oxygen to enhance aerobic digestion of wastewater & in-situ oxygenator systems that reduce the release of volatile organics from wastewater treatment plants** • **In drinking water treatment, oxygen-fed ozone technology replaces chlorine as a disinfectant. Praxair supplied three water-treatment plants in Beijing to provide international standard quality drinking water during the Olympics & after** • **Ozonation process provides a cost-effective means of reducing excess solids generated in wastewater treatment** • **By-product carbon dioxide from various processes (ethanol, chemicals & hydrogen production) converted to a usable product for customers** • **In Brazil, oxygen to reduce emissions in landfill waste.**