Description of Scenario Bundles Homework

Please review the three scenarios and sensitivities in Table 1 that we developed as example scenarios for GHG mitigation analysis in the LEAP model. We would also like to provide Council members the opportunity to provide suggestions on developing additional scenarios beyond the three in Table 1.

To build a new scenario select a bundle of technologies and measures from Table 3 that have the potential to achieve an 80% GHG reduction from 2001 levels by 2050 and enter them into Table 1 (add additional rows as necessary). Then select the various sensitivities you would like to run on the scenario by marking an X in the sensitivity boxes (sensitivity descriptions are provided in Table 2). If you have additional sensitivities (system wide assumptions) that you would like added to the current list, add them to the sensitivity descriptions below and into an empty column in Table 1 (add additional columns as needed). The sensitivities should be a proposed set of assumptions about the entire energy system.

After reviewing feedback from the ADM working group on the proposed below scenarios and any new scenarios you provide us, the project analysis team will distribute a finalized set of scenarios. We ask that you send us comments and newly proposed scenarios and sensitivities by June 10th.

TABLE 1 SCENARIOS & SENSITIVITIES

Sensitivities (System Wide Assumptions) --->	**Existing Nuclear Relicensed A**	**Existing Nuclear Relicensed B**	**Existing Nuclear Relicensed C**	**Nuclear Retires in 2035**	**Nuclear Retires in 2020**	**High Fuel Prices**	**Low Fuel Prices**	**Cost of Renewable Technologies Reaches Parity**	**Sensitivity A**
Scenario 1: Efficiency									
Deep Envelop Retrofits for Existing Buildings	X				X	X			
Expanded high-efficiency lighting	X	X	X	X	X	X	X	X	
Expanded high-efficiency water heating	X	X	X	X	X	X	X	X	
Expanded high-efficiency HVAC (furnaces/boilers)	X	X	X	X	X		X	X	
Scenario 2: Clean & Renewable									
Air-source Heat Pumps	X	X	X	X	X	X	X	X	
Large-scale (utility) solar generation	X	X	X	X	X	X	X	X	
Large-scale (utility) regional wind	X	X	X	X	X	X	X	X	
Large-scale (utility) regional hydro/tidal power			X		X	X	X		
Expanded utility scale energy storage		X		X	X			X	
Expanded advanced vehicles	X	X	X	X	X	X	X	X	
Electrification of intercity buses	X	X	X	X	X	X	X	X	
Electrification of commuter rail	X	X	X	X	X	X	X	X	
Distributed solar (rooftops)		X	X	X	X	X	X	X	
Distribute fuel cells		X	X	X	X	X	X	X	
Distributed energy storage		X		X				X	
Maintain Nuclear	X	X	X			X	X	X	
Maintain Natural Gas	X				X				
Solar Thermal water	X	X	X	X	X	X	X	X	
Scenario 3: Demand Response & Carbon Sinks									
Expanded Demand Response	X	X	X	X	X	X	X	X	
Increased public transit service levels	X	X	X	X	X	X	X	X	
Forestry BMPs	X	X	X	X	X	X	X	X	
Wetlands restoration for "blue" carbon	X	X	X	X	X	X	X	X	
New Scenario X									

TABLE 2 SENSITIVITIES AND SCENARIO DESCRIPTIONS

Sensitivities (System Wide Assumption)	Scenario Description
Existing Nuclear Relicensed A	Existing nuclear plants are relicensed and natural gas plants are maintained. Large expansion of utility scale renewables and both traditional and deep energy efficiency measures.
Existing Nuclear Relicensed B	Existing nuclear plants are relicensed and natural gas plants are not maintained. Large expansion of utility scale renewables and traditional energy efficiency measures. Balancing is achieved by deployment of distributed energy systems and grid scale storage.
Existing Nuclear Relicensed C	Existing nuclear plants are relicensed and natural gas plants are not maintained. Large expansion of utility scale renewables and traditional energy efficiency measures. Balancing is achieved by deployment of distributed energy systems and imported renewables.
Nuclear Retires in 2035	Nuclear retires in 2035 and natural gas plants are not maintained. Large expansion of utility scale renewables and traditional energy efficiency measures. Balancing is achieved by deployment of distributed energy systems and utility scale storage.
Nuclear Retires in 2020	Nuclear retires in 2020 and natural gas plants are maintained. Large expansion of utility scale renewables and traditional and deep energy efficiency measures.
High Fuel Prices	High fossil fuel costs. Existing nuclear plants are relicensed and natural gas plants are not maintained. Large expansion of utility scale renewables and traditional energy efficiency measures. Balancing is achieved by deployment of distributed energy systems and imported renewables.
Low Fuel Prices	Low fossil fuel costs. Existing nuclear plants are relicensed and natural gas plants are not maintained. Large expansion of utility scale renewables and traditional energy efficiency measures. Balancing is achieved by deployment of distributed energy systems and imported renewables.
Cost of Renewable Technologies Reaches Parity	Costs for renewable technologies achieve parity with conventional technologies. Existing nuclear plants are relicensed and natural gas plants are not maintained. Large expansion of utility scale renewables and traditional energy efficiency measures. Balancing is achieved by deployment of distributed energy systems and grid scale storage.
Sensitivity A	Sensitivity A description

TABLE 3 MEASURES & TECHNOLOGIES

	SECTOR(S)	TECHNOLOGY/ MEASURE	DESCRIPTION	ESTIMATED CO2 REDUCTION POTENTIAL*	POTENTIAL CO-BENEFITS (see co-benefit categories and definitions below table)
1	**Buildings (residential & commercial)**	Deep envelope retrofits for existing buildings	Insulation, window, envelope improvements, building energy management systems in existing and new buildings to make them substantially more efficient. (Could be achieved through advanced building codes e.g. Beyond IECC 2012.)	Large	• Social Development • Economic Development • Environmental Sustainability • Health and Well-being
2	**Buildings (commercial, industrial)**	Expanded high-efficiency lighting	LEDs and advanced control systems.	Large	• Economic Development • Environmental Sustainability • Health and Well-being
3	**Buildings (residential)**	Expanded advanced energy-efficient appliances	Adoption of state standards for appliance energy efficiency which are more stringent than federal standards.	Medium	• Environmental Sustainability
4	**Buildings (residential and commercial)**	Expanded high-efficiency water heating	Heat-pumps and other high-efficiency domestic water heaters.	Small	• Economic Development • Environmental Sustainability
5	**Buildings (residential and commercial)**	Expanded high-efficiency HVAC	High-efficiency heating, ventilation, and air conditioning equipment.	Medium	• Economic Development • Health and Well-being • Environmental Sustainability
6	**Buildings (residential, commercial, and industrial)**	Expanded renewable thermal technologies	Renewable energy used for heating or cooling (e.g., air/ground source heat pumps, solar thermal for domestic water heating, biomass, biofuels).	Large	• Enhancing Energy System Security • Environmental Sustainability • Health and Well-being
7	**Buildings (residential, commercial, industrial)**	Increased fuel-switching	Shifting from high-carbon fuel oil to lower-carbon natural gas.	Medium	• Health and Well-being
8	**Buildings (commercial and industrial)**	Expanded district heating/cooling	System for distribution of a heating and/or cooling resource (e.g., chilled water) generated in a centralized location to nearby residential and commercial facilities to satisfy their requirements for space heating, water heating, air conditioning, etc.	Large	• Health and Well-being • Social Development • Economic Development • Environmental Sustainability

9	**Buildings and Electric Power Generation (commercial and industrial)**	Expanded combined heat and power(CHP)	Generate electricity and useful thermal energy in a single, integrated system. Heat that is normally wasted in conventional power generation is recovered as useful energy, which avoids the losses that would otherwise be incurred from separate generation of heat and power.	Medium	• Economic Development • Environmental Sustainability
10	**Electric Power Generation**	Expanded demand response	Programs that enable consumers to reduce their energy usage during periods of peak demand in response to time-based rates or other forms of financial incentives, enabling the grid to meet energy demands at lower cost and with lower emissions. Methods include offering time-of-use pricing, critical peak pricing, variable peak pricing, real time pricing, and critical peak rebates.	Small	• Enhancing Energy System Security • Environmental Sustainability
11	**Electric Power Generation and Buildings (residential, commercial, industrial)**	Expanded distributed generation	Non-centralized generation using renewable energy -- e.g., rooftop solar photovoltaic, community solar, hydrogen fuel cells.	Medium	• Environmental Sustainability • Health and Well-being • Social Development • Economic Development
12	**Buildings (residential, commercial, industrial)**	Distributed energy storage	Storage of electricity for subsequent use at or near the point of generation (e.g., using batteries). Such storage can make it possible to take better advantage of variable sources (e.g., from photovoltaic generation) and integrate them more effectively into the regional grid.	Medium	• Enhancing Energy System Security • Environmental Sustainability
13	**Electric Power Generation**	Expanded utility-scale clean energy technologies	Large-scale generation using solar photovoltaic, on-shore/off-shore wind, large hydroelectric, geothermal, or tidal power.	Large	• Enhancing Energy System Security • Environmental Sustainability • Social Development • Economic Development • Health and Well-being
14	**Electric Power Generation**	Expanded utility-scale energy storage	Centralized storage of electricity for subsequent use (e.g., using batteries, pumped water storage). Such storage can make it possible to take better advantage of variable renewable energy (e.g., from photovoltaic generation) and integrate them more effectively into the regional grid.	High	• Enhancing Energy System Security • Environmental Sustainability
15	**Electric Power Generation and Waste**	Diversion of organics to anaerobic digestion	Diversion of non-recyclable organic waste -- principally yard waste and food scraps -- to an anaerobic digestion facility where microorganisms break down organic materials in the absence of oxygen. This process produces biogas and a solid residual. The biogas, made primarily of	Medium	• Environmental Sustainability • Health & Well-being

			methane and carbon dioxide, can be used as a source of energy similar to natural gas. The solid residual can be land applied or composted and used as a soil amendment.		
16	**Electric Power Generation and Waste**	Advanced waste-to-energy	Incineration of municipal solid waste with capture of waste heat, gasification, pyrolysis.	Medium	• Environmental Sustainability • Health & Well-being
17	**Electric Power Generation**	Expanded advanced natural gas combined cycle gas turbines	Expanded use of the most efficient form of natural gas turbines.	Small	• Enhancing Energy System Security • Environmental Sustainability
18	**Electric Power Generation**	Reductions in natural gas leaks	Enhanced efforts to reduce leakage from the local natural gas distribution network.	Small	• Environmental Sustainability
19	**Electric Power Generation**	Maintain nuclear	Maintain nuclear generation (47% in 2012).	Large	• Enhancing Energy System Security • Health and Well-being
20	**Transportation(fuel switching)**	Expand advanced vehicles	Battery electric vehicles, plug-in hybrid electric vehicles, hydrogen fuel cell vehicles.	Large	• Environmental Sustainability • Health & Well-being
21	**Transportation(fuel switching)**	Low-carbon biofuels	Biofuels in light-duty, medium and heavy-duty/freight modes, plus necessary infrastructure.	Medium	
22	**Transportation(fuel switching)**	Electrification of intercity buses	Conversion to plug-in battery technology	Small	• Environmental Sustainability • Health & Well-being
23	**Transportation(fuel switching)**	Electrification of commuter rail	Conversion of remaining diesel locomotives to electricity.	Small	• Environmental Sustainability • Health & Well-being
24	**Transportation(fuel switching)**	CNG and Propane for medium/heavy duty vehicles	Compressed natural gas and propane instead of petroleum for medium- and heavy-duty vehicles & fueling infrastructure.	Medium	
25	**Transportation(VMT reduction)**	Increased public transit service levels and ridership	Expanded use of bus rapid transit and commuter rail to reduce private passenger vehicle miles traveled.	Medium	• Environmental Sustainability • Health & Well-being

26	**Transportation and Land Use(VMT reduction)**	Transit oriented development/Smart growth practices	Urban planning and transportation practices that concentrate growth in compact urban centers to reduce sprawl and its associated high-emissions forms of building and transportation. Compact, transit-oriented, walkable, bicycle-friendly land use, including neighborhood schools, "complete streets," and mixed-use development.	Medium	• Environmental Sustainability • Health & Well-being
27	**Land-Use and Agriculture (carbon sequestration)**	Urban/suburban tree planting and retention	Urban/suburban tree planting and retention	Small	• Environmental Sustainability • Health & Well-being
28	**Land-Use and Agriculture (carbon sequestration)**	Forestry BMPs	Best management practices for public and private forests to maximize carbon sequestration and storage.	Medium	• Environmental Sustainability
29	**Land-Use and Agriculture(carbon sequestration)**	Conversion of marginal agriculture to forests	Reforestation of marginal agricultural lands to sequester and store carbon.	Small	• Environmental Sustainability
30	**Land-Use and Agriculture(carbon sequestration)**	Improved agricultural practices	Practices to reduce GHG emissions and maintain/build soil carbon: organic farming, nutrient reductions, no-till agriculture, and improved residue management.	Small	• Environmental Sustainability
31	**Land-Use and Agriculture(carbon sequestration)**	Wetlands restoration for "blue" carbon	Protection of salt marshes and other wetlands to maintain their ability to sequester and store carbon.	Medium	• Environmental Sustainability
32	**Non-Energy,**	Reduction of F-gas emissions	Improved management practices for fluorinated gases (e.g., HFC refrigerants) that have high global warming potential.	Small	

33	**Waste**	Increased source reduction and recycling of solid waste	Source reduction, often called 'waste prevention,' is any change in the design, manufacturing, purchase, or use of materials or products (including packaging) to reduce their amount or toxicity before they become municipal solid waste. Recycling, which occurs after waste is produced, is conversion of materials for use in remanufacturing.	Medium	• Environmental Sustainability • Economic Development

*Carbon reduction potentials were estimated based on a literature review and expert opinion.

CO-BENEFIT CATEGORIES

Below are five categories of co-benefits associated with GHG mitigation measures and technologies. These co-benefit categories and the definitions within are adapted from the International Energy Agency's report *Capturing the Multiple Benefits from Energy Efficiency*[1].

ECONOMIC DEVELOPMENT

Macroeconomic development - delivers benefits across the whole economy, with direct and indirect impacts on economic activity (measured through gross domestic product [GDP]), employment, trade balance, and energy prices.

Industrial productivity - delivers substantial benefits in addition to energy cost savings – enhancing competitiveness, profitability, production and product quality, and improving the working environment while also reducing costs for operation and maintenance, and for environmental compliance.

Disposable income: Across all income levels, delivers improvements that have the effect of reducing energy bills will increase disposable income for individuals, households and enterprises.

Public budgets - Whether by reducing government expenditures on energy or by generating increased tax revenues through greater economic activity and/or increased spending on energy efficiency-related and other goods and services, energy efficiency improvements can have important impacts on the budgetary position of national and sub-sovereign entities.

Asset values: Recent evidence suggests that individuals and businesses are willing to pay a rental and/ or sales premium for property with better energy performance.

HEALTH & WELL-BEING

Improved indoor air quality: Retrofits in buildings (e.g. insulation retrofits and weatherization programs) create conditions that support improved occupant health and well-being, particularly among vulnerable groups such as children, the elderly and those with preexisting illnesses. The potential benefits include improved physical health such as reduced symptoms of respiratory and cardiovascular conditions, rheumatism, arthritis and allergies, as well as fewer injuries and improved mental health such as reduced chronic stress and depression.

Reduction in outdoor air pollution: Reduces outdoor concentrations of local and/or regional air pollutants (such as sulphur dioxide, particulate matter, unburned hydrocarbons and nitrogen oxides); in doing so, it can drive a range of associated economic, environmental and health benefits

[1] Published by the International Energy Agency, the book was written to build knowledge of the multiple benefits of energy efficiency, and to demonstrate how policy makers and other stakeholders can use existing tools to measure and maximize the benefits they seek. http://www.iea.org/publications/freepublications/publication/Captur_the_MultiplBenef_ofEnergyEficiency.pdf

ENHANCING ENERGY SYSTEM SECURITY

Energy delivery: lower costs for energy generation, transmission and distribution, improved system reliability, dampened price volatility in wholesale markets and the possibility of delaying or deferring costly system upgrades

Energy system security: Improvements that result in reduced demand can improve the security of energy systems across the four dimensions of risk: fuel availability (geological), accessibility (geopolitical), affordability (economic) and acceptability (environmental and social).

ENVIROMENTAL SUSTAINABILITY

Climate change resilience: reduces impact of climate change threats such as hurricanes, flooding, draught, public health disasters, asset loss, etc.

Resource management: Reduced energy demand can reduce pressure on scarce natural resources, reducing the need to explore increasingly challenging contexts for extraction (such as ultra-deep offshore, arctic and shale). Reducing energy consumption and emissions also plays a role in reducing waste and associated pollution of land and water, thereby contributing to efforts to combat ocean acidification and limit negative impacts on biodiversity.

SOCIAL DEVELOPMENT

Affordability/poverty alleviation: Enhances the affordability of energy services for poorer families by reducing the per-unit cost of lighting, heating, refrigeration and other services.

Employment: Generates a net gain in employment rates both directly and indirectly.