Energy Supply
Technical Work Group

Summary List of Pending Priority Policy Options for Analysis

	Policy Option	GHG Reductions ($MMtCO_2e$)			Net Present Value 2008–2025 (Million $)	Cost-Effectiveness ($/t$CO_2$e)	Level of Support
		2015	**2025**	**Total (2008–2025)**			
ES-6	Nuclear Power Support and Incentives						
	Installation of a nuclear power station after 2025	**0**	**0**	**0**	**$0**	**$0**	Pending
	Installation of a nuclear power station in 2020	0	8.0	47.8	$3,355	$70	Pending

Notes:

1. ES TWG recommendation in **bold** above.

2. All option total are relative to the underlying assumption that electric expansion in MN proceeds with the recently legislated Conservation Improvement Program, Renewable Energy Standard and all planned additions including the Mesaba and Big Stone 2 stations.

ES-6. Nuclear Power Support and Incentives

Policy Description

The role of nuclear power in a GHG-constrained energy supply system is both important and controversial. Today, nuclear power plants provide about 20% of electric power both nationally and in Minnesota. The role of both existing and new units needs to be considered for a comprehensive climate change policy process.

This policy provides support and incentives for life extension at existing nuclear power plants and for study of potential new nuclear power plants in Minnesota.

Policy Design

Goals: The policy would be intended to ensure that utilities undertake analyses of their operating systems to identify and pursue cost-effective opportunities to reduce emissions with an emphasis on nuclear power through

- Life extension,
- Capacity upgrades,
- Purchase of imported nuclear power, and
- Potential new nuclear power plants. *This is the specific option proposed; i.e., one 1,100 MW unit installed in Minnesota in the post-2025 period.*

Timing: This policy would become applicable as soon as possible.

Parties Involved: It would cover Minnesota load-serving entities.

Implementation Mechanisms

The planning requirements would be implemented through the Integrated Resource Planning (IRP) process already implemented by the Public Utilities Commission. Thorough consideration of the safety, economics, and environmental implications of nuclear power would be explicitly called for.

In addition, the ongoing work at the Minnesota Legislature periodically produces reports and positions that enable a more comprehensive look at the issues surrounding nuclear power. These efforts would continue to inform the debate.

Related Policies/Programs in Place

Existing IRP requirements (see above). These require consideration of relatively low-value GHG adders in the planning process, but do not require specific analysis of nuclear power as a GHG-reducing supply option. In the event that a comprehensive GHG policy were implemented in the state's electric power sector, it would likely overlap with this policy, although it is likely that full consideration of nuclear power options could still require a dedicated policy.

Type(s) of GHG Reductions

Avoided emissions from fossil-fuel generation.

Estimated GHG Reductions and Net Costs or Cost Savings

Data Sources:

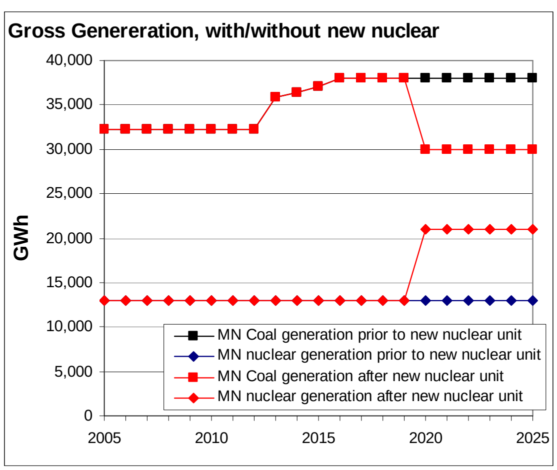
- Energy Information Administration, "Assumptions to the Annual Energy Outlook 2007," DOE/EIA-0554, April 2007, available at: http://www.eia.doe.gov/oiaf/aeo/assumption/pdf/electricity.pdf)
- Capital cost, transmission, fixed O&M and variable O&M escalation factors developed by the ES TWG

Quantification Methods:

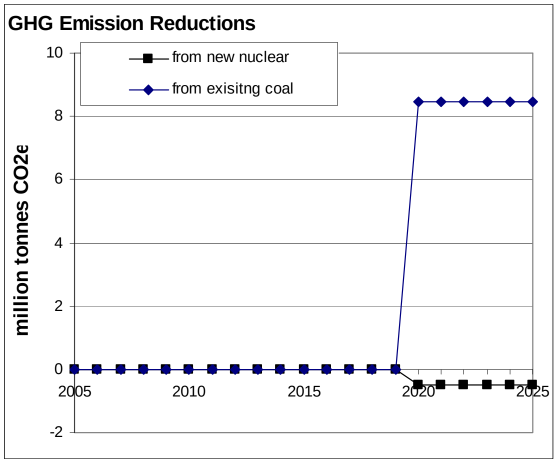
This option would provide support and incentives for life extension at existing nuclear power plants and for study of potential new nuclear power plants in Minnesota. Since the policy calls for the installation of a new unit in the post-2025 time frame, it is a non-quantified option. As a sensitivity to obtain a sense of the cost-effectiveness of the option, it has been modeled as a new nuclear power station in MN as per the following key assumptions:

- The online for the station is 2020.
- Upstream fuel cycle GHG emissions associated with nuclear generation should be accounted for.
- Size of the station is 1,100 MW.
- New nuclear power would displace generation from existing, fully depreciated coal-fired generation within MN.

Regarding generation, the impact of the option is summarized in the chart below. The upper curve represents the total MN coal generation before and after the introduction of the new nuclear station. The lower curve represents the total MN nuclear generation before and after the introduction of the new nuclear station.



Regarding CO2-equivalent (CO2e) emission reductions, the impact of the option is summarized in the chart below. The upper curve represents the annual CO2e reductions associated with backed down generation from existing coal-fired power stations in MN. The lower curve represents the annual CO2e reductions associated with increased generation from the new nuclear power station in MN. The net annual emission reductions in 2015 and 2025 are 0.0 and 8.0 million tonnes CO2e, respectively. The cumulative net emission reductions over the 2005-2025 forecast period are 47.8 million tonnes CO2e.



Regarding costs, there are cost savings associated with avoided fuel and O&M at existing coal-fired facilities located in MN (i.e., $39/MWh after deducting the capital cost component, 2005$). There are incremental costs associated with new nuclear capital costs, transmission costs, variable O&M costs, fixed O&M costs and fuel costs (i.e., $164/MWh in 2005$) and then escalated to 2020 by 1.45 using the TWG escalation assumptions. The annual product of real levelized costs and displaced generation is an estimate of the annual cost savings. The net present value of these annual costs are $3.4 billion over the 2020-2025 period (2005$).

Regarding the cost effectiveness of the option, it was calculated as the quotient of the NPV and cumulative GHG emission reductions, $70.2/tCO2e (2005$) (i.e., 3.4 billion divided by 47.8 million tonnes and multiplied by a conversion factor of 1,000).

Key Assumptions: See Annex 2

Key Uncertainties

- Nuclear fuel availability
- Nuclear waste storage and disposal
- Security requirements
- Changes in federal policy (e.g., Nuclear Regulatory Commission relicensing, long-term waste repository)
- Technology and economics of new units
- Industry-wide developments

Additional Benefits and Costs

None

Feasibility Issues

Mostly captured in the Key Uncertainties items above. Political feasibility also affects nuclear power, to differing degrees for life extensions and capacity upgrades as opposed to new units.

Status of Group Approval

Pending—[until MCCAG moves to final agreement at meeting #8]

Level of Group Support

TBD—[blank until MCCAG meeting #8]

Barriers to Consensus

TBD—[blank until final vote by the MCCAG]

Annex 2: ES-6: Nuclear Power Support and Incentives

Online year for new nuclear power 2020

Upstream fuel stages considered? 1

1 Upstream fuel stages **are** considered for coal and nuclear generation (default)
2 Upstream fuel stages are **not** considered for coal and nuclear generation

Cost & performance characteristics of new nuclear power stations in the online year

	Units	Effect of escalation: without	with	Ratio
Size	MW	1,100	1,100	1.0
Contingency factor	dimensionless	1.00	1.00	1.0
Capital	2005 $/kW	49	71	1.45
Transmission	2005 $/kW	1	1	1.0
Fixed O&M	2005 $/kW-yr	1	1	1.0
Variable O&M	2005 mills/kWh	0.47	0	1.0
Fuel	2005 $/mmbtu	2.0	2.0	1.0
Capacity factor	%	84%	84%	1.0
Heat rate	btu/kWh	10,400	10,400	1.0
Annual gross generation	GWh/yr	8,128	8,128	1.0

Resource displaced 100% coal

CO2 emissions of nuclear fuel cycle

0.06 tonnes CO2 per MWh electricity produced

Stages of nuclear fuel cycl	Considered in above value?
Mining & milling	Yes
Conversion & transformation	Yes
Enrichment	Yes
fuel fabrication	Yes
electricity generation	Yes
reprocessing	No
LLW disposal	No
HLW disposal	No

CO2e emission factors (tonnes of CO2e per mmbtu)

	Natural gas	petroleum	Coal	gasoline	diesel	heavy fuel oil	Biomass	electricity (end use)
emission factor	0.0539	0.0783	0.0959	0.0783	0.0783	0.0783	0.0000	NA

Fuel cycle inputs

MMbtu input per MMBtu of coal delivered to the power station

Stages of coal fuel cycle	Considered?	Natural gas	petroleum	Coal	gasoline	diesel	heavy fuel oil	Biomass	electricity (end use)
Extraction	Yes	0.0001	0.0051	0.0006	0.0002	0.0039	0.0005	0.0000	0.0017
Beneficiation and processing	Yes	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Transport to power station	Yes	0.0000	0.0000	0.0000	0.0000	0.0088	0.0000	0.0000	0.0000
Total	NA	0.0001	0.0051	0.0006	0.0002	0.0128	0.0005	0.0000	0.0017

Additional tonnes CO2e per MMBtu associated with upstream fuel cycle stages

Stages of coal fuel cycle	Considered?	Natural gas	petroleum	Coal	gasoline	diesel	heavy fuel oil	Biomass	electricity (end use)	Total
Extraction	Yes	0.0000	0.0004	0.0001	0.0000	0.0003	0.0000	0.0000	NA	0.0008
Beneficiation and processing	Yes	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	NA	0.0000
Transport to power station	Yes	0.0000	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000	NA	0.0007
Total	NA	0.0000	0.0004	0.0001	0.0000	0.0010	0.0000	0.0000	NA	0.0015

Estimated MN levelized costs (2005$/MWh) - All Scenarios

Capacity type	Capacity	ransmissio	Fixed O&M	ariable O&	Fuel	Total
Pulverized coal	68.8	2.3	5.9	8.5	23.1	108.7
Nuclear	127.6	2.4	15.5	0.8	18.7	165.0