



SEAB *Future of Nuclear Power*

Secretary Moniz charged the Task Force to

**Describe a U.S. led new nuclear power initiative with significant capacity to deploy units by 2030 – 2050.
e.g. 3,000 to 5,000 MWe per year.**

Principal motivation for this initiative is the vital contribution that nuclear power, along with other carbon free technologies, can make to avoiding worldwide emissions.

The Task Force described an initiative but did not address whether it was practical or necessary.



SEAB *Future of Nuclear Power*

Task Force Members:

| | |
|------------------------------------|----------------------|
| John Deutch * | Dan Reicher * |
| Michael Greenstone * | Joy Rempe |
| Shirley Ann Jackson * | Gary Samore * |
| William Madia | Clay Sell |
| Richard Meserve * | Phil Sharp |
| Arun Majumdar (ex. Officio) | Steve Specker |
| * Denotes SEAB member | Joe Turnage |



SEAB *Future of Nuclear Power*

Outlook for Nuclear Power

United States:

- Four new units under construction – one restart (Watts Bar 2)
- Anticipate wave of retirements beginning 2030
- In 2016, several utilities announced premature closures:
Clinton IL, Quad Cities IL (2 units), Ft. Calhoun NE,
Diablo Canyon CA (2 units).

Europe Flat

Major New Plants: China, India, Russia, South Korea

New Entrants: United Arab Emirates, Jordan, Vietnam, Turkey ...



SEAB *Future of Nuclear Power*

Challenges for Nuclear Power

- Overnight capital costs > \$5,000/kWe.
- Projected low natural gas electricity generation cost.
- Market Structure
- Program Structure
 - Schedule for Development, Demonstration, Deployment
 - Financing
 - Management
- Safety & Licensing
- Fuel Cycle and Waste Management
- International Linkages.



SEAB *Future of Nuclear Power*

Economics: What does Nuclear capital cost need to be to match the LCOE of competition? (Based on AEO 2015/2016)

| Competing Technology | Breakeven Over night Nuclear Capital Cost \$/kWe | |
|--|--|---------|
| | 2016 | 2015 |
| NGCC | \$1,968 | \$2,895 |
| NGCC w/ CCS | \$3,787 | \$4,463 |
| NGCC w/ \$40/MT Social Cost of GHG emissions | \$4,030 | \$4,821 |
| Photovoltaics | \$5,470 | \$8,432 |
| Photovoltaics with Natural Gas Backup | \$4,434 | \$5,868 |

For comparison EIA estimate nuclear overnight capital cost (\$2015) as \$ 4,782 in AEO 2015 and \$5,288 in AEO 2016.



SEAB *Future of Nuclear Power*

Electricity Market Impediments

- No carbon pricing
- RPS do not admit nuclear (Diablo Canyon. In CA)
- Base load generation not properly valued.

Many possible market design solutions must be worked out on a case-by-case for existing nuclear plants.

e.g. NY Public Service Commission created Zero Emission Credits program providing financial support for upstate reactors.

The Task Force believes that significant market restructuring is a prerequisite for the success of any nuclear power initiative.



SEAB *Future of Nuclear Power*

For new plants the Task Force Recommends a two part program

Plants based on proven LWR technology

- **2.7 ¢ /kWe-hr production payment to recognize carbon free generation.***
 - **No additional financial incentives.**
 - **Continued DOE assistance on NRC licensing and construction on DOE or DOD sites.**
- * Some owner/operators may prefer an investment tax credit in lieu of a production payment for FOAK units such as SMRs.**



SEAB *Future of Nuclear Power*

For new advanced reactor systems the TF recommends a 4 phase program.

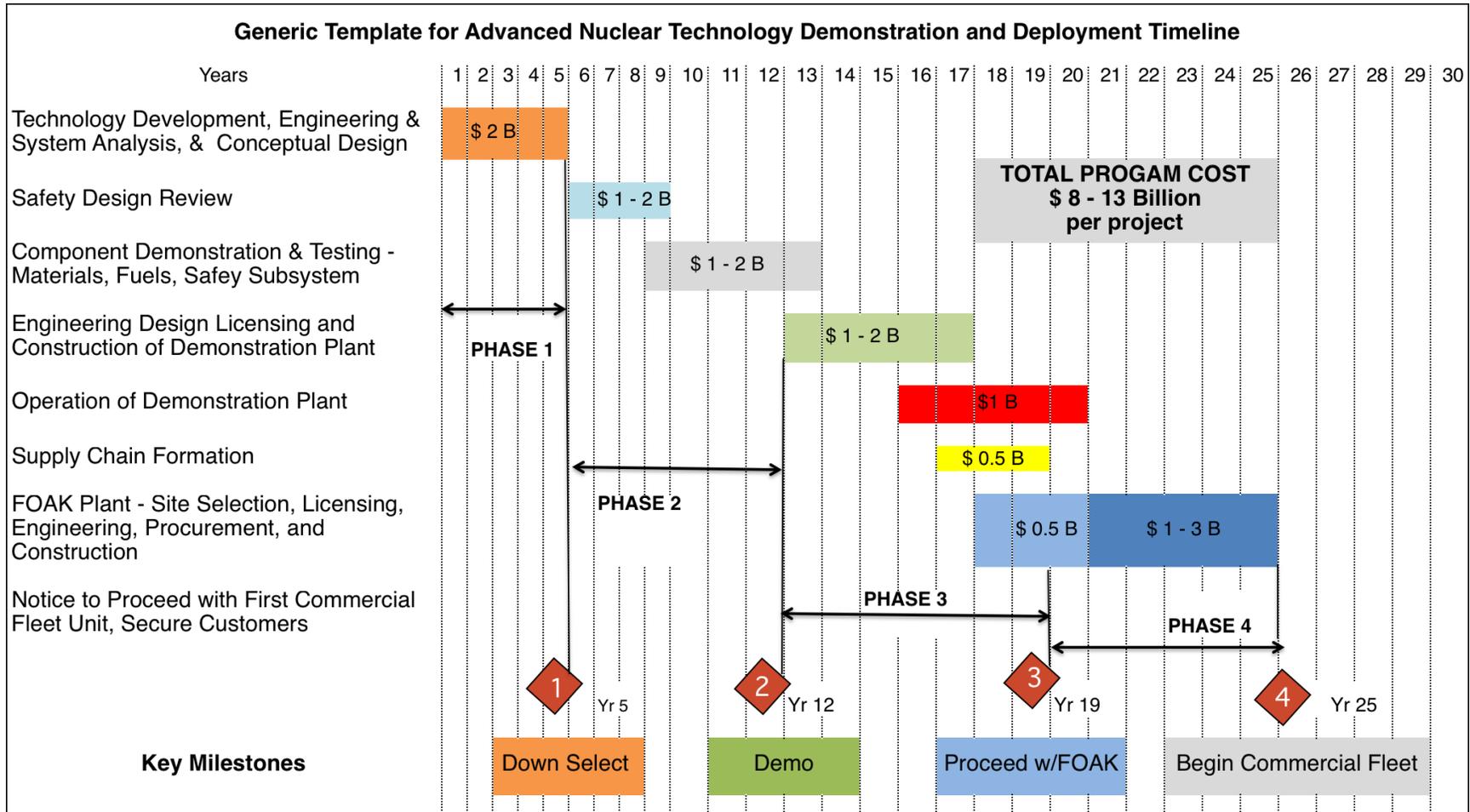
- Phase I – R&D, down select reactor system
- Phase II – Component Development, NRC licensing
- Phase III – Demonstration plant construction and operation, if needed.
- Phase IV – Construction of FOAK commercial plant.

Although estimates very uncertain the Task Force believes this is a 25 year* \$11.5 billion program with cost split 50% government and 50% private investors with government contribution earlier in the program.

*** Includes 5 yrs. Phase I R&D; 5 yrs. Phase IV FOAK Const.**



SEAB *Future of Nuclear Power*





SEAB *Future of Nuclear Power*

Program Management.

- **The Task Force recommends creation of a quasi-public independent corporation to manage the advanced reactor initiative.**
- **This is an appropriate structure for high technical program that takes place over many years and requires stable funding if it is to achieve a successful commercial outcome.**
- **The Corporation should be funded by a one-time Congressional appropriation.**
- **The Corporation should be free of federal acquisition and personnel regulations.**
- **Annual report and financial statement of activities for Congressional and Executive Branch oversight.**



SEAB *Future of Nuclear Power*

Nuclear Licensing and Safety.

- **U.S. remains the gold standard.**
- **For power reactor applications the NRC only has recent experience with licensing LWRs.**
- **NRC has authority to develop a staged approach for licensing of advanced reactors and should do so.**
- **More financial support will be needed.**
- **Some developers may choose to construct and license new advanced reactors abroad, e.g., China, but U.S. deployment will require full NRC review.**



SEAB *Future of Nuclear Power*

International Linkages.

- Past U.S. leadership in nuclear power has been important in advancing U.S. nonproliferation, safety and security policies.
- If U.S. and OECD Europe nuclear deployments and exports decline influence inevitably shifts to China, India, South Korea and Russia.
- U.S. must continue to encourage:
 - (a) Safety & security in all countries.
 - (b) Defense against cyber or terrorist attacks
 - (c) Foreign participation in its advanced nuclear technology programs.
- **A nuclear accident anywhere is a nuclear accident every everywhere.**



SEAB *Future of Nuclear Power* Concluding Points

- Nuclear is not cost competitive with natural gas at currently projected prices – but natural gas prices are notoriously volatile .
- Absent a carbon emission price extend a 2.7 ¢/kWe-hr payment for existing and new nuclear generation.
- Establish a new quasi-public corporation to manage an advanced nuclear initiative. :
 - (a) Cost & Schedule estimate: four phase \$11.5 billion over 25 years with 50% public/private split.
 - (b) One-time Congressional appropriation.
 - (c) Corporation operates under commercial not gov't practice.
- Attention to safety, security and fuel cycle/waste are integral to successful future nuclear systems.
- **A nuclear accident anywhere is a nuclear accident every everywhere.**



SEAB *Future of Nuclear Power* **Concluding Points**

There is no shortcut to reestablish a vigorous U.S. nuclear power initiative that could be a major source of carbon-free generation.

Such an initiative will take time, significant public resources, restructured electricity markets, and sustained and skilled management attention.

If the Nation wants an Advanced Nuclear Option 20 – 30 years in the future it needs to begin now an incentive such as that described by this TF.