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Selecting the Technology and Vendor for NPP's

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Selecting the Technology and Vendor for NPP's

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Factors in Reactor Technology

- The number of distinct reactor technologies and types of nuclear plants has diminished in the last 20-25 years due to economics and commercial reasons.
- Many reactor technologies have proven to be less efficient, or difficult to control and operate safely in a commercial environment.
- Many reactor technologies produce new fuel in the process of operation, or produce weapons-grade fission products, both of which require special handling and increase operational and security burdens on commercial power enterprises.
- Commercial reactor technologies greatly rely upon 3rd-party supplier infrastructures to be viable, which is strongly influenced by the number of a particular technology deployed, its popularity and fleet sizes.
- Conversely, reduction in popularity and deployment of a technology can cause the supply chain to be irrevocably altered, rendering the technology no longer viable or obsolete.
- The ability of a reactor technology to adapt and be upgraded to increasingly stringent safety and engineering margin standards can impact long-term viability.

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Today's Leading NPP Reactor Technologies

PWR/VVER

CANDU

BWR

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Reactor Technology – PWR

Pressurized Water Reactor

Advantages

- Most common commercial reactor in the world; most operating hours.
- Originally intended for high-power-density applications, such as community power plants and marine propulsion
- Respond fairly well to economies of scale
- Generally mainstream technology and materials for fabrication
- Negative temperature coefficient and controllable design basis accident scenarios
- Fuel sealed in fuel pellets, fuel assemblies and reactor vessel, theft or compromise nearly impossible.
- Very low weapons-grade fissionables (U-235/U-239) production rate
- Radionuclide inventory in coolant is short-lived and easily moderated.
- Advanced Gen III+ models and passive safety features reduce accident scenarios to very low probability (10E-8).

Disadvantages:

- Light-water reactor requiring enriched fuel
- Operate at very high pressure, high fuel temperature
- Accident scenarios center around loss of coolant, and structural and materials failures.

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Reactor Technology – VVER

Russian PWR Design

Advantages

- Same advantages of Western PWR's, plus new 460 models have additional passive safety design and features.
- Margins and tolerance for operating limits are very large to accommodate previous inefficiencies of Russian-sourced I&C and control systems, realizing increased safety with little loss of overall efficiency.
- New VVER models utilize I&C and control systems from Siemens and Westinghouse.
- Many VVER features accommodate requirements of component transport and isolated siting scenarios, such as reduced complexity, compound and multi-piece components, horizontal steam generators, etc.
- ASE offers very aggressive commercial terms for financing, building and operating of new VVER NPP's.

Disadvantages

- Similar to Western-sourced PWR reactor technologies.

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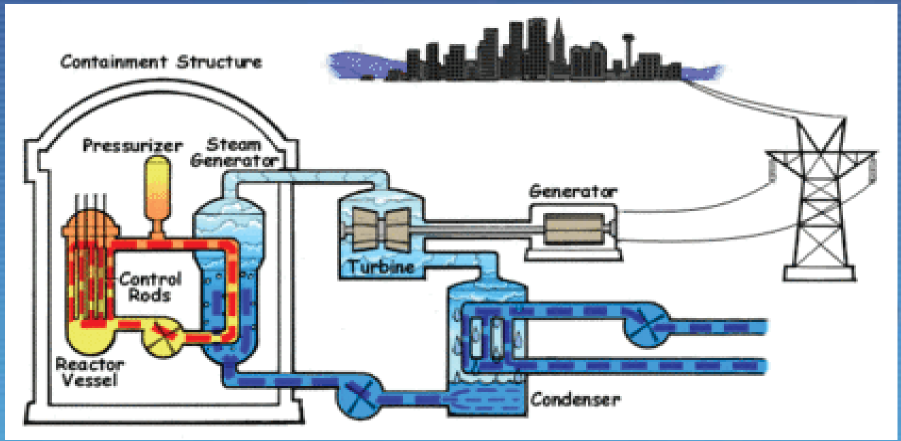
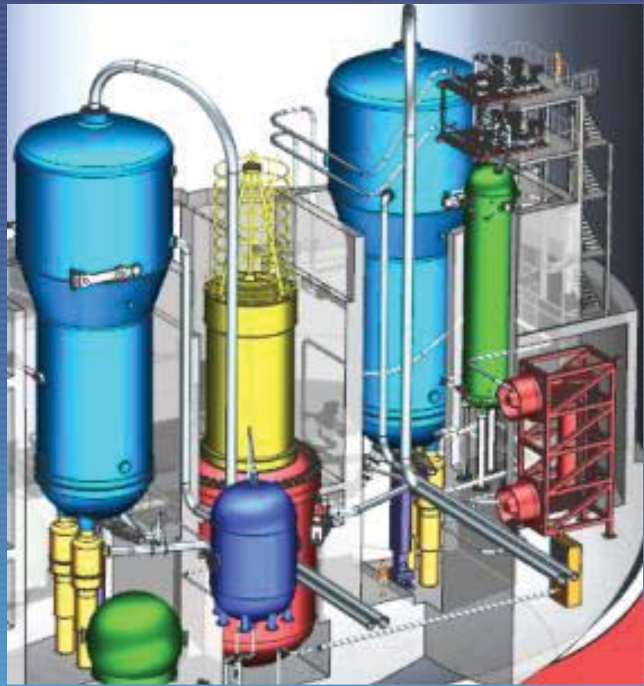
Reactor Technology – PWR

Pressurized Water Reactor

PWR models and vendors. Most designs are available in electric output ratings of nominal 1100 to 1400 MWe:

- Westinghouse AP-600/1000 (USA)
- ASE/Atomstroyexport VVER 460+ (Russian Federation)
- AREVA EPR (France)
- Korean KHNP APR+ (South Korea)
- Mitsubishi APWR (Japan)





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Reactor Technology – BWR

Boiling Water Reactor

Advantages

- Single-loop heat transport and reduced component count
- Operates at 50% or less of nominal PWR operating pressure
- Respond fairly well to economies of scale
- Containment and coolant inventory management is simpler, most models employ a self-contained blowdown or pressure-release system
- Generally mainstream technology and materials for fabrication
- Fuel sealed in fuel pellets, fuel assemblies and reactor vessel, theft or compromise nearly impossible.
- Very low weapons-grade fissionables (U-235/U-239) production rate
- Negative temperature coefficient and controllable design basis accident scenarios
- Radionuclide inventory in coolant is short-lived and easily moderated.

Disadvantages

- Light-water reactor requiring enriched fuel
- Accident scenarios center around loss of coolant, and structural and materials failures.
- Early low-power models do not employ a full containment structure (cf. Fukushima)
- Control rod geometry and mechanism more complex because the vessel-bottom rod insertion design negates gravity as a rod-insertion mode.
- Single-loop heat/steam transport system poses additional biological and health physics hazards.

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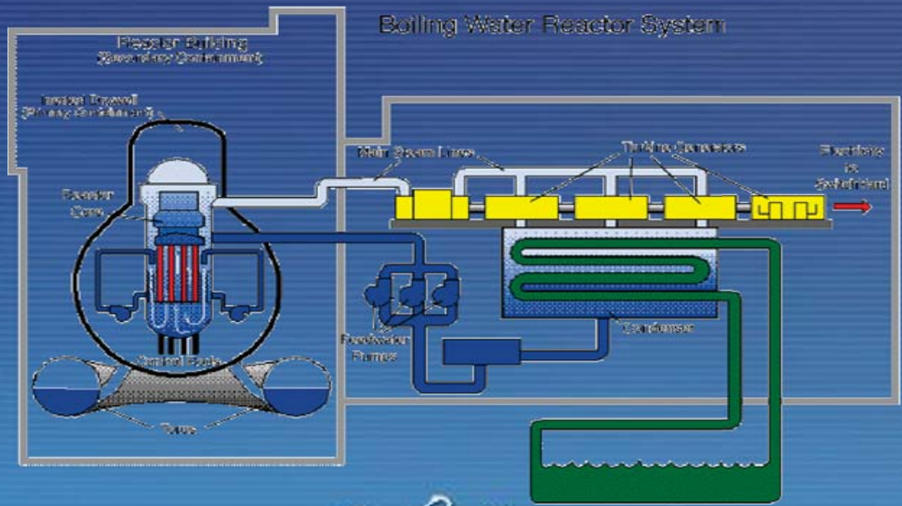
Reactor Technology – BWR

Boiling Water Reactor

GE BWR Models

Hitachi/GE ESBWR



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Reactor Technology – CANDU

CANadian Deuterium Uranium Reactor

Advantages

- Natural Uranium Fuel, D2O moderated, light water cooled.
- Shares bulk of design with PWR technology, except for reactor design; principal of operation is nearly identical to pressurized water technology.
- Operates at 50% or less of nominal PWR operating pressure
- Respond fairly well to economies of scale, but not as well as PWR due to size and design of CANDU reactor.
- No large high-pressure reactor vessel to fabricate.
- No single reactor vessel to fail; individual leaking fuel/water channels/tubes in reactor may be easily isolated.
- Generally mainstream technology and materials for fabrication (except D2O)
- Ability to refuel individual reactor channels on continuous, as-needed basis during power operation.
- Radionuclide inventory in coolant is short-lived and easily moderated.

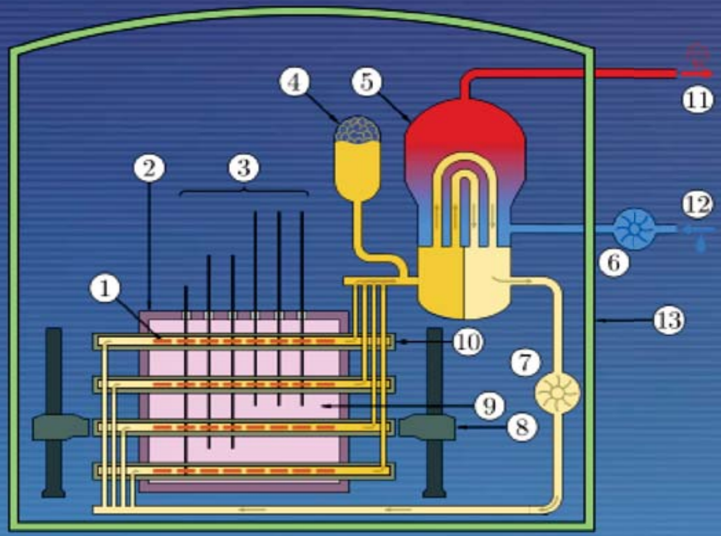
Disadvantages

- Heavy water moderator difficult and expensive to make; carries false stigma of toxicity.
- Irradiated fuel may be removed and stored at any time; greater risk of theft.
- May be “tuned” to produce significant weapons fissionables (U-239) if desired
- Some models have non-volume containment structures supplemented by a “vacuum building”.
- Accident scenarios center mainly around structural and materials failures, loss of coolant is somewhat less likely.
- Positive temperature coefficient creates environment for control difficulty that is inherent in tube-based reactors (like RBMK and CANDU), but CANDU’s do not exhibit significant issues.

Reactor Technology – CANDU

CANadian DeUterium Reactor

AECL* CANDU



*recently split into manufacturer and EPC, which is owned by SNC Lavalin

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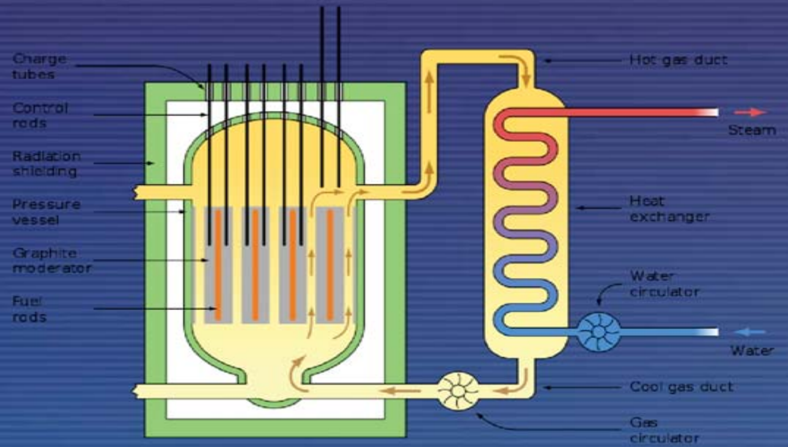
Experimental, Inactive and Obsolete Technologies

Gas Reactors

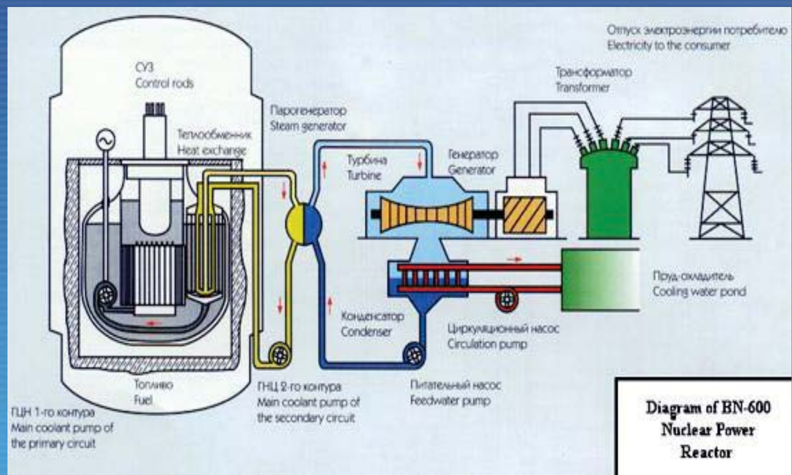
HTGR/AGR/MagNox



Advantages: benign accident scenarios, natural U238 fuel

Disadvantages: Difficult fuel cycle, fire risk, inefficient.

Liquid Metal/Fast Breeder (LMFBR)

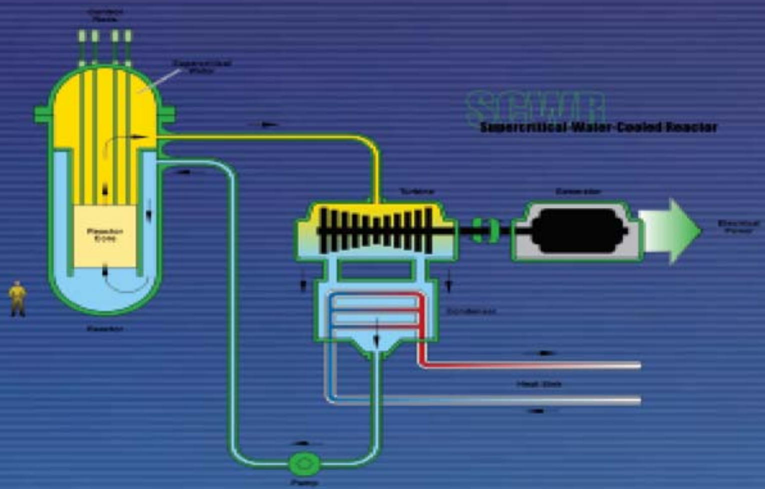


Advantages: wide fuel tolerance, high power density, auto-regeneration of fuel

Disadvantages: Difficult fuel cycle, complex three-loop design, liquid metal coolant volatile

Experimental, Inactive and Obsolete Technologies

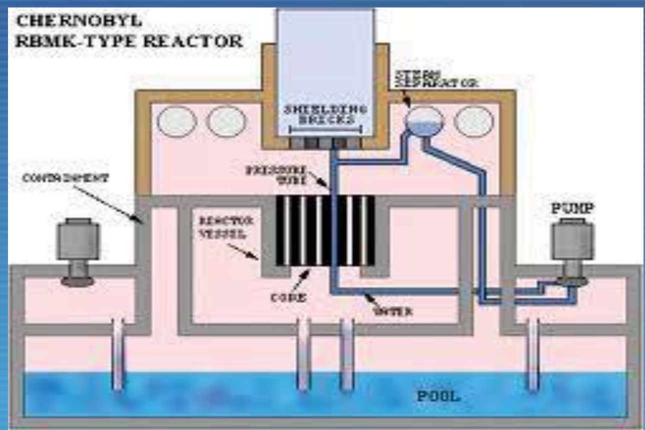
Supercritical Light Water Reactor (SLWR)



Advantages: High efficiency, combines advantages of PWR and BWR designs

Disadvantages: Very high operating pressures and temperatures, requires more exotic materials, expensive.

Light-water Graphite Reactor LGR/RBMK



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Advantages: High power levels (1600 MWe+) achievable, Inexpensive, can refuel at power, creates custom nuclides for weapons.

Disadvantages: No containment, carbon moderator burns easily, fuel not secure.

Experimental, Inactive and Obsolete Technologies

Pebble-Bed Modular Reactor (PBMR)

Advantages:
benign accident scenarios, natural U238 fuel

Disadvantages:
Difficult fuel cycle, fire risk, inefficient.

Light-water Graphite Reactor (LGR)/RBMK (reaktor bolshoy moshchnosty kanalny)

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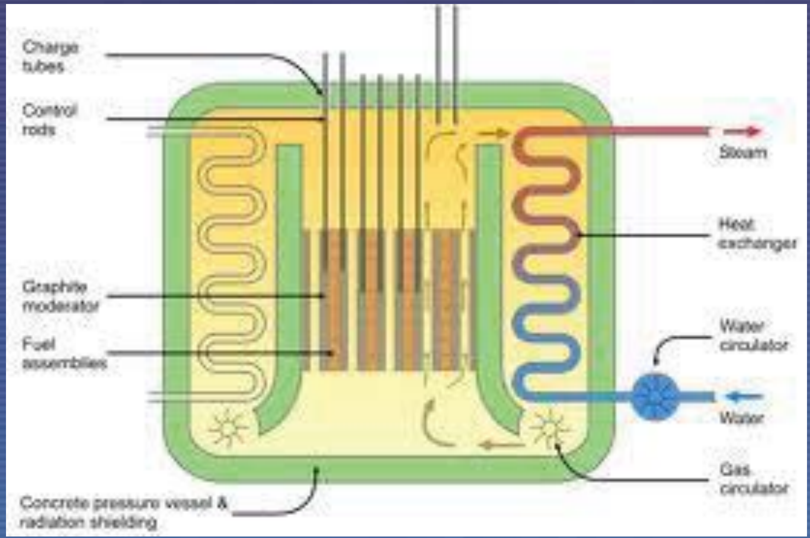
Experimental, Inactive and Obsolete Technologies

HTGR/AGR/MagNox



Advantages: benign accident scenarios, natural U238 fuel

Disadvantages: Difficult fuel cycle, fire risk, inefficient.

Liquid Metal/Fast Breeder (LMFBR)

Pebble-Bed Modular Reactor(PBMR)

Light-water Graphite Reactor (LGR)/RBMK (reaktor bolshoy moshchnosty kanalny)

Supercritical Light Water Reactor (SLWR)

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NEPIO Preparation for Nuclear Power

IAEA NG-G-3.1

3 Steps:

Ready for Commitment to Nuclear Power

Ready to Invite Bids for First NPP

Ready to Commission and Operate First NPP

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Vendor Selection Criteria

Ready for Commitment to Nuclear Power

- Existing familiarity and comfort with a technology in your country's Scientific, utility, NEPIO or academic community. Regulator, TSO's and other government organs formed and operating.
- Current technologies of NP's already built in country
- Cost and Availability of NPP Component Manufacturing, Construction, Manpower
- Select or develop Knowledge Management and Document/Content Management systems to capture and process early nuclear information.
- For Tier 1 Nuclear States, availability of fuel types. For example, CANDU technology is deployed in India because they are not an NPT signatore, and have difficulty obtaining enriched fuel.
- Degree to which localization, domestic sourcing and/or technology transfer is desired (e.g., Westinghouse AP-1000 in China).
- Economic factors, such as total cost, financing and credit offers.
- Construction and operating scenarios offered, such as turn-key, BOT (Build-Operate-Turnover) or co-managed construction.
- Ability of vendor to deliver integrated approach in design, construction and turnover, including Quality Systems, Supply Chain, IT, Configuration Management, Knowledge Management, and other systems.

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Vendor Selection Process

Ready to Invite Bids for First NPP

- Consider criteria from the previous step, and:
- Research and identify potential vendors and technologies that will fit the conditions set previously.
- Identify special conditions for the country that may drive the choice of a particular technology or NPP type (political alliances, geography, siting issues, sources of water, etc.)
- Develop a complete list of all potential candidate vendors. This may be upwards of 10 vendors and suppliers, and may also include owner's engineer candidates.
- Issue Requests for Interest (RFI's) to the vendors, Owner's Engineers, and NSSS suppliers identified. If not already selected, include TSO's for regulator.
- Based on the responses, develop a "short list" or 3 or 4 vendors, maximum, from which to deliver more detailed bid requests to.
- Develop a Bid Invitation Specification (BIS), which is a very detailed set of questions for the short-list vendors to respond with the way they would meet the requirements for the NPP.
- The BIS should include integrated services, such as Knowledge Management, IMS and Quality Systems, Configuration Management, and IT.
- Review electric grid infrastructure for addition of large single source of power load, as well as grid protection issues, such as load-shedding, station blackout, etc.

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Vendor Selection Process

Ready to Commission and Operate First NPP

- Select the vendor and technology from the previous step.
- Determine the preferred commercial and engineering relationships, such as incorporation of local and/or imported design, engineering and construction companies.
- Determine the level of activity for the NPP owner, such as co-operative design and construction, "turn-key" or BOT. This will be determined by both commercial factors and level of experience and talent available in the country.
- The Owner will most likely engage the services of an "Owner's Engineer" to serve as an engineering supervisor, as well as providing 6D project management services such as cost and schedule, IT support, configuration management, design review and control, materials and supplier support.
- Determine the commissioning and continuing commercial operation support to be furnished by the NSSS or EPC contractor beyond contract and warranty agreements.

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Questions?

Thank you!
Grazie!

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