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Idaho National Engineering and Environmental Laboratory

The Supercritical-Water-Cooled Reactor (SCWR)

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Outline

-*General characteristics of the SCWR concept*

-*Benefits from deployment*

-*Major R&D gaps*

-*International interest in the SCWR*

-*Conclusions*

Supercritical Water in Nature – Black Smoker

Water depth: 2600 m

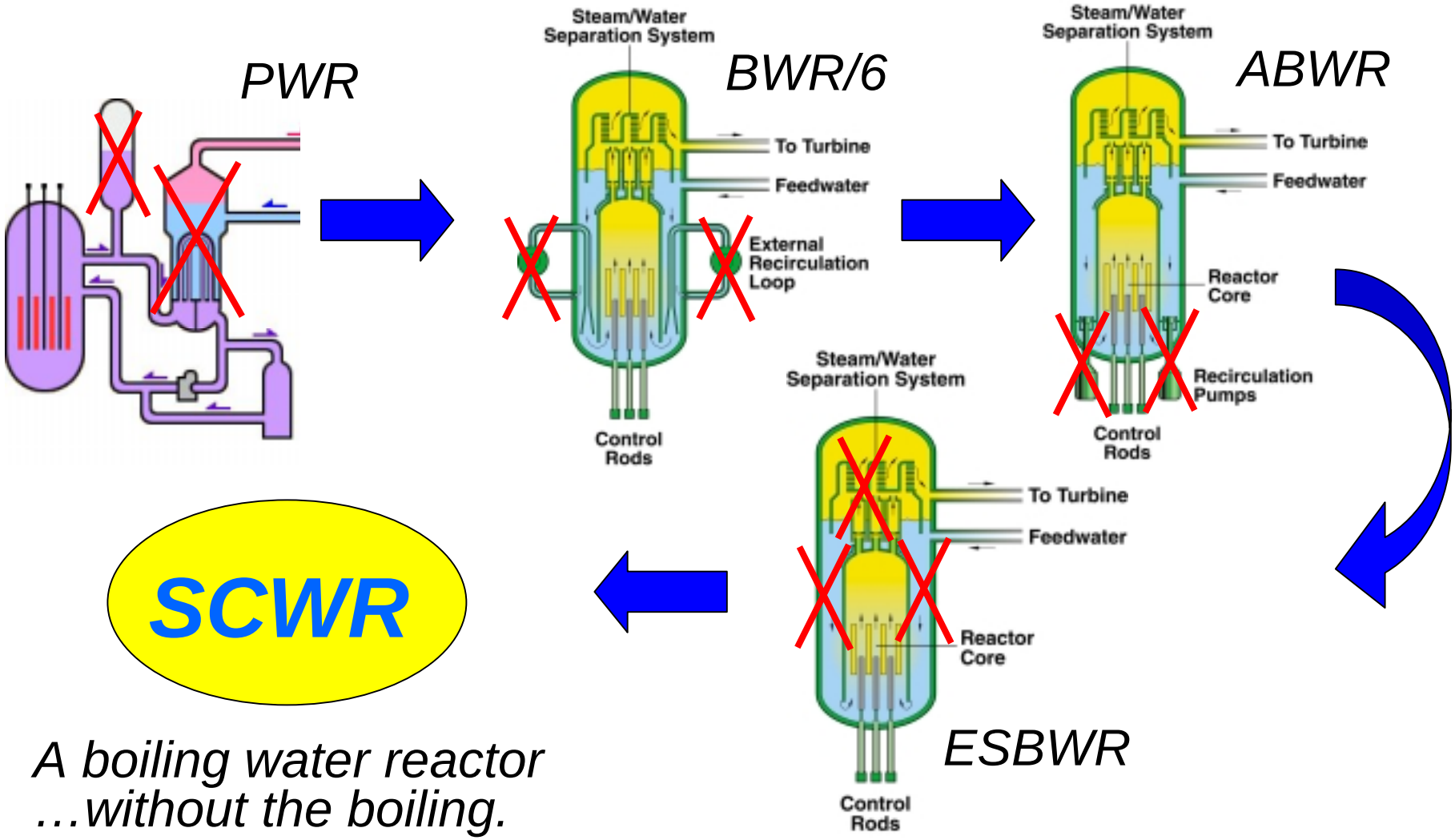
Pressure: 25 MPa (3700 psia)

Temperature: 300°C

http://www.jamstec.go.jp/opedia/Docs/BlueEarth/200007/Pdf/22-23.pdf

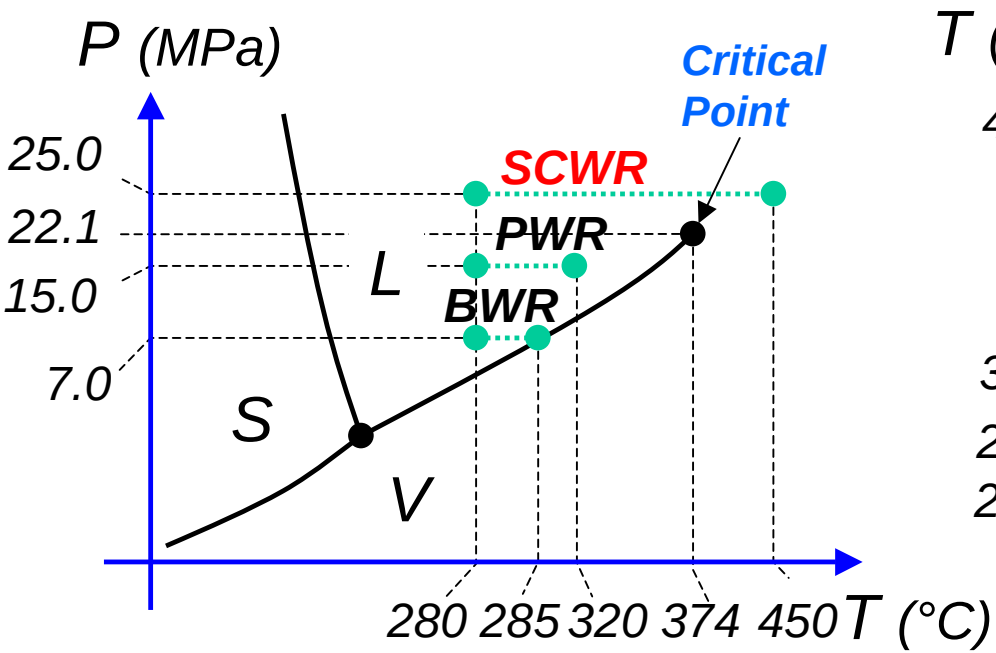
What is the SCWR ?

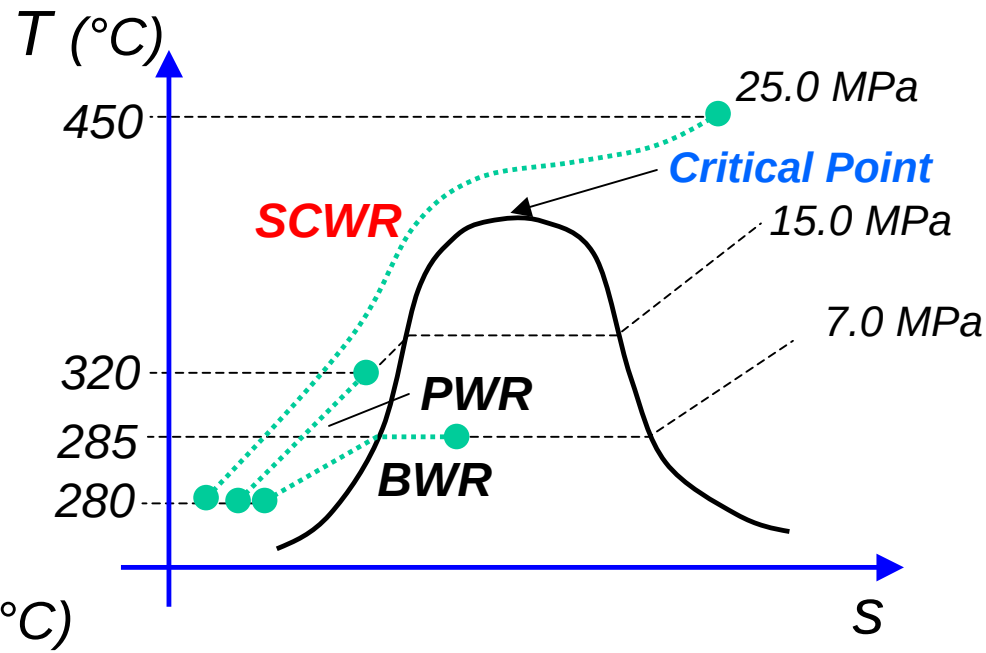
The next logical step in the LWR path toward simplification



A boiling water reactor
…without the boiling.

Supercritical Water

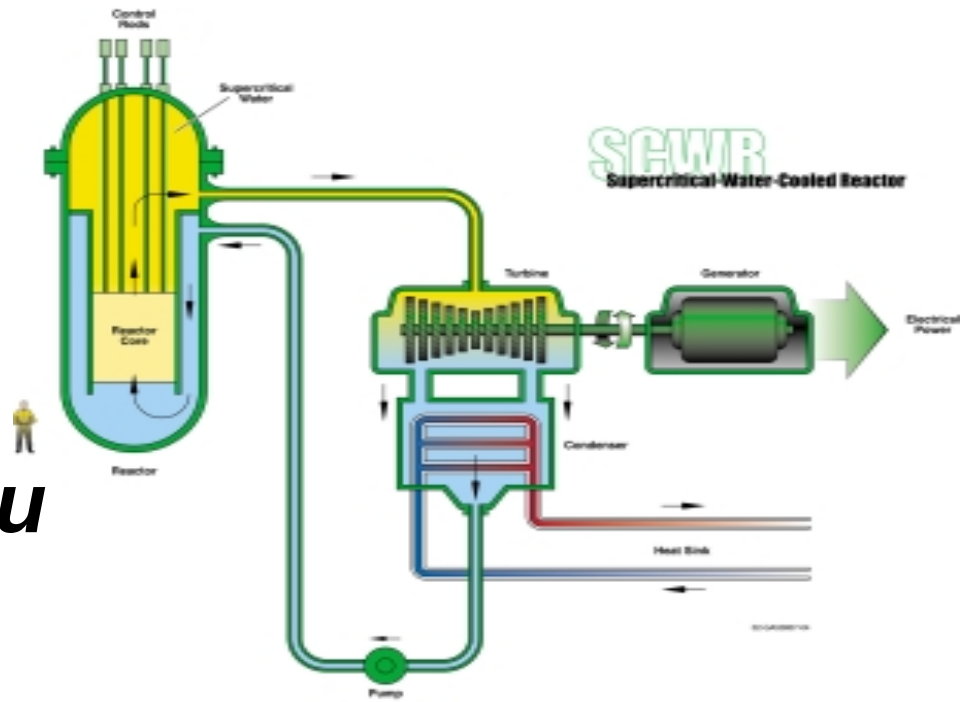




With operation above the critical pressure

NO CHANGE OF PHASE

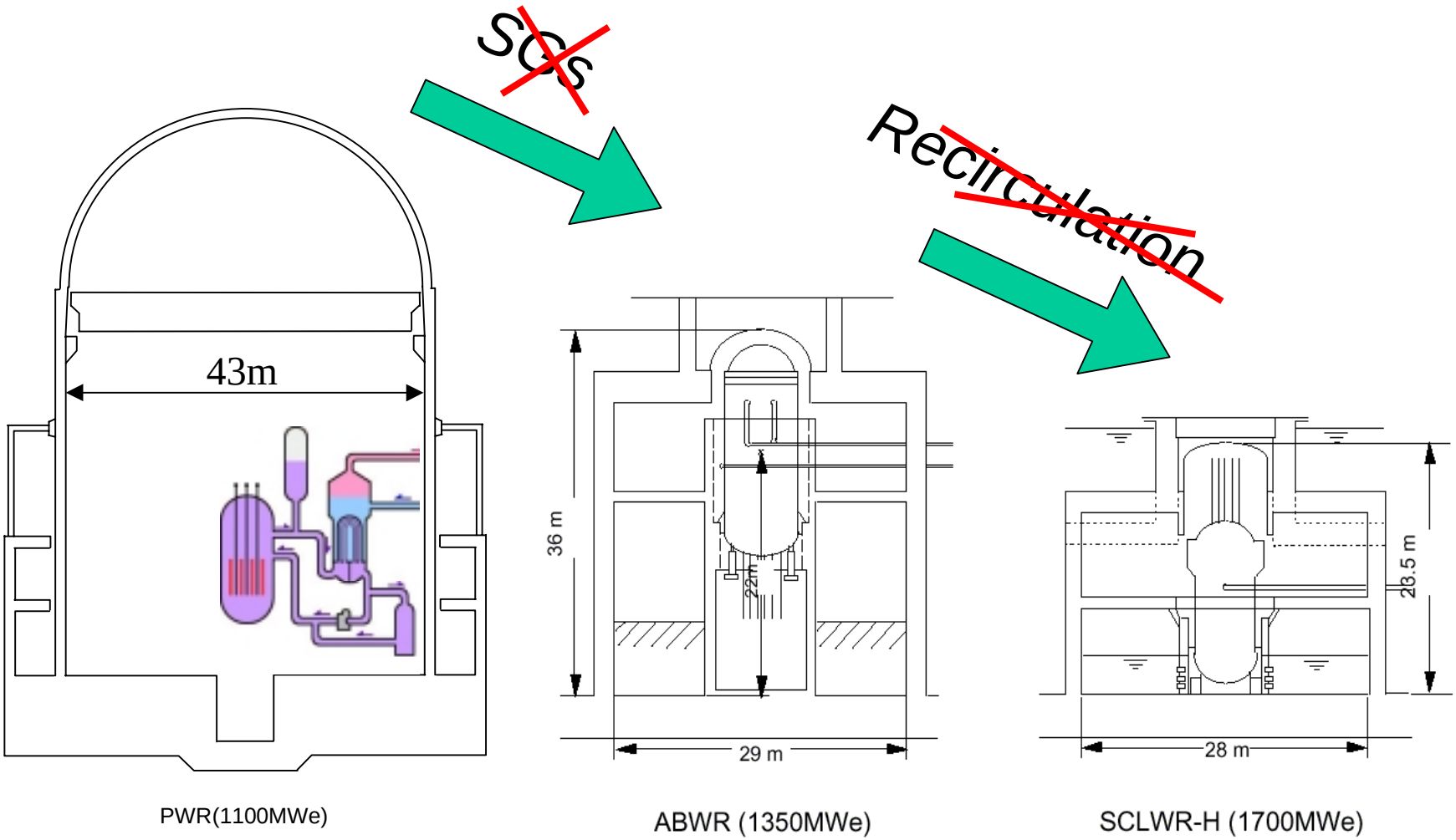
~~Phase Change~~



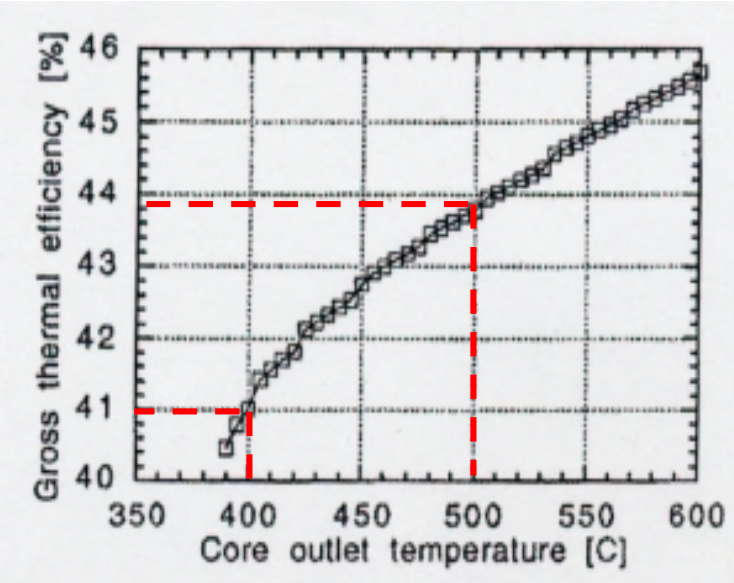
Simplified Once-Thru Direct Cycle

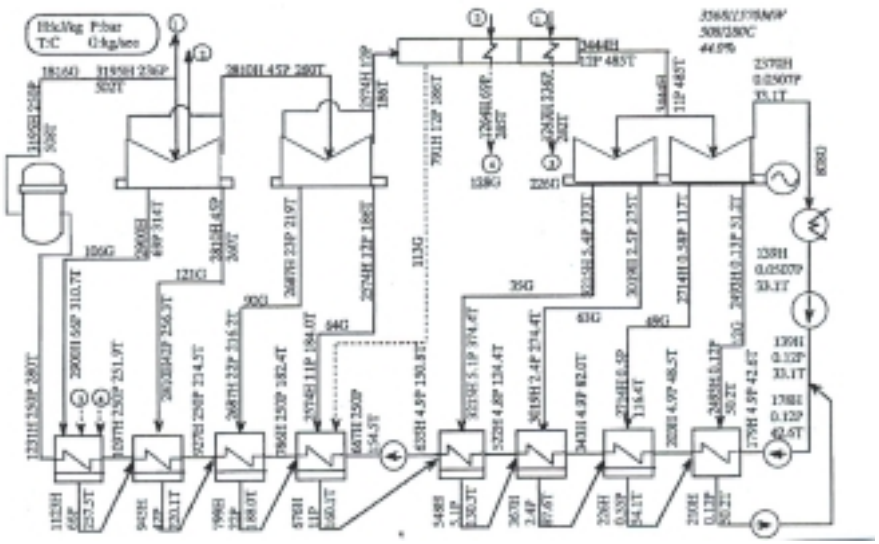
	Core	SGs / Steam Separators	Press.	Recirc. Pumps	Steam Lines	RPV	CRs	Containment
PWR	Yes	Yes	Yes	Yes	4	Small	Top	Large
BWR	Yes	Yes	No	Yes	4	Large	Bottom	Small
SCWR	Yes	No	No	No	2	Small	Top	Very Small

Very Small BWR-style Containment



BOP and Thermal Efficiency





	Thermal Efficiency	Low Pressure Turbines	Turbine Speed	Condenser Modules
LWR	33-35%	3	1800 rpm	3
SCWR	41-44%	2	3600 rpm	2

Supercritical Water in the Power Industry (2)

Coal-fired SC plants in the world and their performance

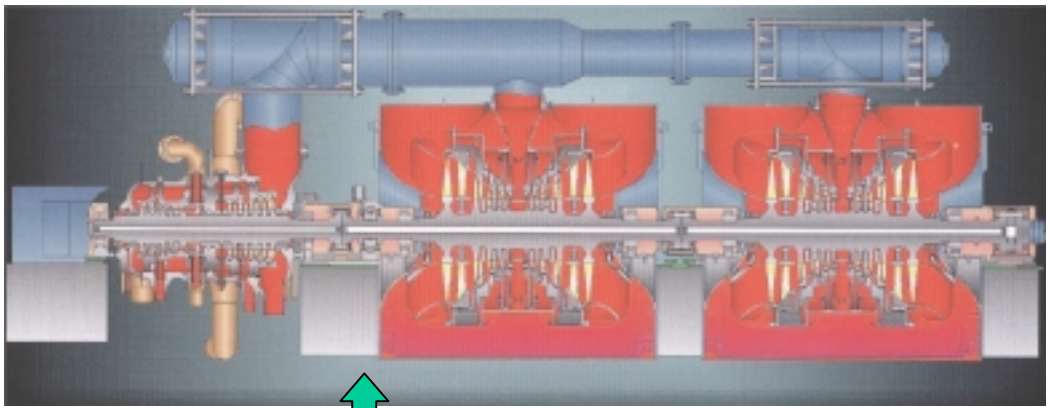
Country / Region	Number of SC Units	Installed MW
U.S.A.	149	106,454
Japan	108	67,900
Eastern Europe	123	51,810
Western Europe	53	29,310
Other Countries	29	13,520
TOTAL	**462**	**268,994**

Year	Subcritical	Supercritical
1993	82.0	89.8
1994	83.8	83.0
1995	83.7	84.7
1996	86.6	79.5
1997	88.5	90.3

Source: World Bank Organization

Most new coal-fired power plants are supercritical.

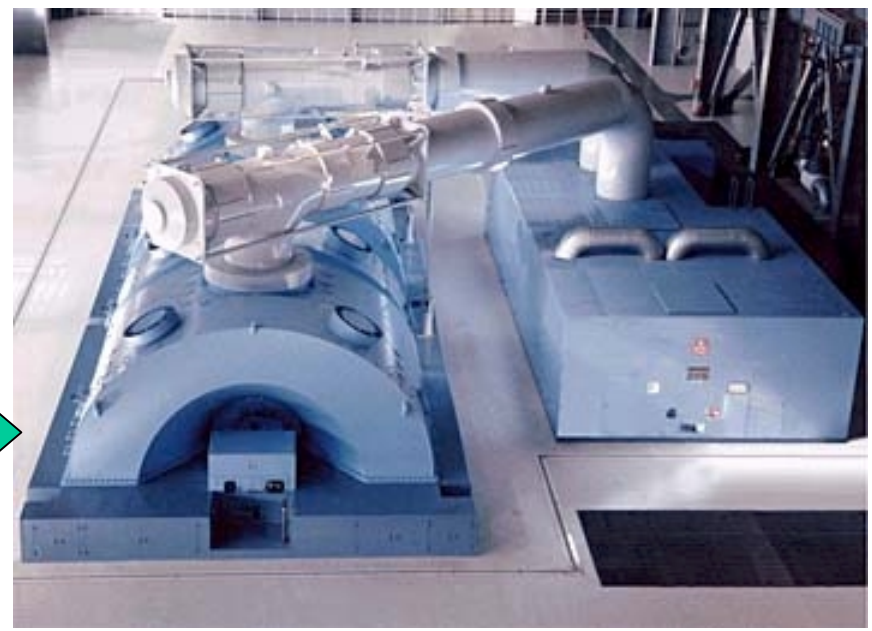
SC turbines are proven technology



Major vendors of SCW components include GE, Toshiba, Hitachi, MHI, B&W, Siemens

Toshiba: 700 MWe (24MPa, 593/593°C)

MHI: 1000 MWe (24.5MPa, 600/600°C)



Benefits from Deployment of the SCWR

- *Reduced capital cost from plant simplification and high thermal efficiency. The Gen-IV estimates are $900/kWe and ¢2.9/kWh.*
- *Could combine two proven technologies: LWRs and supercritical-water fossil plants.*

Open Issues

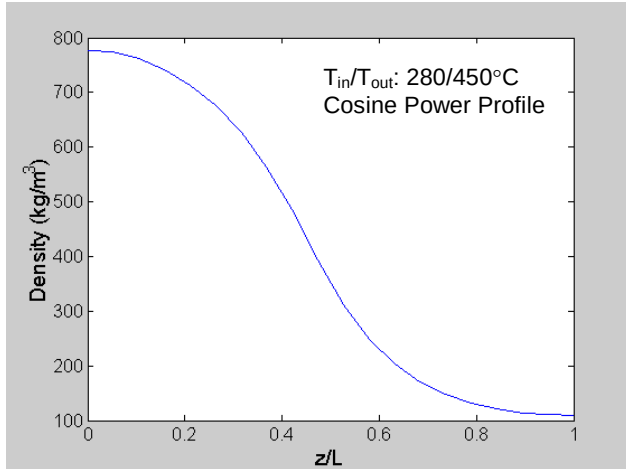
- *Core Design*
- *Safety*
- *Stability and Control*
- *Core Materials*

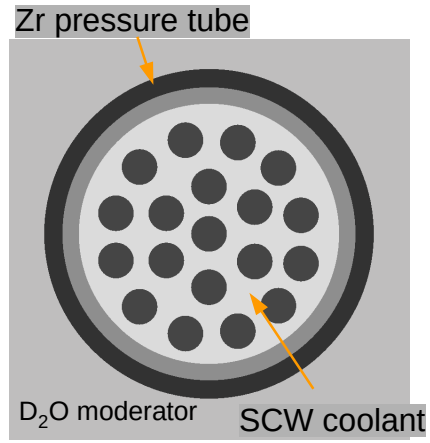
Core Design

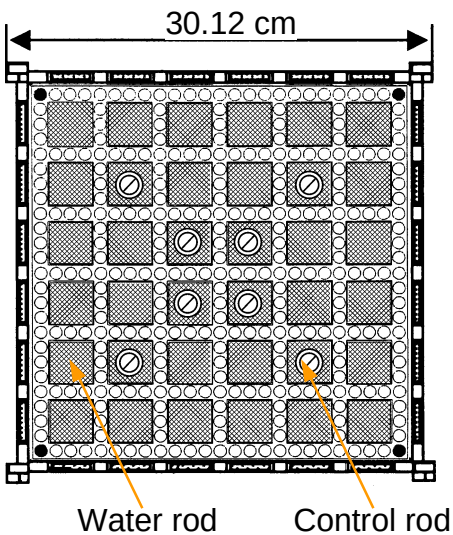
Low average density in the core

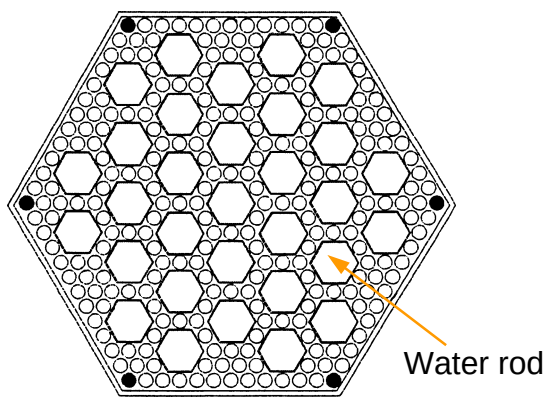
Fast core is possible

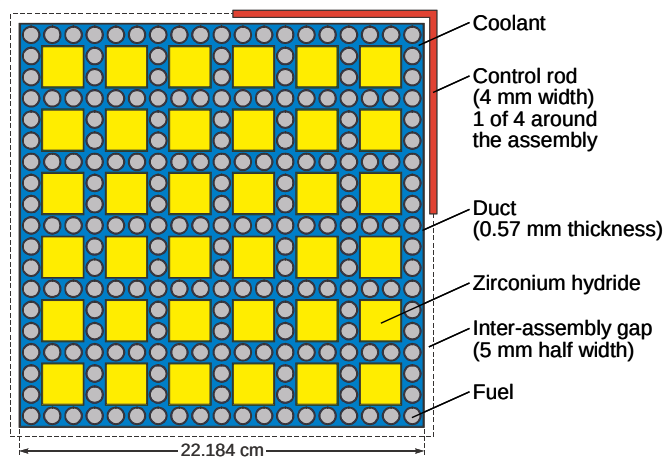
Thermal core needs dedicated moderator





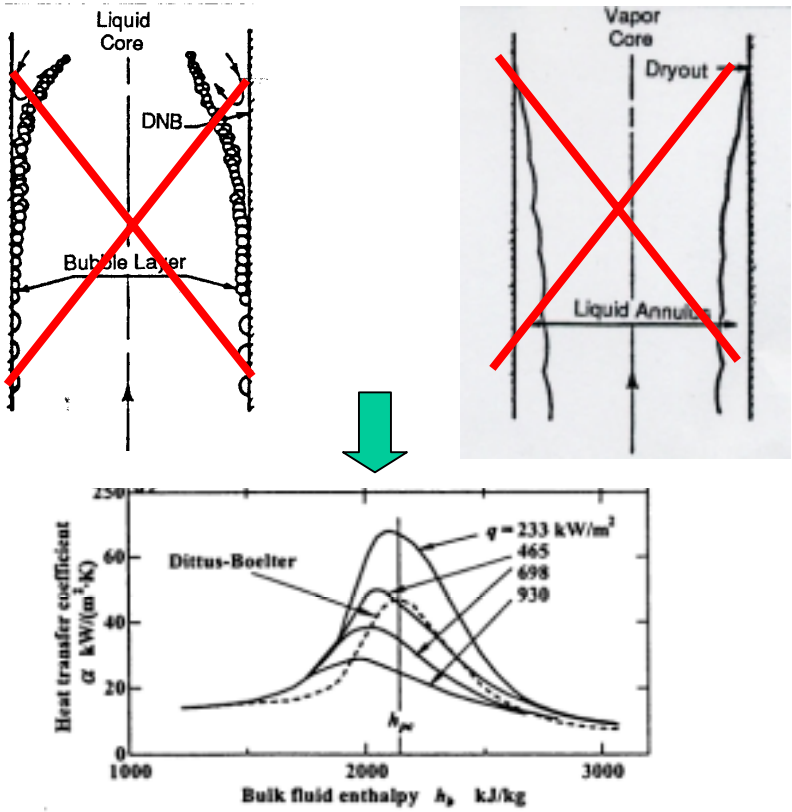






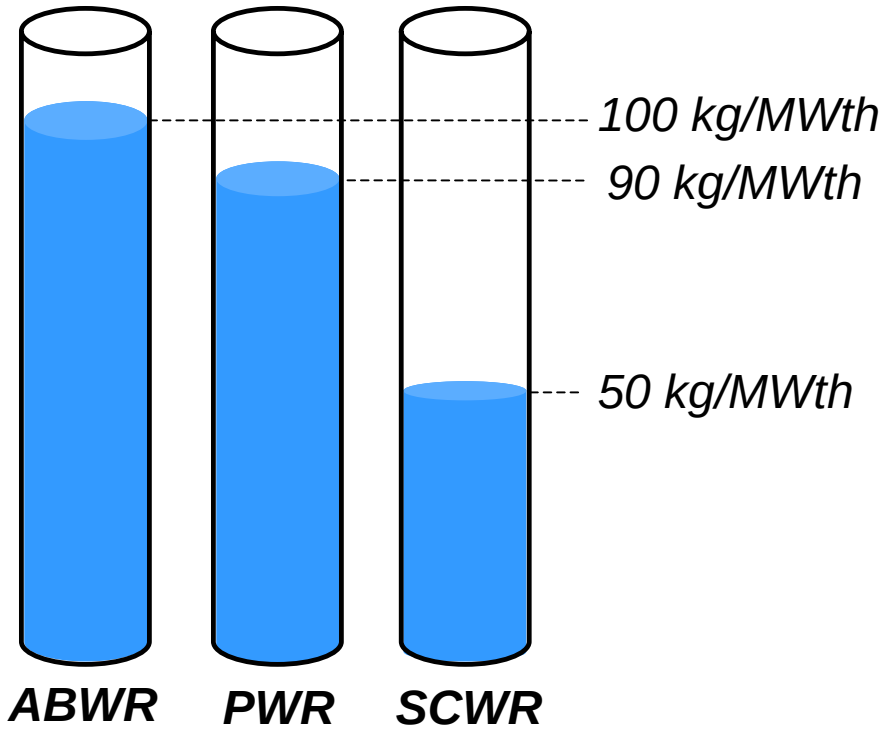
Safety

One Advantage



Elimination of the boiling crisis under normal operating conditions

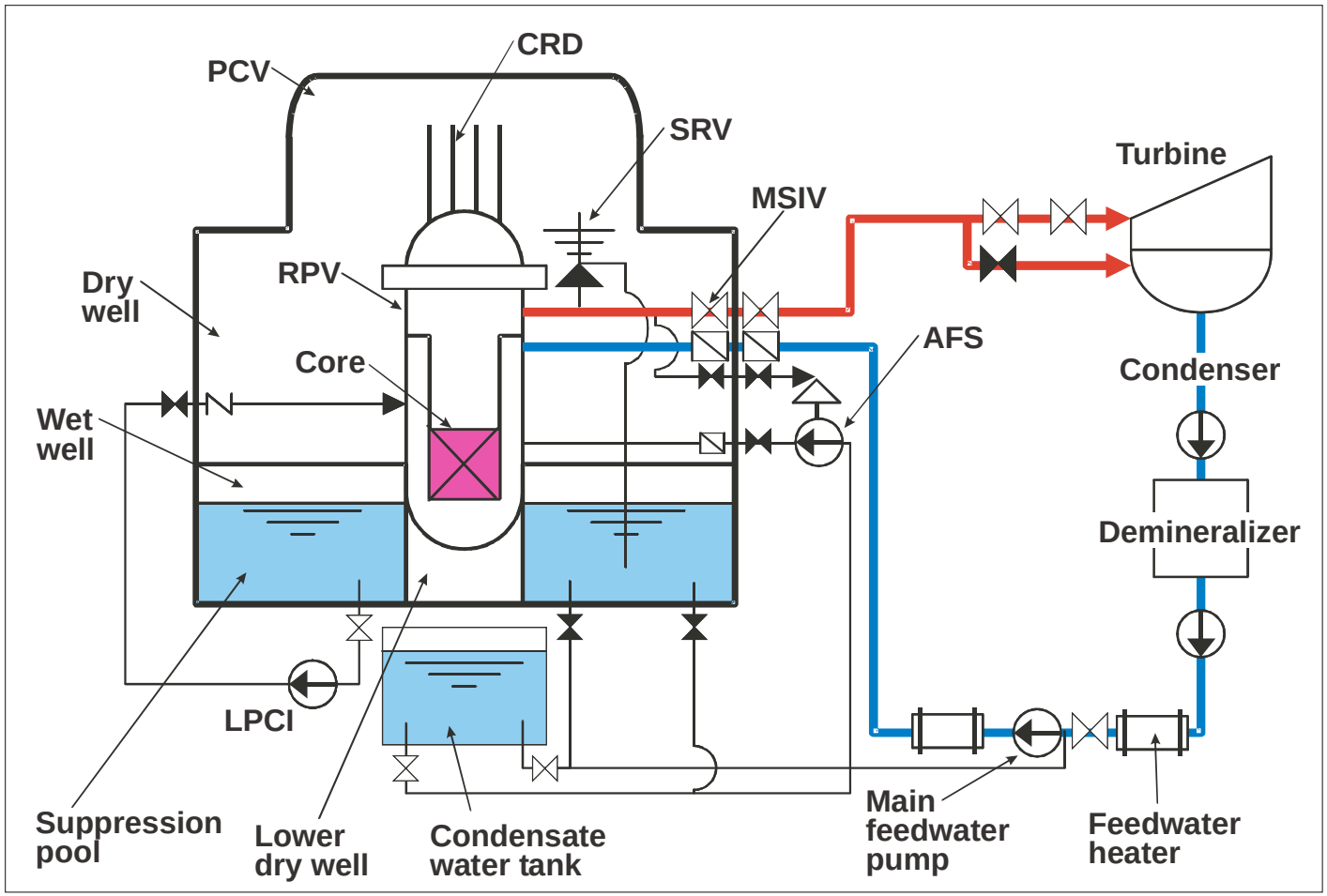
One Disadvantage



Low primary water inventory

Safety

SCWR safety is deemed comparable with ABWR.



Can it be designed with ESBWR-type passive safety systems?

Stability and Control

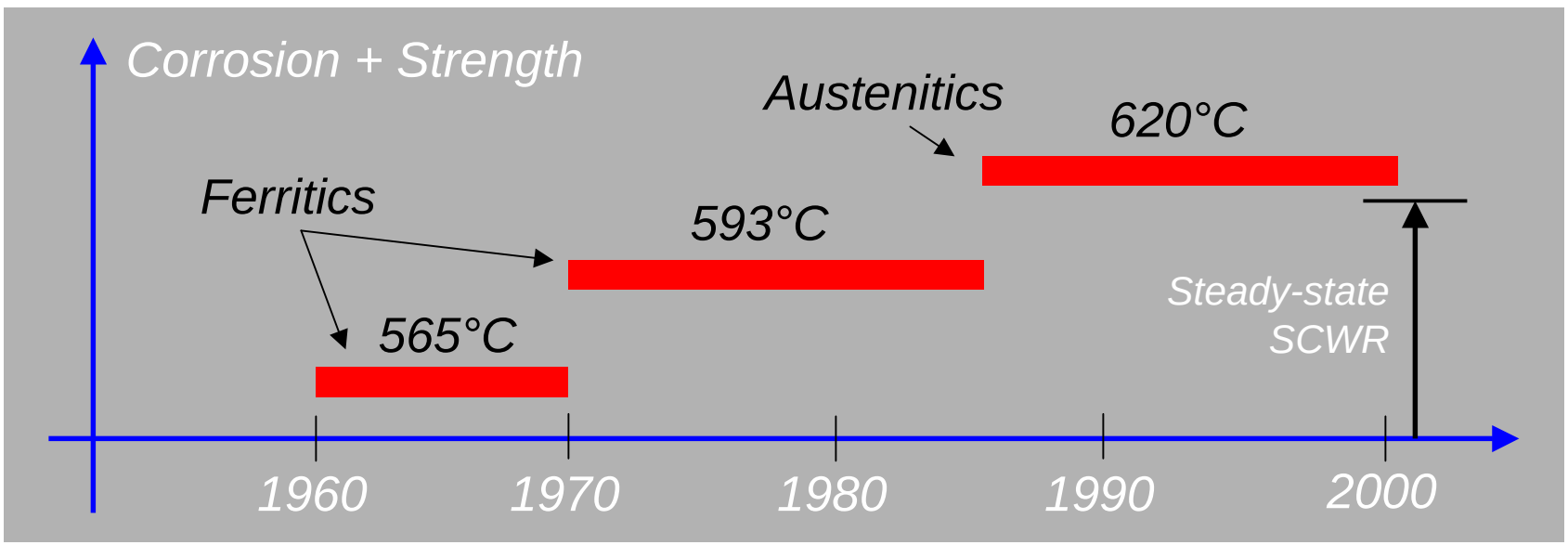
- *Density-wave, coupled neutronic/thermal-hydraulic and natural circulation instabilities are theoretically possible. Is the SCWR actually susceptible?*
- *How to control power, temperature and pressure? E.g., feedwater controls power, CRs control temperature, turbine throttle controls pressure.*
- *How to start up the plant? E.g., constant pressure vs. sliding pressure.*

Core Materials

Requirements

- *High-strength and corrosion resistance at up to 500-600°C*
- *Low susceptibility to SCC*
- *Reasonably-low neutron absorption*
- *Dimensional stability at up to 5 dpa*

Experience in SC power plant industry



Core Materials (2)

Open Questions

- *Effect of radiation on corrosion and SCC.*
- *Effect of radiolysis on coolant chemistry.*
- *Effect of radiation on microstability.*
- *Effect of radiation on mechanical properties.*

International Interest in the SCWR

Organizations currently involved in the development of the SCWR concept:

Country	National Labs	University	Industry
U.S.	INEEL, ANL	Michigan, Wisconsin, MIT	Westinghouse, SRI International
Canada	/	/	AECL
Japan	/	Tokyo, Kyushu, Hokkaido	Toshiba, Hitachi, TEPCO
Europe	FZK (D), CEA (F), PSI (CH), VTT (FIN), KFKI (HUN)	/	Framatome-ANP (F,D), EdF (F)
Korea	KAERI	/	/
Russia	Kurchatov Institute, IPPE	/	/

Conclusions

- *Key features of SCWRs are high thermal efficiency and plant simplification for improved economics.*
- *Major R&D gaps include in-core materials development and demonstration of adequate safety and stability.*
- *Broad international interest in the concept: 10 countries involved with national laboratories, universities and industry.*