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New Nuclear Build Licensing & Large/Small Modular Reactor Technology

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Evolution, Overview and Status of Gen-III/III+ NPPs

The IAEA School of Nuclear Energy Management
Trieste, August 10, 2011

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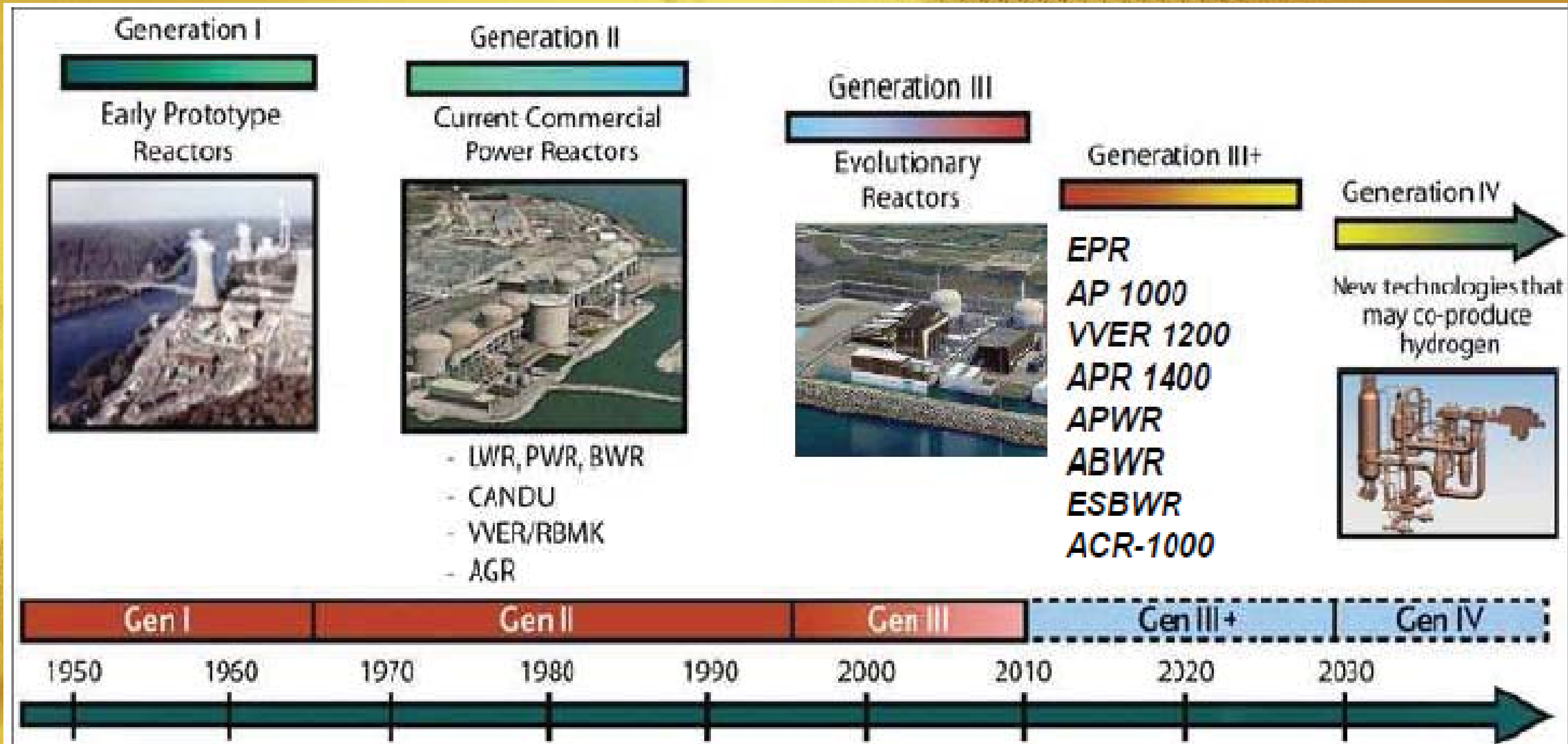
Overview - Evolution of Large Commercial NPP Designs



Overview of
<u>large</u> Nuclear New Build (NNB) Gen-III/III+ Technology Options offered for Deployment today (1000 – 1700 MW)

Commercial Gen III/III+ NPP Designs offered today (1000 – 1700 MW)

– ABWR	GE-Hitachi, Toshiba
– ESBWR	GE-Hitachi
– EPR	AREVA
– AP1000	Westinghouse
– APR1400	KHNP
– APWR1700	Mitsubishi
– VVER1200 (V-392, V-491)	Atomstroyexport (ASE)
– ACR1000	AECL

in operation / under construction

Commercial Gen III/III+ NPP Designs under development (1000 – 1700 MW)

– ATMEA1	AREVA & Mitsubishi (1100MW PWR)
– KERENA	AREVA & E.ON (former SWR1200)
– EU-ABWR	Toshiba / Westinghouse Sweden (1650MW, EU requirements)
– EU-APWR	Mitsubishi (1700MW, EU requirements)

Evolution of Commercial NPP Designs - BWR

- **GE is the 'mother' of all BWRs:**
  - in the1950's GE and AECL developed the CANDU prototype design
  - early 1960's GE made a strategic switch to light water BWR concept
  - next GE deployed the BWR concept in U.S., Europe and Japan via license agreements with AEG (merged into KWU), Hitachi, Toshiba
  - refused to give a license to ASEA/Sweden (who later became ABB)
- **ABB developed their own BWR independently of GE:**
  - in mid-1970's deployed the 'original' ABWR design (4-Division, Reactor Internal Pumps, Fine-Motion-Control-Rod-Drives, etc)
  - Built (6) plants of ABWR-type in Sweden / Finland - first ABB ABWR startup was 1978 TVO OL1 in Finland (built in 48 months)
  - In 1978 the Swedish ABWR Technology was transferred to GE / Hitachi / Toshiba under Agreement ➔ ABWR redesigned for TEPCO by GE/Hitachi/Toshiba Team with participation of ABB

Evolution of Commercial NPP Designs – BWR (2)

- **KWU (later merged into AREVA):**
  - KWU also designed their own 'ABWR-type' BWR (Reactor Internal Pumps, Fine-Motion-Drives, etc) and built (6) such BWRs in Germany
  - late 1990's AREVA decided to 'revive' the KWU BWR line and started out developing the SWR-1000 → now renamed KERENA
- **GE-Hitachi:**
  - in 2000's GE-Hitachi merged their nuclear business
  - started to develop the ESBWR concept – based on ABWR but relying on natural circulation and passive systems
  - ESBWR name has changed several times reflecting its original pedigree (European Simplified BWR, later Economic Simplified BWR)
- **Toshiba:**
  - in 2006 split from GE/H/T family when taking over Westinghouse
  - developing 'European' ABWR II / 1650MWe with aircraft protection incorporating features from ABB BWR90+ design

Evolution of Commercial NPP Designs – BWR (3)

Vendor		1960's	1970's	1980's	1990's	2000's	3G NPPs
GE/Hitachi/ Toshiba		**BWR/1**		**BWR/6**			**ABWR**
GE-Hitachi							**ESBWR**
Toshiba							**ABWR**
							EU-ABWR
ABB			**BWR75**		**BWR90+**		
			OL-1/2	F-1/2/3, O-3	'original 6 ABWRs'		F-3 is ABWR Ref Plant
KWU			**KKB**	**KKK**			
AREVA							**KERENA**

GE License to AEG/KWU

ABB ABWR Technology Transfer

Evolution of Commercial NPP Designs - PWR

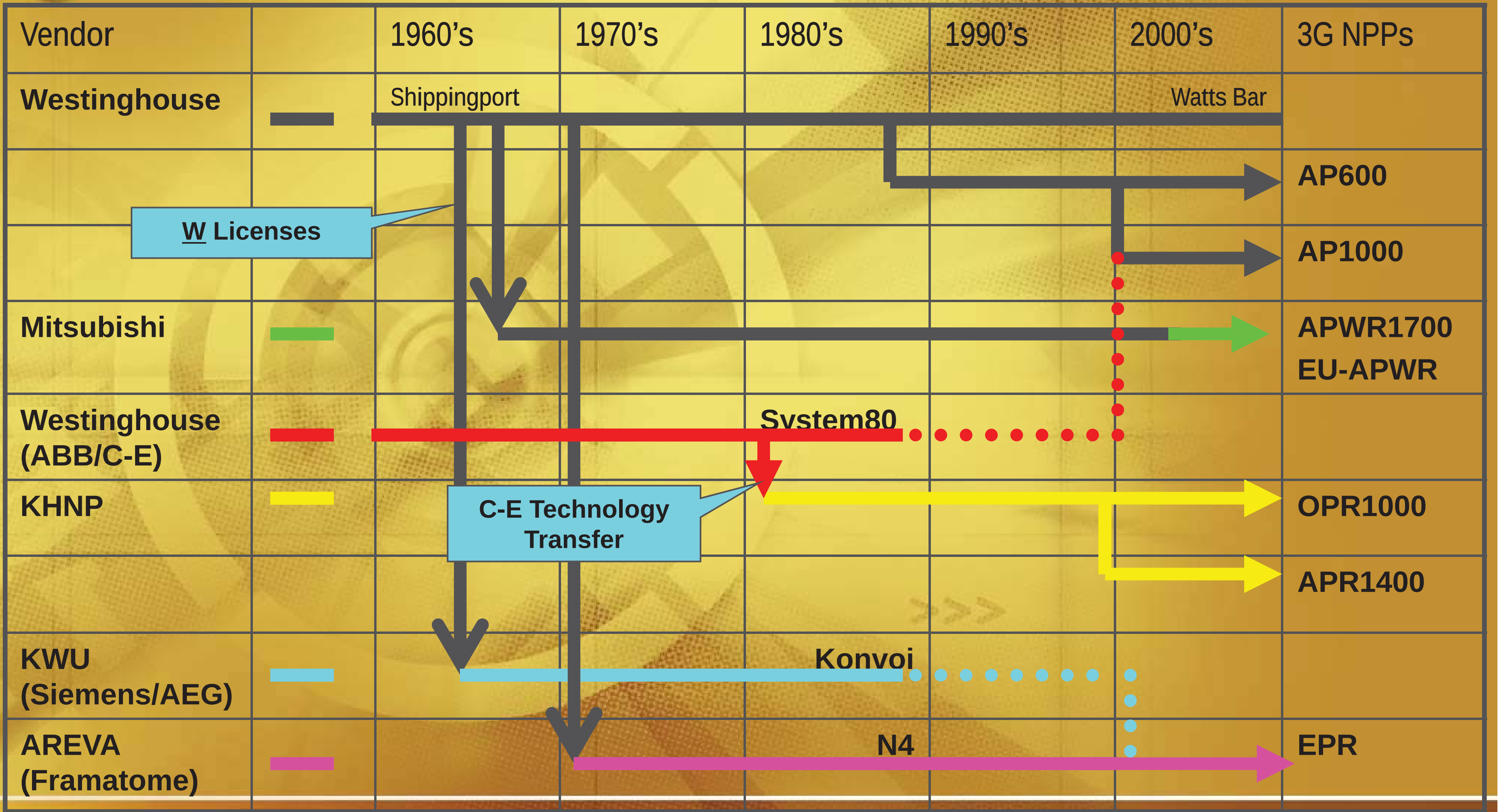
- **Westinghouse (W) is the 'mother' of all PWRs:**
  - in late 1950's naval reactor (Nautilus) was put on Land (Shippingport)
  - in 1960's W deployed the PWR in U.S., Europe and Asia via license agreements with Mitsubishi and Siemens (later merged into KWU)
  - early 1970 W licensed Framatome to build the 58 PWR French fleet and many more PWRs worldwide (eventually more PWRs than W)
  - W / Mitsubishi developed the evolutionary APWR until Toshiba takeover of W
  - in 1990's and 2000's W developed the passive safety AP600/1000
- **KWU (Siemens/AEG merger):**
  - in 1970's and 1980's KWU developed their own PWR design resulting in the 1300 MWe class Konvoi design
- **AREVA (Framatome/KWU merger):**
  - developed their own 1400 MWe N4 design, which was combined with Konvoi design to develop & deploy the European PWR (EPR)

Evolution of Commercial NPP Designs – PWR (2)

- **Combustion-Engineering (C-E, later ABB/C-E, then W):**
  - C-E independently developed their own PWR designs for U.S. market, which in key technical areas was ahead of W (even today the key components in AP1000 are based on C-E technology)
  - crowning achievement was the System-80 design (Palo Verde-1/2/3)
  - C-E made a total Technology Transfer Agreement with South Korea, which is the basis for their fleet of (12) OPR1000 (8 in operation), and (4) APR1400 (under construction)

- **KHNP (Korean Hydro & Nuclear Power Company):**
  - the OPR1000 was directly based on C-E System-80/80+ design
  - the APR1400 is using Korean technology, and represents a further development of the System-80+ design

Evolution of Commercial NPP Designs – PWR (3)



NOTE: B&W is not shown here since they had limited impact (7 PWRs) apart from TMI.

Evolution of Commercial NPP Designs - VVER

- **Rosatom / AtomStroyExport (ASE):**
  - today Rosatom is vertically integrated like a Russian AREVA
  - VVER program started out in 1960's with 200 MWe plant design, and in 1970's it became the successful VVER-440 fleet
  - characteristic for all VVERs are following:
    - Hexagonal fuel lattice (allows smaller RPV transportable by rail)
    - Horizontal SGs (long life, no issues like Western SGs)
  - in 1980's the VVER1000 came along, named AES91, and it has been exported to Tianwan/China (in operation), Kudankulam/India (startup 2011), and Busher/Iran (startup 2011)
  - Latest VVER1000/AES92 (V-466) satisfies EUR – planned for Belene
  - the AES92 has been stretched to 1200 MW class, renamed AES2006, and it comes in two versions: V-392M (Russia) and V-491 for export
  - latest VVER1000 and VVER1200 have Siemens TELEPERM -XS I&C

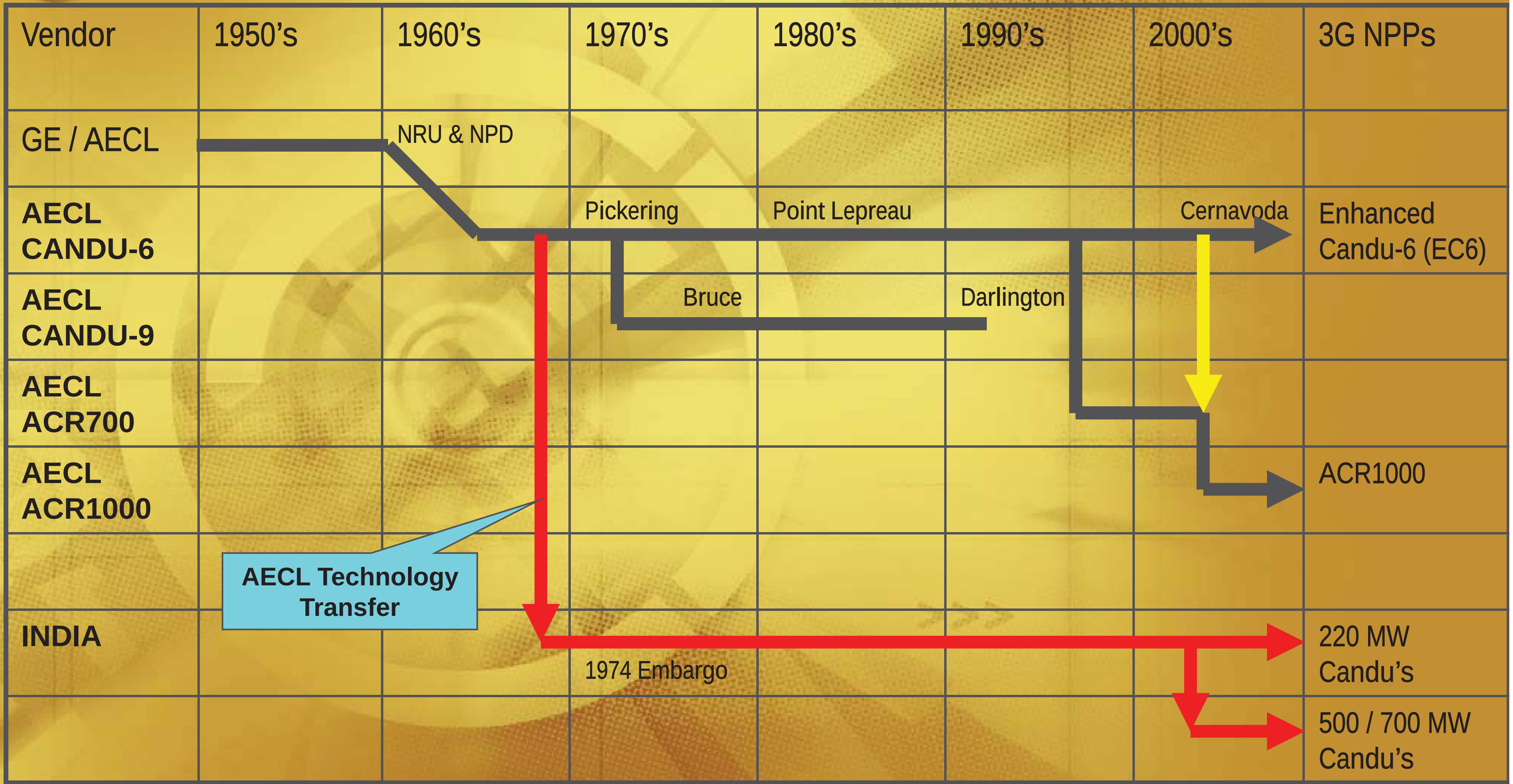
Evolution of Commercial NPP Designs – VVER (2)

Vendor		1960's	1970's	1980's	1990's	2000's	3G NPPs
Rosatom / AtomStroyExport		Novovoronesh	VVER210				
			Loviisa	VVER440		Mochovce	
				Zaporozhie		Tianwan	**VVER1000/ AES91**
					Novovoronesh II		**VVER1200/ V-392M**
					Leningrad II		**VVER1200/ V-491 (for Export)**

Evolution of Commercial NPP Designs - CANDU

- **GE / AECL:**
  - in the 1950's GE and AECL cooperated on the development of the CANDU prototype design (NRU, NPD plants)
- **AECL:**
  - in 1960's AECL developed CANDU design with typical characteristics:
    - Heavy water moderated and cooled
    - Pressure tubes / on-line refueling
    - Runs on natural uranium
  - in 1970' & 1980's two standard CANDU designs (C-6/C-9) were deployed in Canada and worldwide (C-6 only)
  - in 1990's the ACR700 was developed, but failed to get acceptance in U.S. Consequently, a scaled up ACR1000 was developed.
  - with ACR1000, AECL moves the CANDU design towards PWR, utilizing light water cooling and <u>enriched uranium</u> (2.4% initially, but ultimately 4%) to reach higher burnup

Evolution of Commercial NPP Designs – CANDU (2)



Characteristics of Gen III/III+ Plants

- **Improved Safety**
- **Improved Licensing**
- **Improved Economics**
- **Improved Construction**
- **Improved Operations**
- **Improved Standards**
- **Reduced Uncertainties**
- **First-Of-A-Kind Engineering (FOAKE)**

Characteristics of Gen III/III+ Plants (2)

- **Improved Safety**
  - 4 Safety Trains
  - Aircraft Crash Protection (Double Containment)
  - Severe Accident Mitigation (Core Catcher)
  - Digital I&C Systems
  - Significantly Lower CDF and LRF Values
  - Some Passive Safety System Features
- **Improved Licensing**
  - Standardized Designs (DCD approval)
  - Streamlined Licensing Process (e.g., COL, GDA)

Characteristics of Gen III/III+ Plants (3)

- **Improved Economics**
  - Standardized, Simplified, Robust Design
  - Higher Plant Efficiency
  - 60 years Plant Life (80 years anticipated)
  - 90+% Capacity Factor
- **Improved Construction**
  - Modular Design
  - Prefab of Systems and Components off-site
  - Open Top Construction

Characteristics of Gen III/III+ Plants (4)

- **Improved Operations**
  - Less Operational Radioactive Waste
  - Less Doses to Plant Staff
  - Less Maintenance (fewer active systems)
  - Shorter Outages (typically 15 days)
- **International Standards**
  - Compliant with IAEA QA and Safety Guides
  - Compliant with EPRI URD
  - Compliant with EUR
  - Further Benefits from Code Harmonization

Characteristics of Gen III/III+ Plants (5)

- **Reduced Uncertainties for Owner/Investor**
  – Anticipated as a result from all improvements
  – Not yet demonstrated for current Gen III/III+ NPPs

- **First-Of-A-Kind Engineering (FOAKE)**
  – So far FOAKE efforts much underestimated
  – Benefits from Standardization not yet reached (AP1000 in China may be first to achieve these benefits)
  – Significant re-learning of NPP Construction Lessons

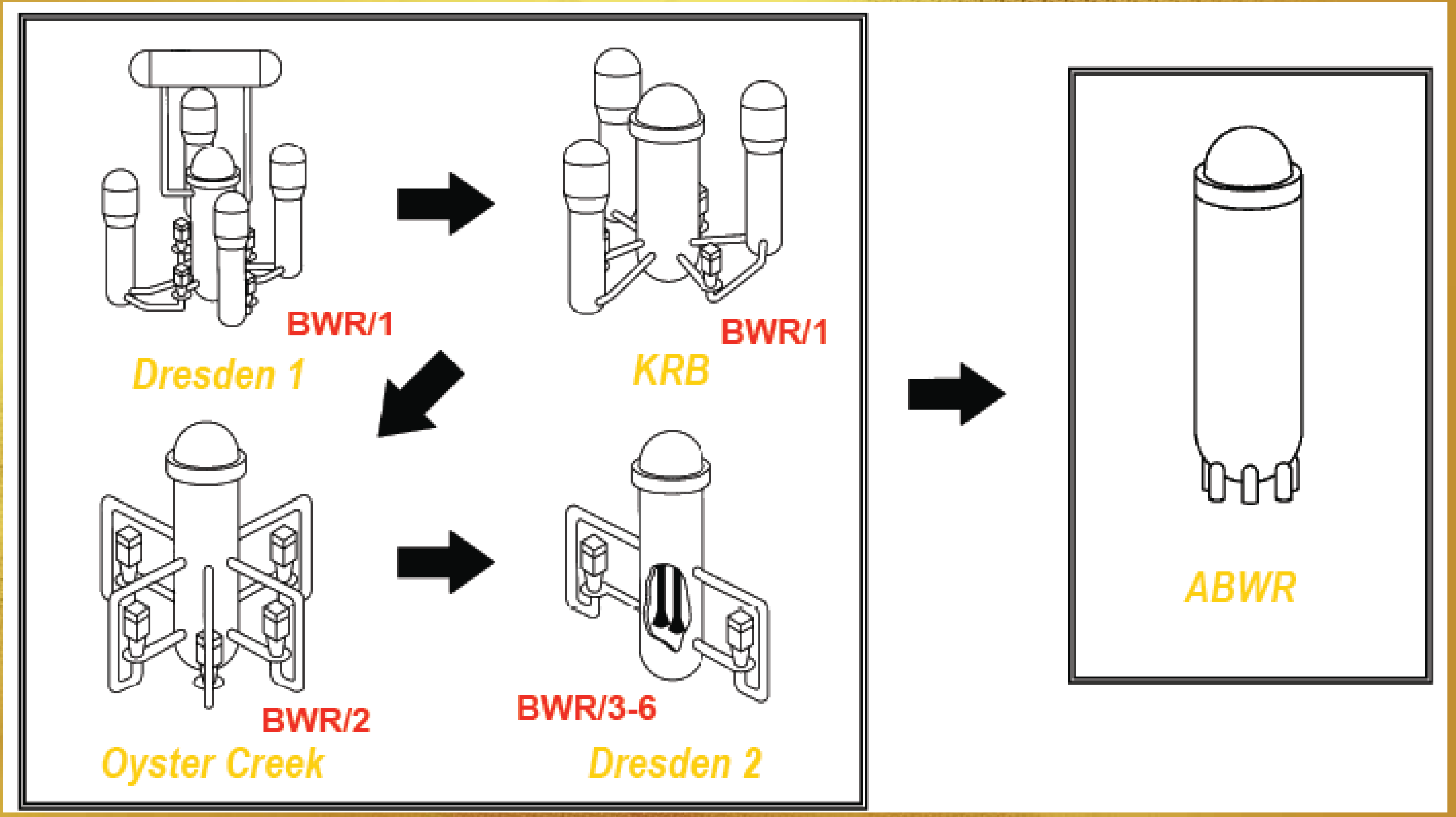
Description of Gen III/III+ Plants

- ABWR
- EPR
- AP1000
- APR1400
- APWR
- VVER1200 (V-392M, V-491)
- ESBWR
- ACR1000

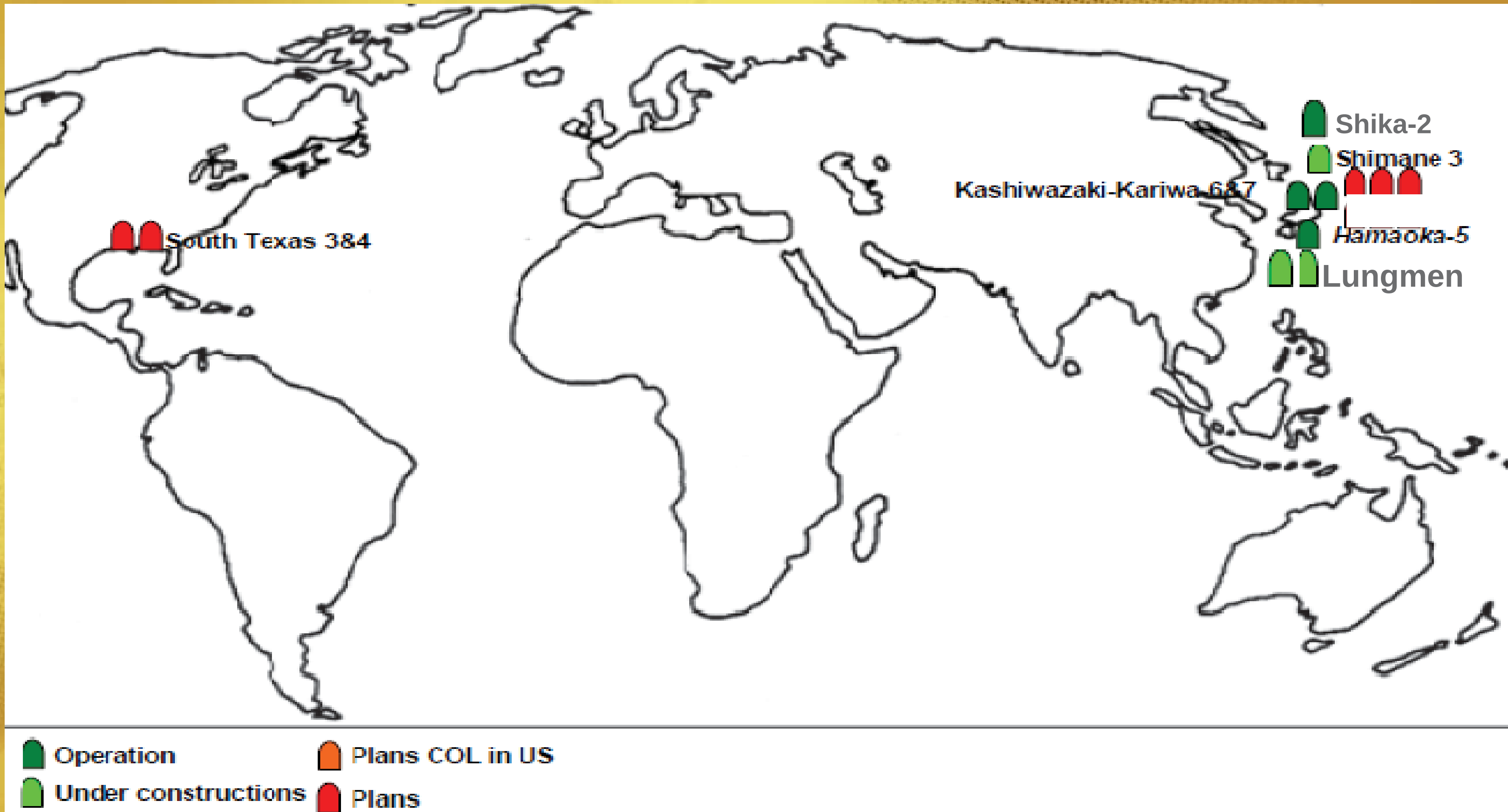
ABWR

- 3/4-Train Safety Systems
- Reactor Internal Pumps eliminate external loops
- Fully digital I&C
- Modularized design & Prefab construction experience
- Integrated containment and reactor building
- Lowest Core Damage Frequency amongst 3G Designs (except for ESBWR)
- Proven Capital and O&M cost structure (in Japan)
- No Steam Generators – reduced life time costs
- No external coolant loops and no core uncovery

Design Evolution - ABWR

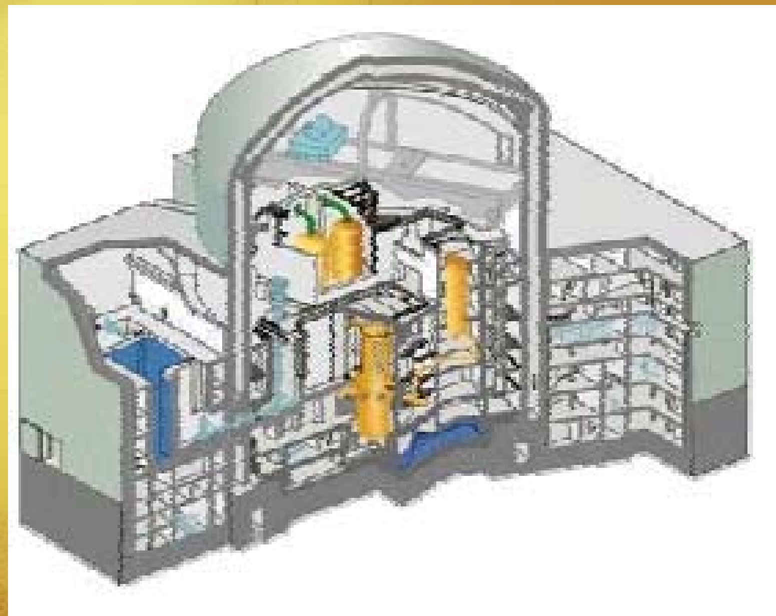


Worldwide – ABWR

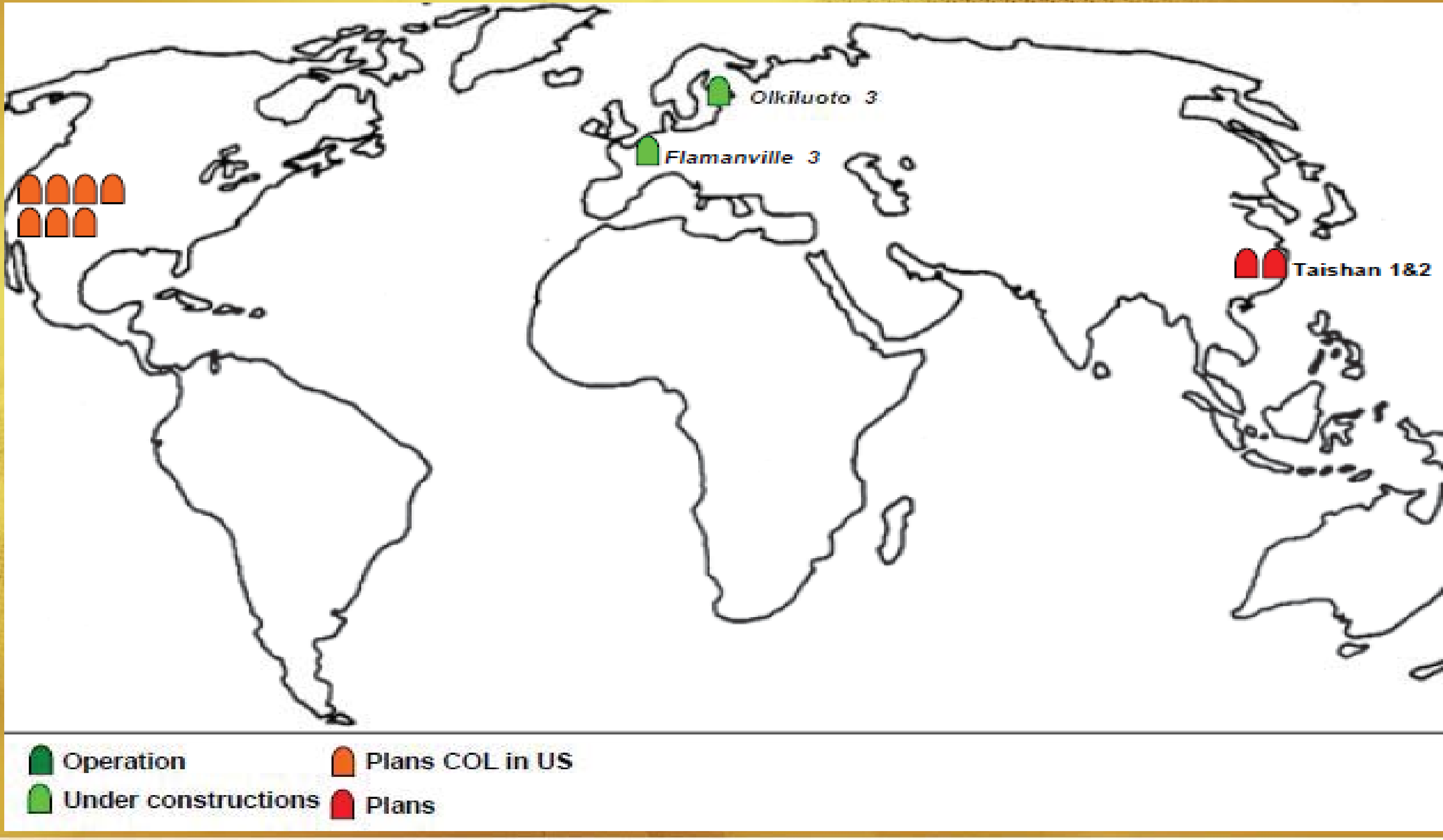


EPR

- 4-Train Safety Systems
- Double Containment to protect against commercial aircraft crash
- Core Catcher for severe accident mitigation
- Can run on full MOX Core
- Higher Plant Efficiency (37%)
- Digital I&C (Siemens TELEPERM-XS)
- 10-15% less uranium consumption
- 15 days outages
- Above 90% life time capacity factor
- Robust design with small technology leap

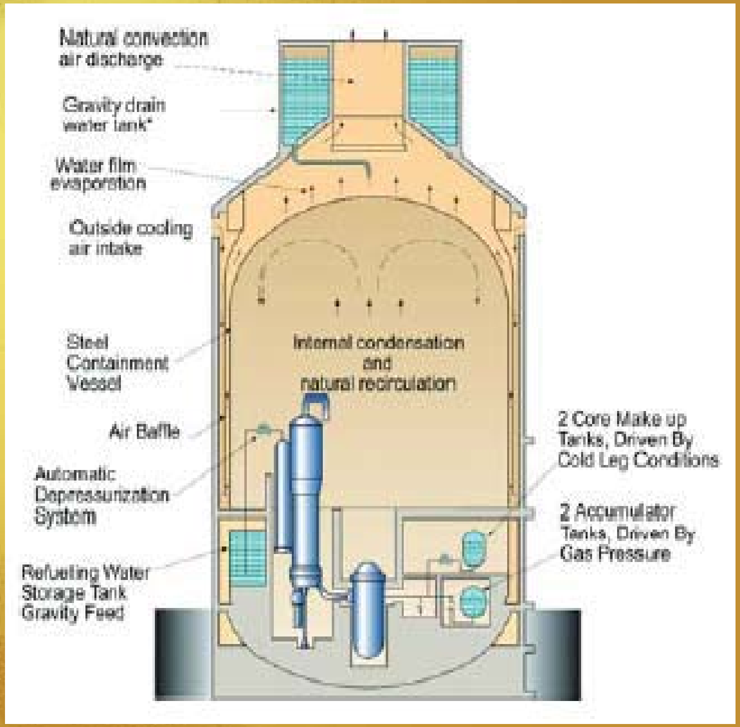


Worldwide – EPR

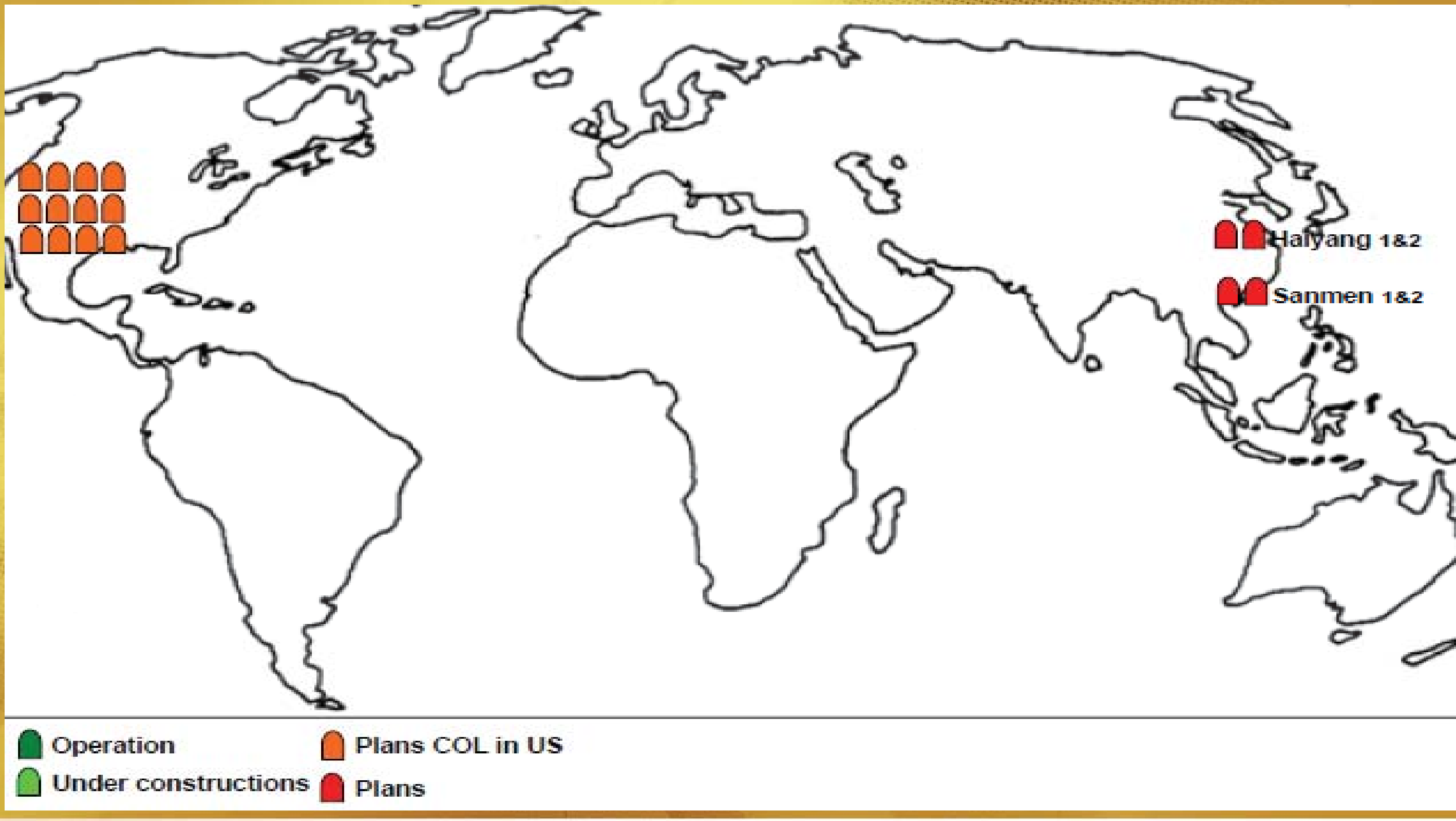


AP1000

- Passive Safety Systems – use forces of nature (gravity, convection, natural circulation to improve safety and simplify systems)
- Passive systems are used for core cooling, containment isolation, residual heat removal and containment cooling
- No outside electricity needed for 72 hours
- Number of pumps and safety class valves reduced by about 50%
- In-vessel retention of core melt
- Passive Containment Cooling system
- Proven PWR components



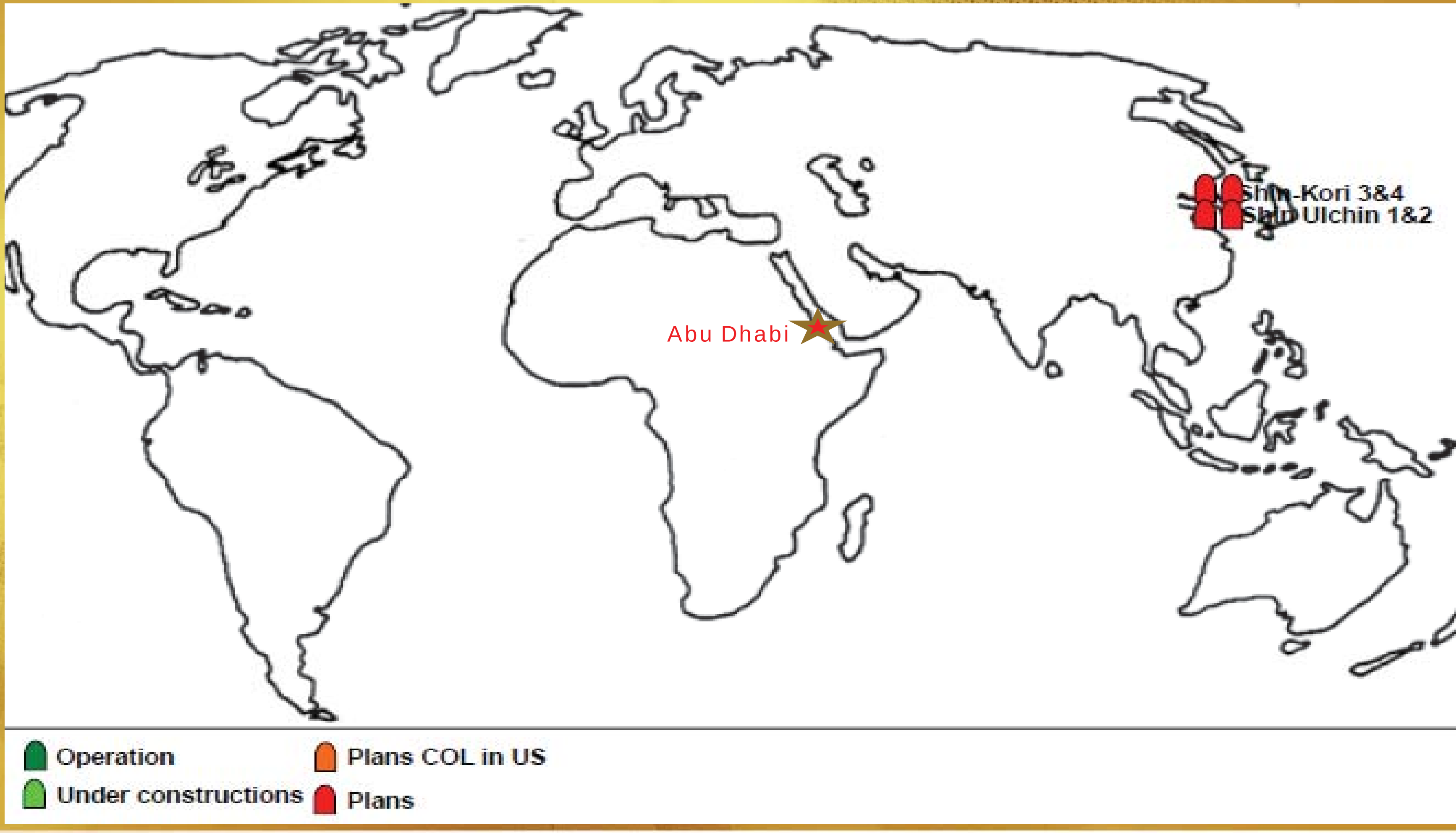
Worldwide – AP1000



APR1400

- Designed based on EPRI ALWR Requirements (URD)
- Up-rated power of 4,000 MWt (1,450MWe)
- 60-year design life
- Use of proven technology plus extensive testing
- Fully digitalized control system
- In-Containment Water Storage System (ICWRS)
- 4-Train Safety Systems
- Passive design features
- Prefab and modularized design
- Severe accident mitigation:
  - External RPV Cooling System
  - Cavity Flooding System
- World's largest 2-loop arrangement (2 hot-legs, 4 cold-legs, 2 SGs)
- World's largest 60Hz Turbine

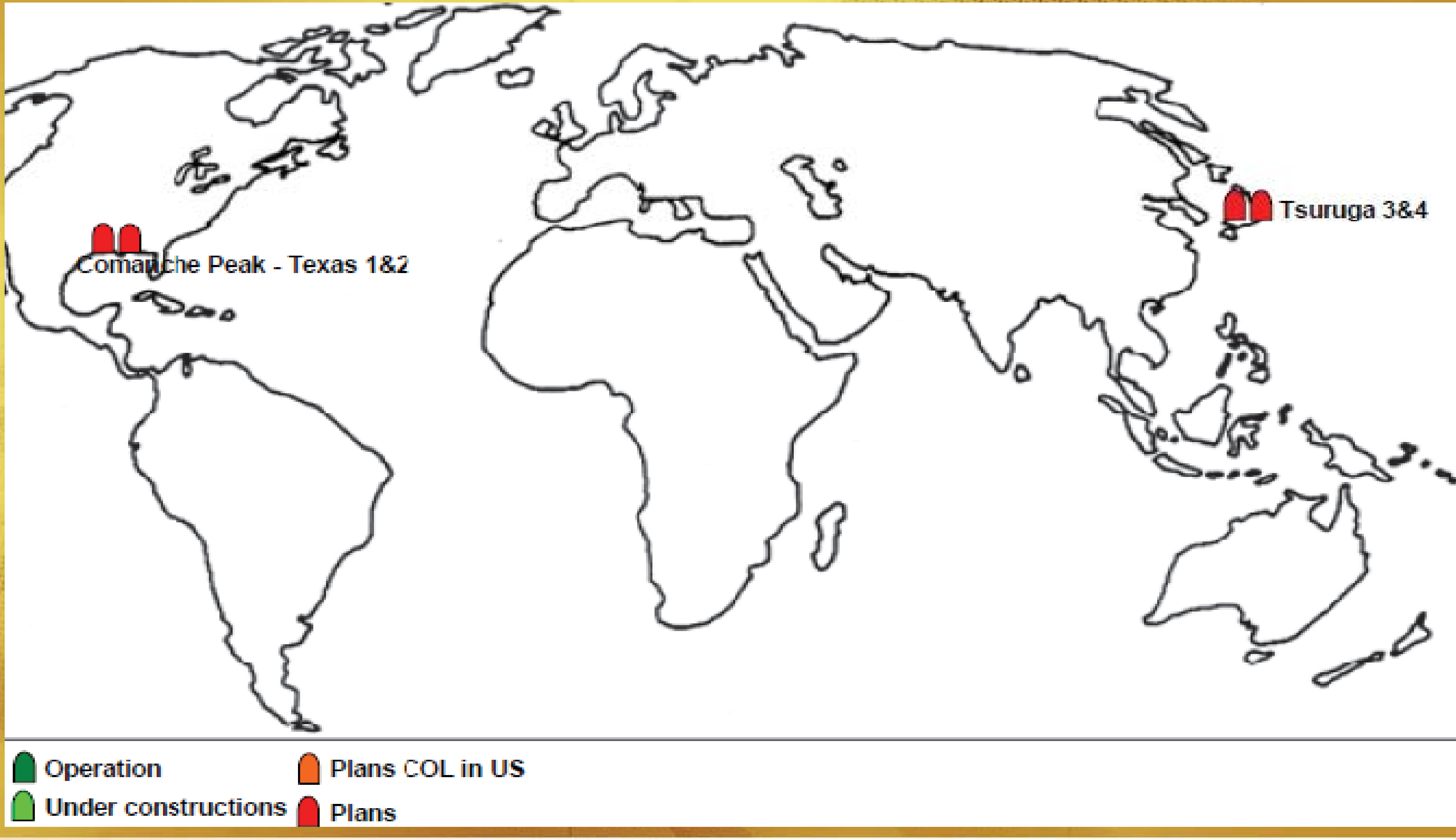
Worldwide – APR1400



APWR

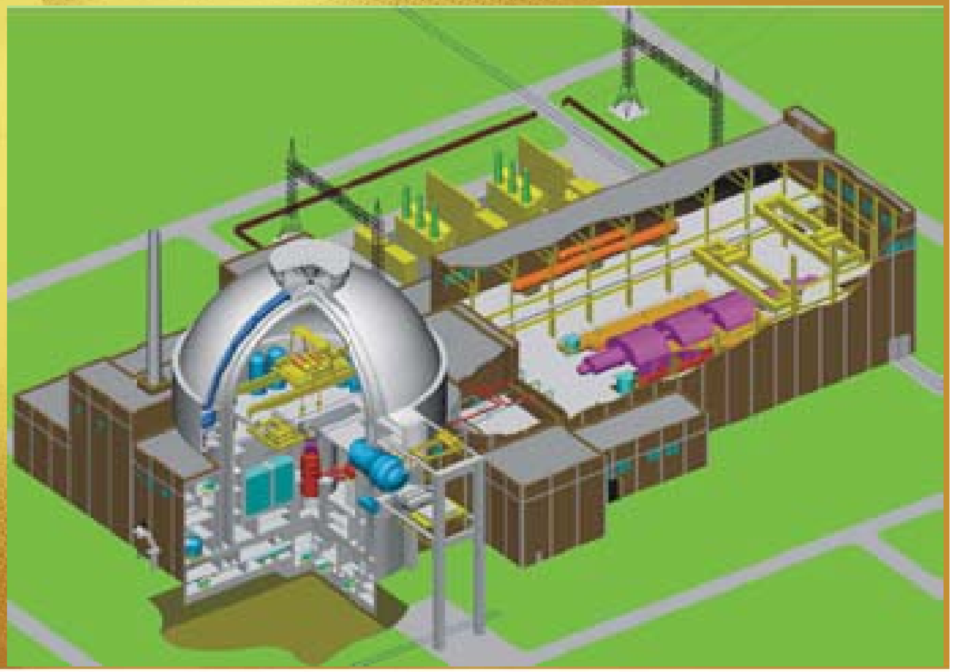
- 4-Train Safety System (4 x 50%)
- Core has extra Neutron reflector to improve fuel economy
- In-Containment Refueling Water Storage
- Thermal Effciency 39% in USA Version – 160 MWe extra from TG plant
  - means 30% larger heat transfer surface in SGs
  - last stage Turbine Blades increased from 54” to 70” length
- Can handle full MOX fuel core
- 14 ft fuel length
- Reduced Staff exposure
- Fully Digital I&C
- Reduced Operational Waste
- PreFab and modularized design

Worldwide – APWR



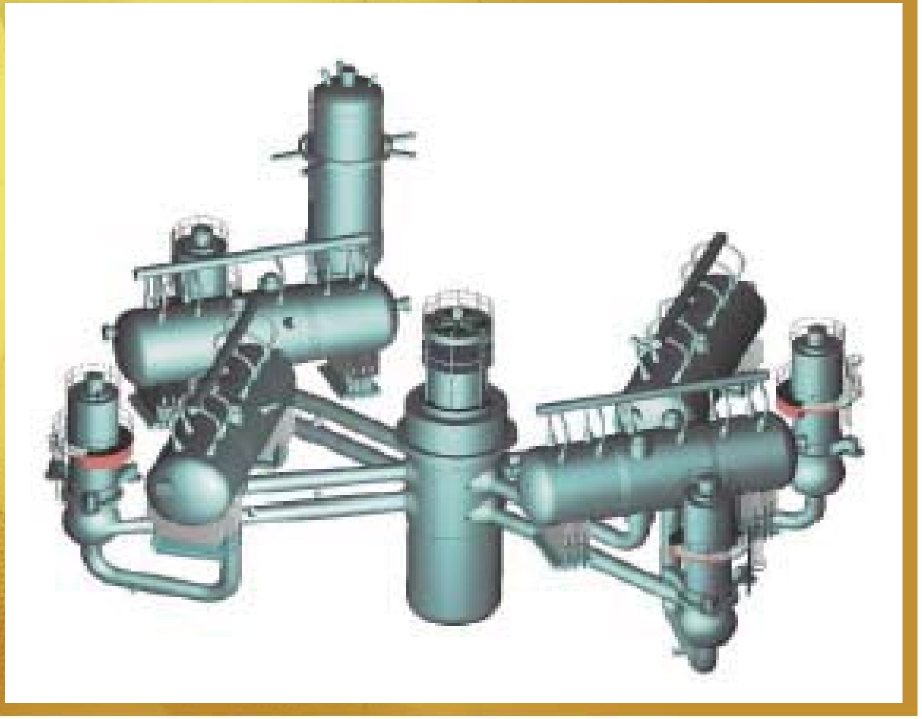
VVER1200 – V-392M and V-491

- V-392M designed by Moscow Atomenergoproekt Institute, and two Units under construction at Novovoronesh II site (COD 2012)
- V-491 designed by St.Petersburg Atomenergoproekt Institute, and two Units under construction at Leningrad II site (COD 2013)
- VVER1000 stretched to 1200 Mwe
- 60 years service life
- Higher thermal efficiency (35.7%)
- 4-loop design with horizontal SGs
- Most recent VVER1000 export NPPs:
  - in China (Tianwan-1/2)
  - in India (Kudankulam-1/2)
  - in Iran (Busher)

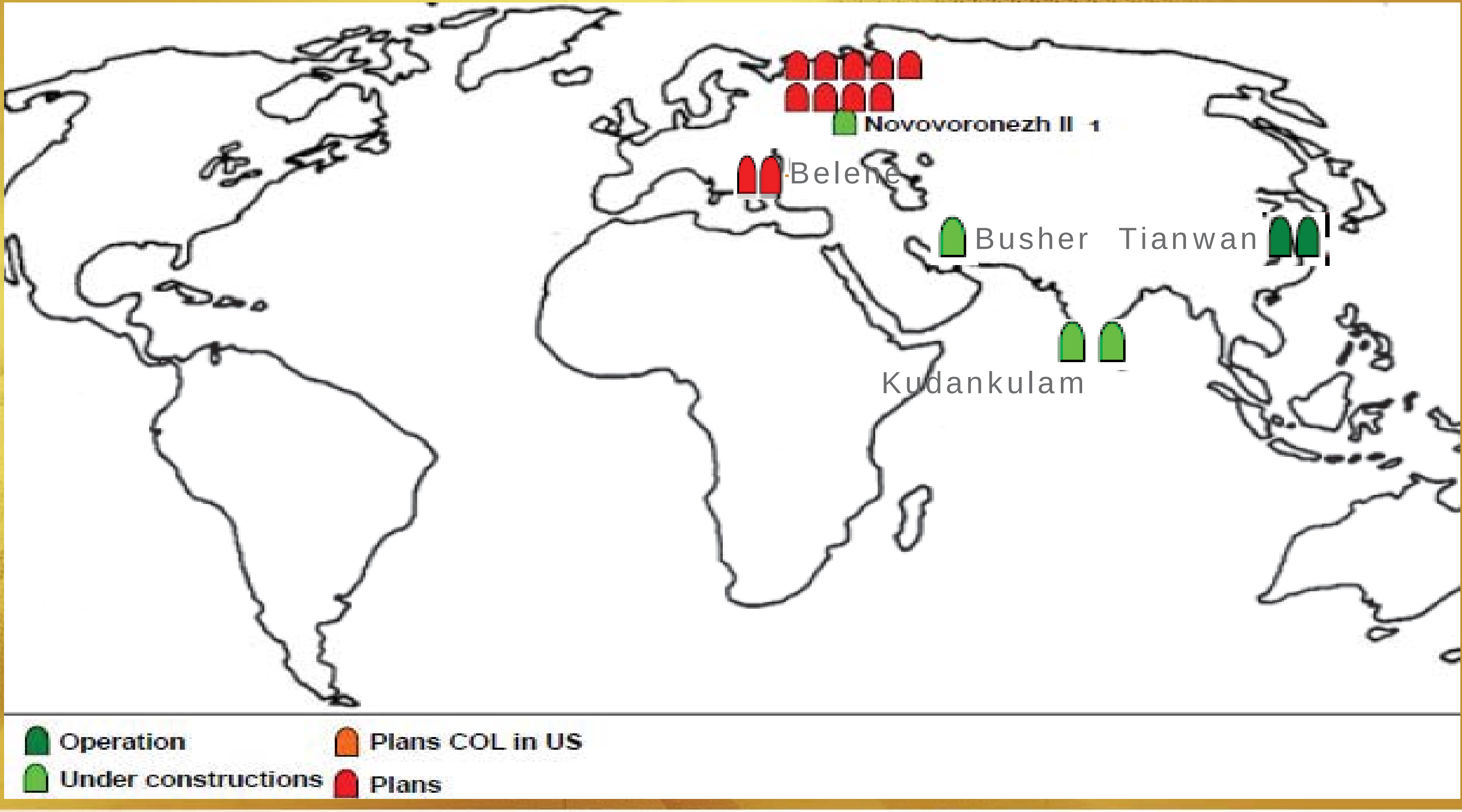


VVER1200 – V-392M and V-491 (2)

- V-392M design focuses more on passive safety, less redundancy (e.g., 2-train)
- V-491 design focuses more on active safety, redundancy (e.g., 4-train)
- No Operator's intervention needed for 24 hours
- Passive systems (containment, residual heat removal)
- Double Containment
- Core Catcher
- Proven Construction schedules from VVER1000 plants (4.5 years)
- Siemens Digital I&C (TELEPERM-XS)
- Belene / Bulgaria was planned to be first in EU satisfying EUR standards
- V-491 is the VVER1200 export version designed to satisfy Western standards (IAEA, EUR)
- V-491 has been evaluated by Finnish Authority (STUK) and has been pre-qualified with some exceptions



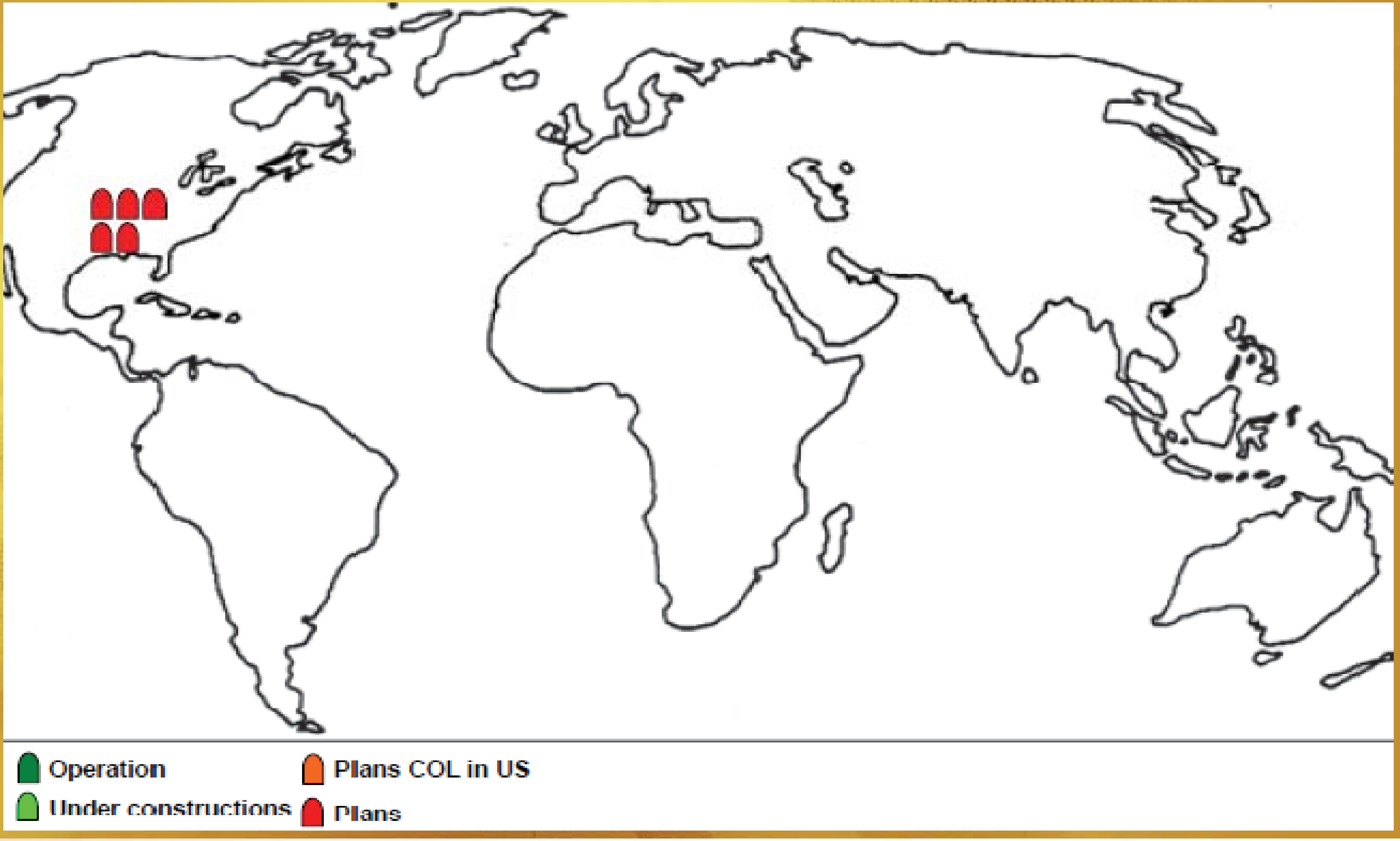
Worldwide – VVER1000/VVER1200



ESBWR

- Simpler safer BWR using passive concepts to the max
- No Operator action required for up to 72 hours
- 11 ABWR systems eliminated from ESBWR
- 25% of pumps, valves and motors eliminated
- Passive Residual heat transfer to atmosphere
- Using best features of existing BWRs / ABWR
- Core Damage Frequency 1.7E-8, is lowest in 3G world
- Reduced construction costs and schedule
- Reduced O&M costs
- Prefab and modular design reduce construction costs

Worldwide – ESBWR



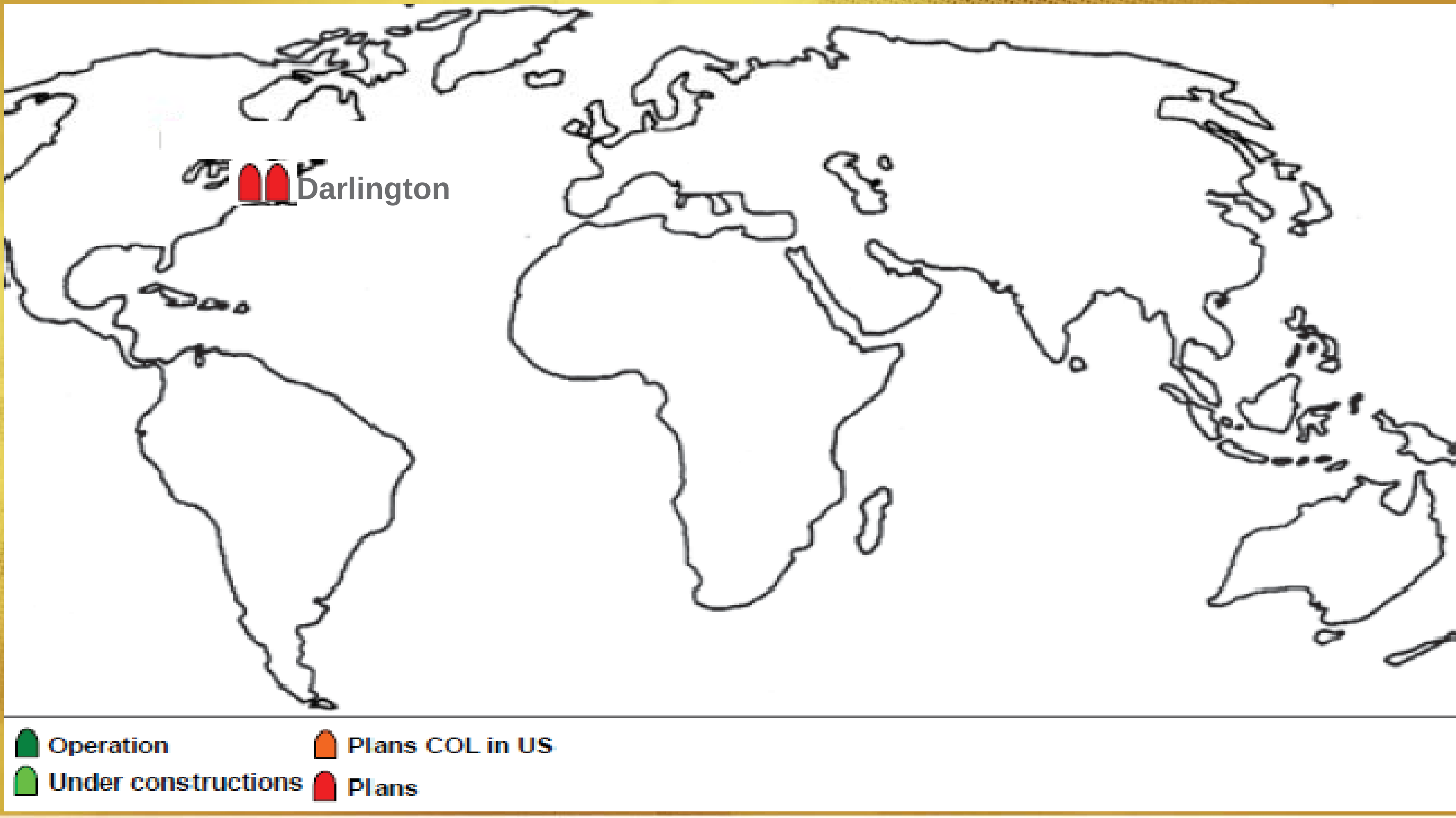
ACR1000

- 1165 MWe advanced CANDU (evolutionary development)
- Light-water-cooled, heavy-water-moderated
- 2.4% enriched uranium in fuel achieves 20 MWd/kgU burnup (4.0% enriched fuel to achieve 40 MWd/kgU burnup / future target)
- 4-Loop design
- Strengthened containment building (single wall)
- Reactor Vault is waterfilled (Core catcher function)

ACR1000 (2)

- Retains all basic CANDU features:
  - modular design and construction
  - horizontal pressure tube core
  - heavy water moderator
  - on-line refueling
  - on-line maintenance
- 60% reduced heavy water inventory
- Can burn MOX, Thorium fuels
- 2.4% enriched uranium fuel ensuring negative reactivity coefficients

Worldwide – ACR1000



Key Features – Gen III/III+ Designs

Major Features	*ABWR*	*EPR*	*AP1000*	*APR1400*	*APWR*	*VVER1200 V-491*	*ESBWR*	*ACR1000*
Vendor	GE-Hitachi Toshiba	AREVA	Westinghouse	KHNP	Mitsubishi	Rosatom	GE-Hitachi	AECL
Output, MWe	1370	1600 (Finland) 1700 (USA)	1117	1400	1538 (Japan) 1700 (USA)	1200	1535	1165
Plant Efficiency, %	35	37	34	35	35 (Japan) 39 (USA)	36	35	36
Design Life, years	60	60	60	60	60	60	60	60
Construction, months from 1st Concrete to COD	48 44 (in Japan)	51	42	48	46	54	42 estimate	42
First Unit COD	1996 (Japan) 2017 (USA)	2012 (Finland)	2014 (China)	2014 (S. Korea)	2015 (Japan)	2013 (Russia)	No order	No order
Extensive use of PreFab modules	Yes	No	Yes	Yes	Yes	No	Yes	Yes
Digital I&C	GE	Siemens TELEPERM-XS	ABB ADVANTAGE	Korean	MHI	Siemens TELEPERM-XS	GE	Dual computer
Containment	Single	Double	Single	Single	Single	Double	Single	Single
Safety Systems	3/4-train active	4-train active	4-train passive	4-train active	4-train active	4-train active	4-train passive	4-train active
Core Catcher function	Partially	Yes	In vessel	No	No	Yes	Partially	Partially
Fuel Lattice type	10x10	17x17XL	17x17XL	16x16	17x17XL	Hexagonal	10x10 short	43-rod
Discharge Burnup, MWd/kg	60	62	62	62	62	49 (VVER1000) 65 (VVER1200)	60	20 40 (future)
Steam Generators	n/a	4 U-tube	2 U-tube	2 U-tube largest in world	4 U-tube	4 horizontal	n/a	4 U-tube

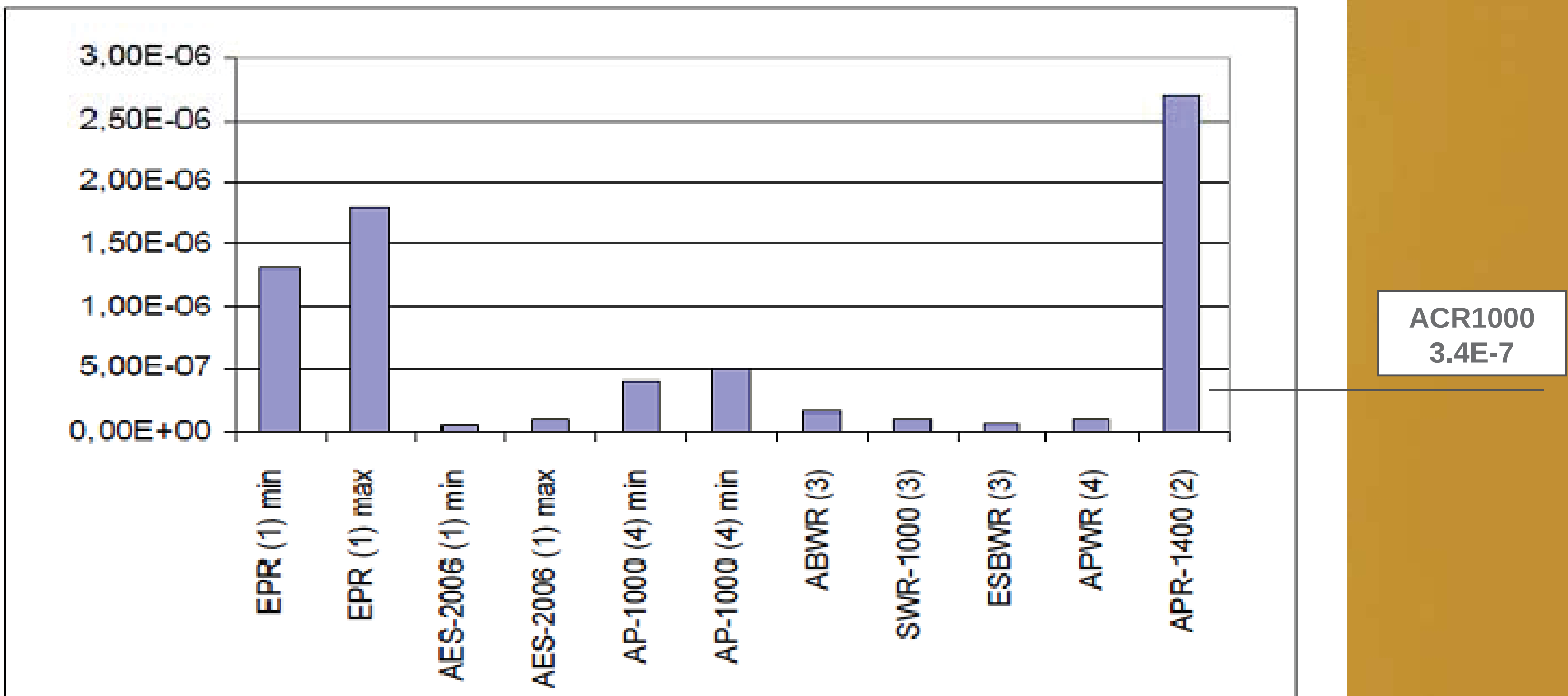
Key Features – Gen III/III+ Designs (2)

Risk Factors	*ABWR*	*EPR*	*AP1000*	*APR1400*	*APWR*	*VVER1200 V-491*	*ESBWR*	*ACR1000*
Output, MWe	1370	1600 (Finland) 1700 (USA)	1117	1400	1538 (Japan) 1700 (USA)	1200	1535	1165
Certification	EUR NRC	EUR NRC ongoing	EUR NRC ongoing	System-80+	EUR ongoing NRC ongoing		NRC ongoing	
Status	In operation in Japan	Under construction in Finland, France	Under construction in China	Under construction in South Korea	Under construction in Japan	28 VVER1000 in Operation. V-491 designed to satisfy Western standards		
Completed Engineering	A	A	A	A	A	A	D	D
Licensing Certainty	A	A	A	N	N	N	N	D
Operating Certainty	A	N	N	A	A	A	D	N
Construction Certainty	A	N	A	A	N	A	N	A
Cost Certainty	A	D	A	A	N	N	D	D
Manufacturing Capability	A	A	A	A	A	N	D	A
Labor Supply	N	N	N	N	N	N	N	N
Life-cycle cost	A	A	N	A	A	N	A	N

Advantage = A **Neutral = N** **Disadvantage = D**

Summary of an EXCEL Report prepared in 2009

Core Damage Frequency – Gen-III/III+



Source: Report 0162 Umweltbundesamt, Vienna 2008

Figure 1: Core damage frequency of different Generation III reactors.

Footnotes for Figure 1:

(1) internal and external initiators, operational and shutdown states

(2) internal and external initiators; not clear if shutdown states included

(3) internal initiators, operational and shutdown states

(4) no specification regarding events and states

Overview of worldwide NNB Trends and Order Books

Current NNB Status & Trends Worldwide

(with Fukushima impact estimated)

Region	NNB Trend	NNB Projects	Comments
North America	→	First wave (2) COLA in progress for total of 4 reactors	Waiting for Loan Guarantees, US Nuclear Renaissance halted. Canada on hold (AECL sell-off).
South America	↔	(1) Gen II reactor to be completed (Angra-3)	Planning stage (Mexico, Brazil, Chile, Argentina)
Europe	↗	(4) Reactors under construction; (17) planned	Finland (1+2), Sweden (2), UK (6), France (1+1), Switzerland (0), Czech Republic (2), Slovakia (2), Bulgaria (2), Italy (0)
Russia	↗	(7) Under construction	Steady growth, but slower
MENA	↗	(4) Under construction	Accelerating growth expected. UAE (4) on order. Firm plans in Turkey. Egypt, Jordan, Saudi Arabia slowed down.
Asia	↗	(29) Under construction, (8) firm orders. This excludes Chinese domestic NPPs.	Slower growth in China. Delayed growth in India. Healthy growth in South Korea, plus new countries, zero in Japan.
Australia	↔	(0) planned.	Waiting on Gov policy decision.

Current NNB Constructions and Contracts

Vendor	Plant	Type	COD	Status
AREVA	Angra 3	Gen II Konvoi	2016	Under construction
AREVA	Calvert Cliff 3	EPR1700	2018	Waiting on EPC Contract, COL and LG
AREVA	Flamanville 3	EPR1600	6/14	Under construction, 2yrs delay
AREVA	Olkiluoto 3	EPR1600	6/13	Under construction, 4 yrs delay
AREVA	Penly 3	EPR1700	2017	Firm plans, but no contract
AREVA	Taishan 1	EPR1700	12/13	Under construction
AREVA	Taishan 2	EPR1700	11/14	Under construction
ASE	Belene 1	VVER1000	2014	2008 contract, now re-bidding
ASE	Belene 2	VVER1000	2015	2008 contract, now re-bidding
ASE	Kundankulam 1	VVER1000	12/10	Under construction, near startup
ASE	Kundankulam 2	VVER1000	6/11	Under construction
ASE	Leningrad 2-1	VVER1200	2014	Under construction
ASE	Leningrad 2-2	VVER1200	2016	Under construction
ASE	Mochovce 3	VVER 440	2012	Under construction
ASE	Mochovce 4	VVER 440	2013	Under construction
ASE	Novovoronesh 2-1	VVER1200	2014	Under construction
ASE	Novovoronesh 2-2	VVER1200	2015	Under construction
ASE	Rostov 2	VVER1000	3/10	Under startup
ASE	Rostov 3	VVER1000	2015	Under construction
ASE	Rostov 4	VVER1000	2017	Under construction
ASE	Tianwan 3	VVER1000	2017	Under contract
ASE	Tianwan 4	VVER1000	2018	Under contract
ASE	Tianwan 5	VVER1200	2017	Firm plans, but no contract
ASE	Tianwan 6	VVER1200	2018	Firm plans, but no contract

Current NNB Constructions and Contracts (2)

Vendor	Plant	Type	COD	Status
GE-H	Lungmen 1	ABWR	2011	Under construction
GE-H	Lungmen 2	ABWR	2012	Under construction
Hitachi	Ohma	ABWR	11/14	Under construction
Hitachi	Shimane 3	ABWR	12/11	Under construction
KEPCO	Shin Kori 1	Gen II OPR1000	12/10	Under construction
KEPCO	Shin Kori 2	Gen II OPR1000	12/11	Under construction
KEPCO	Shin Kori 3	APR1400	9/13	Under construction
KEPCO	Shin Kori 4	APR1400	9/14	Under construction
KEPCO	Shin Kori 5	APR1400	12/18	Firm plans
KEPCO	Shin Kori 6	APR1400	12/19	Firm plans
KEPCO	Shin Ulchin 1	APR1400	12/15	Under contract
KEPCO	Shin Ulchin 2	APR1400	12/16	Under contract
KEPCO	Shin Wolsong 1	Gen II OPR1000	3/12	Under construction
KEPCO	Shin Wolsong 2	Gen II OPR1000	1/13	Under construction
KEPCO	UAE-1	APR1400	6/17	2010 contract
KEPCO	UAE-2	APR1400	6/18	2010 contract
KEPCO	UAE-3	APR1400	6/19	2010 contract
KEPCO	UAE-4	APR1400	6/20	2010 contract
Mitsubishi	Tsuruga 3	APWR1538	3/16	Under construction
Mitsubishi	Tsuruga 4	APWR1538	3/17	Under construction
Mitsubishi	North Anna 3	APWR1700	2018	Firm plans, waiting on EPC Contract, COL and LG
Mitsubishi	Comanche Peak 3	APWR1700	2017	Firm plans, waiting on EPC Contract, COL and LG
Mitsubishi	Comanche Peak 4	APWR1700	2018	Firm plans, waiting on EPC Contract, COL and LG

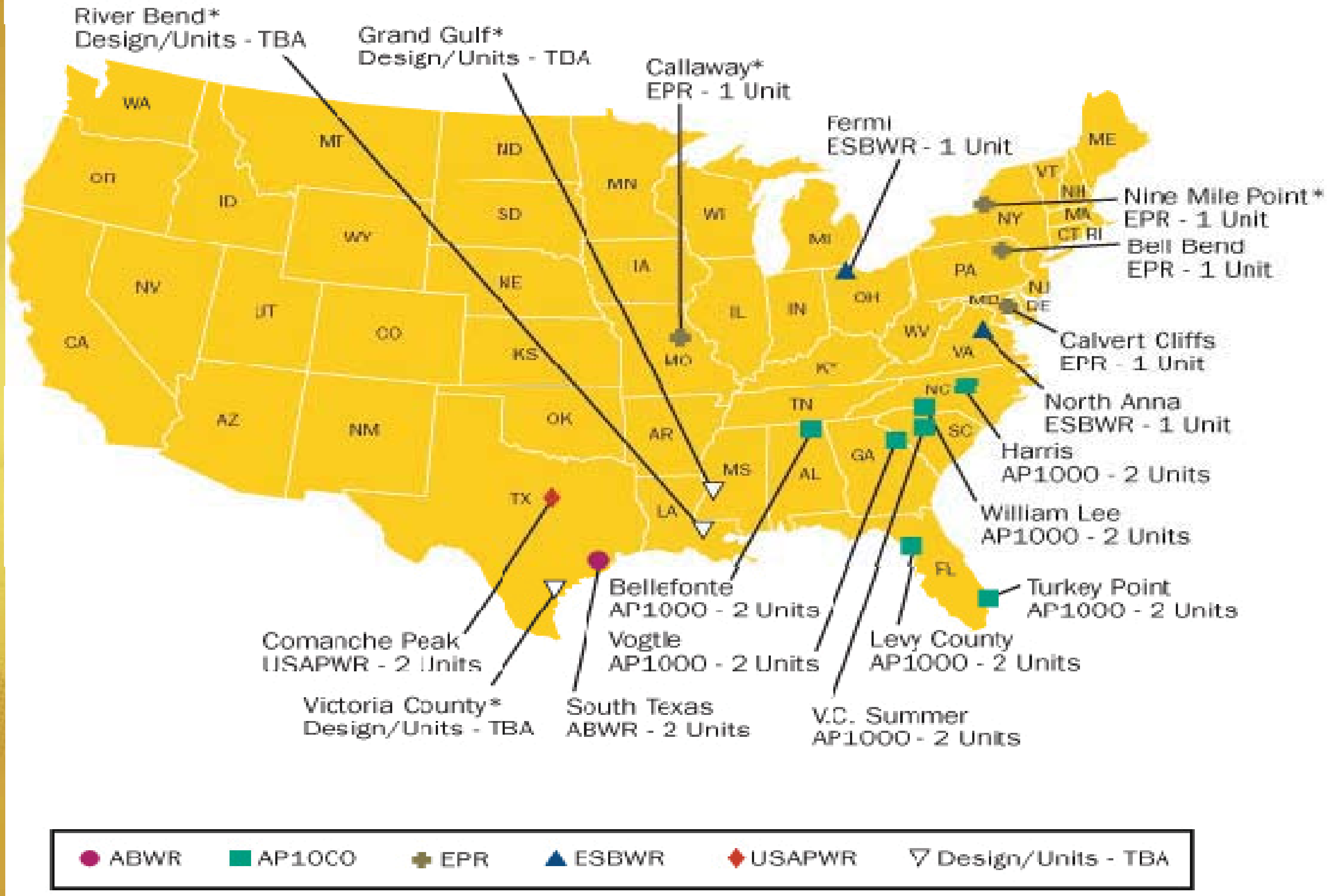
Current NNB Constructions and Contracts (3)

Vendor	Plant	Type	COD	Status
Toshiba	Higashi Dori 1 (TEPCO)	ABWR	3/17	Under contract
Toshiba	South Texas 3	ABWR	2017	EPC contract, waiting on COL and LG
Toshiba	South Texas 4	ABWR	2018	EPC contract, waiting on COL and LG
Westinghouse	Haiyang 1	AP1000	5/14	Under construction
Westinghouse	Haiyang 2	AP1000	3/15	Under construction
Westinghouse	Sanmen 1	AP1000	11/13	Under construction
Westinghouse	Sanmen 2	AP1000	9/14	Under construction
Westinghouse	Vogtle 3	AP1000	2017	EPC contract, LG, waiting on COL
Westinghouse	Vogtle 4	AP1000	2018	EPC contract, LG, waiting on COL
Westinghouse	Watts Bar 2	Gen II PWR 1100	2013	Under construction
Westinghouse	Taohuajiang 1	AP1000		Firm plans
Westinghouse	Taohuajiang 2	AP1000		Firm plans
Westinghouse	Da fan 1	AP1000		Firm plans
Westinghouse	Da fan 2	AP1000		Firm plans
Westinghouse	Peng ze 1	AP1000		Firm plans
Westinghouse	Peng ze 2	AP1000		Firm plans
Westinghouse	Haiyang 3	AP1000		Firm plans
Westinghouse	Haiyang 4	AP1000		Firm plans

Status July 2010 - Under Construction: (3) BWRs and (53) PWRs
Data Source: IAEA, WNA, ICJT - Version 8/04/10 - EXCEL

Overview of U.S. NNB Status and Activities for large commercial NPPs

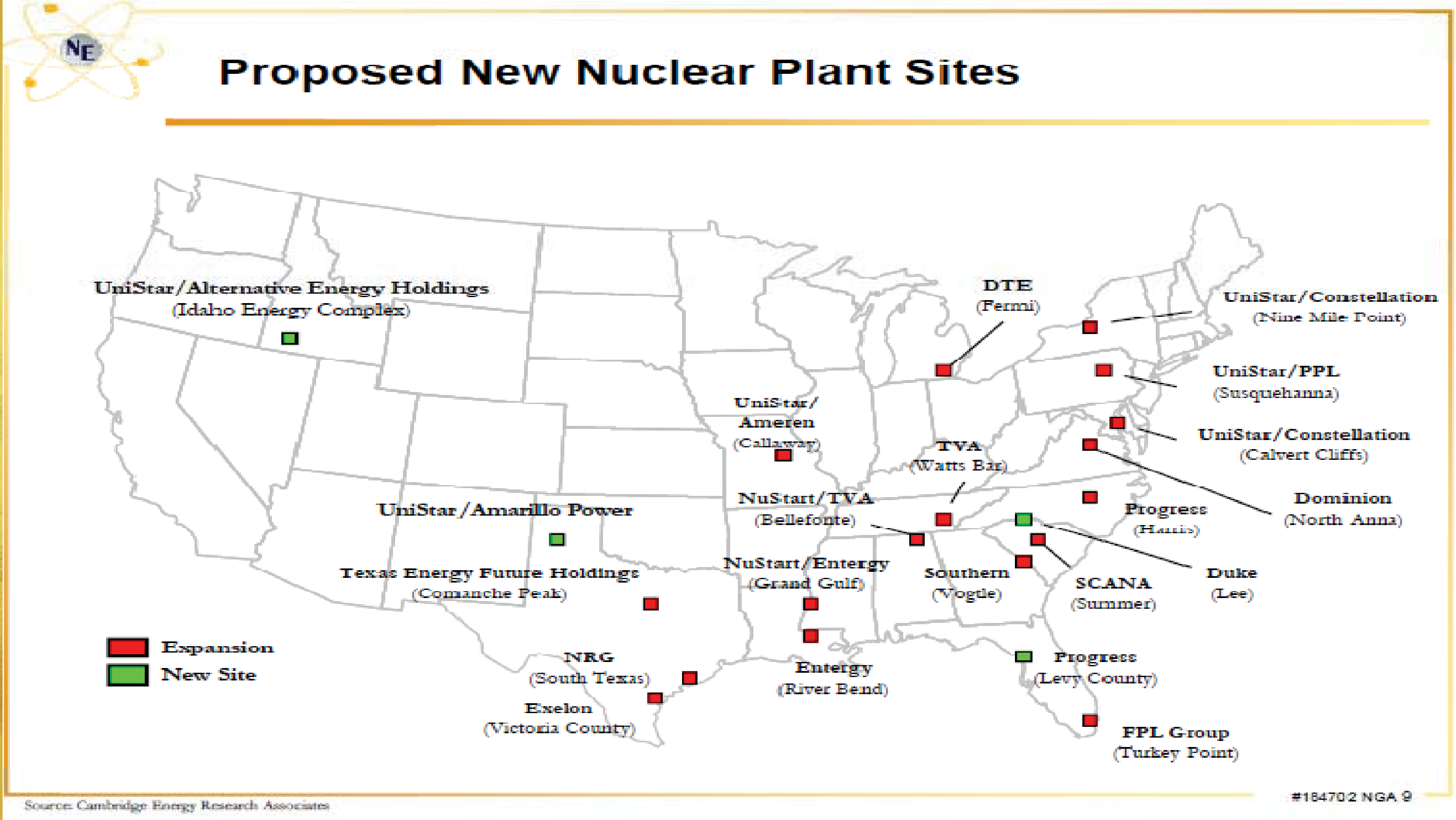
U.S. – Gen III/III+ NNB Plans



*Review Suspended

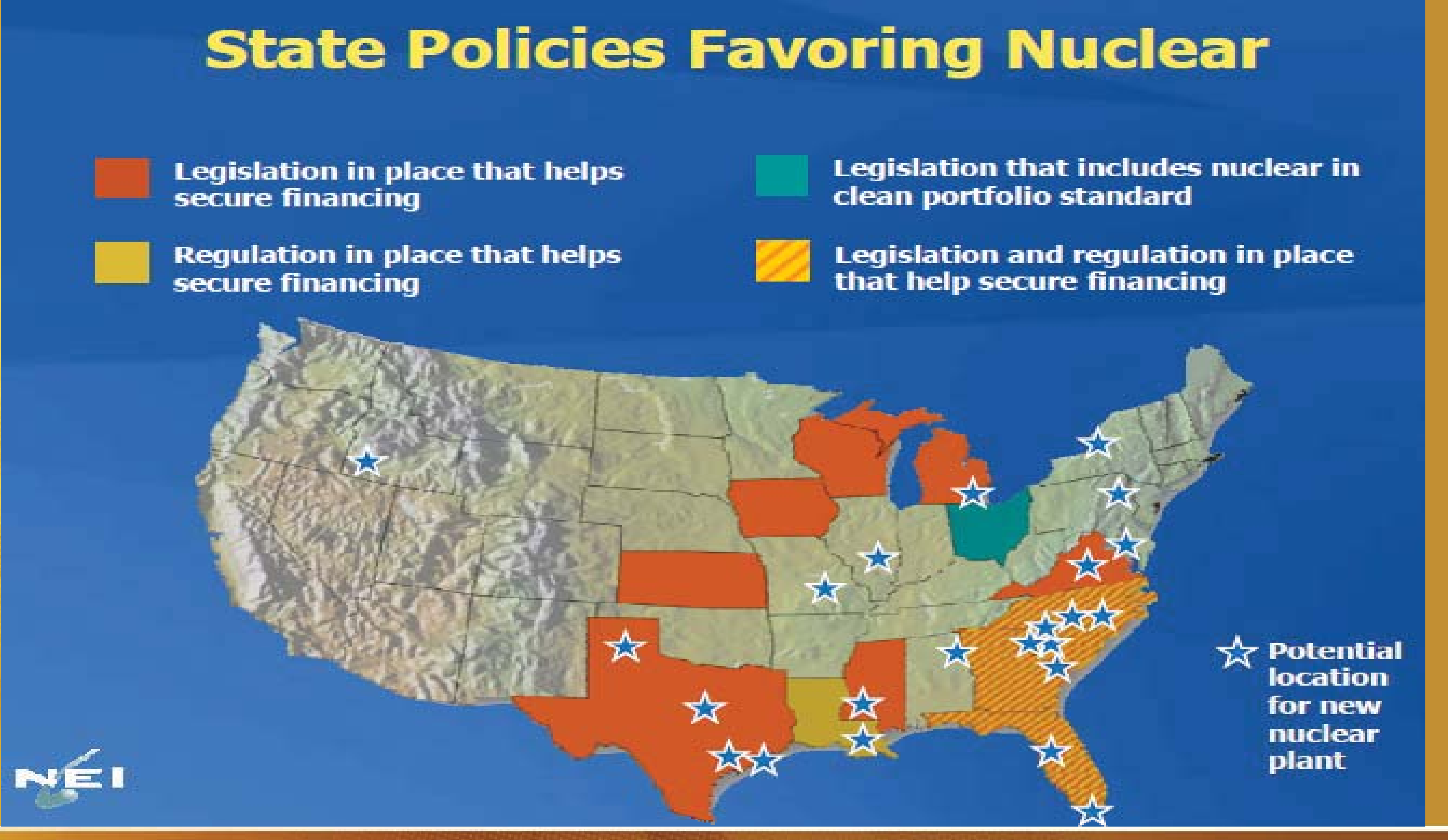
U.S. – Gen-III/III+ NNB Plans (2)

Greenfield Sites

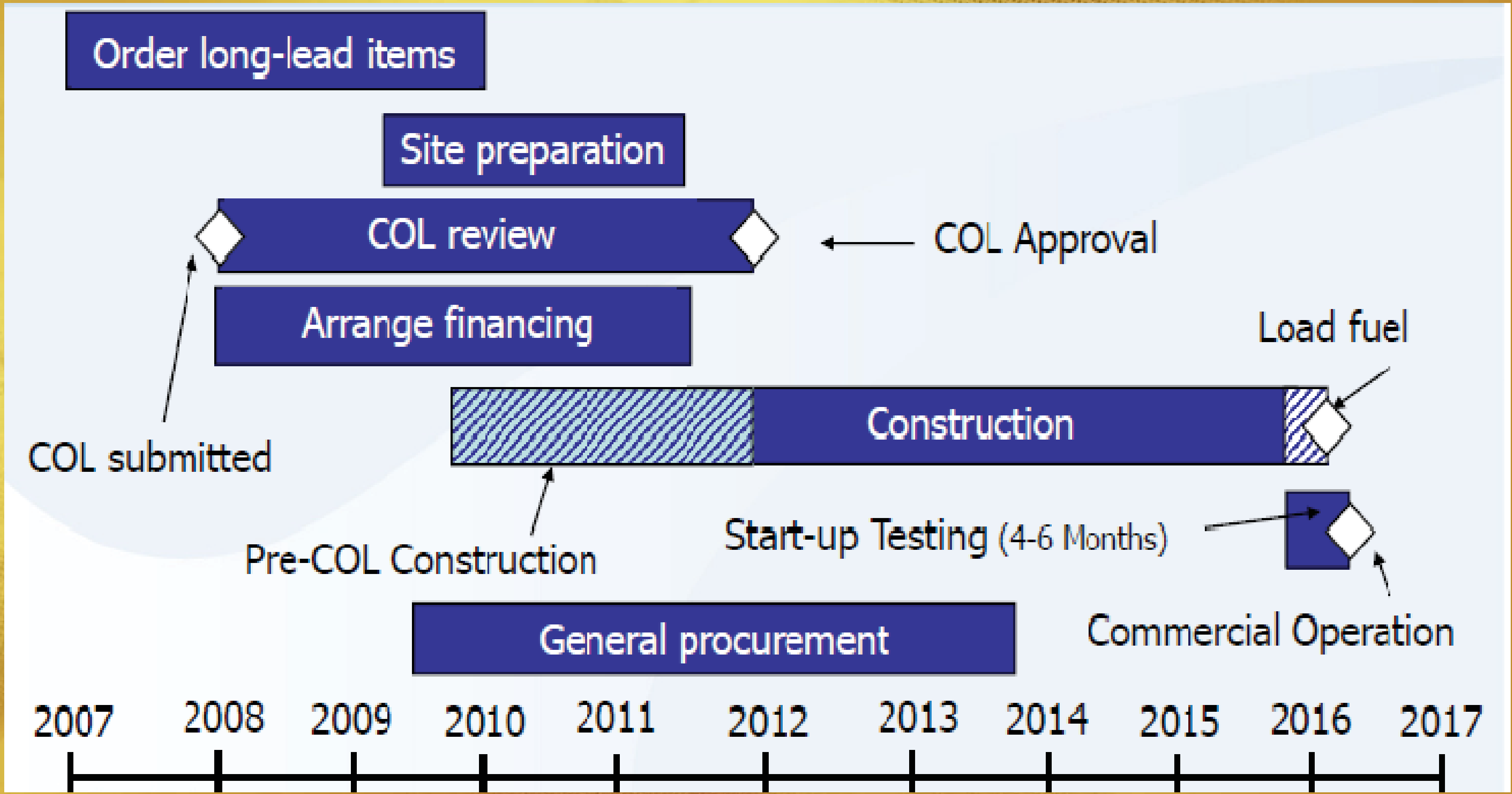


U.S. – Gen-III/III+ NNB Plans (3)

Politics and Financial Factors



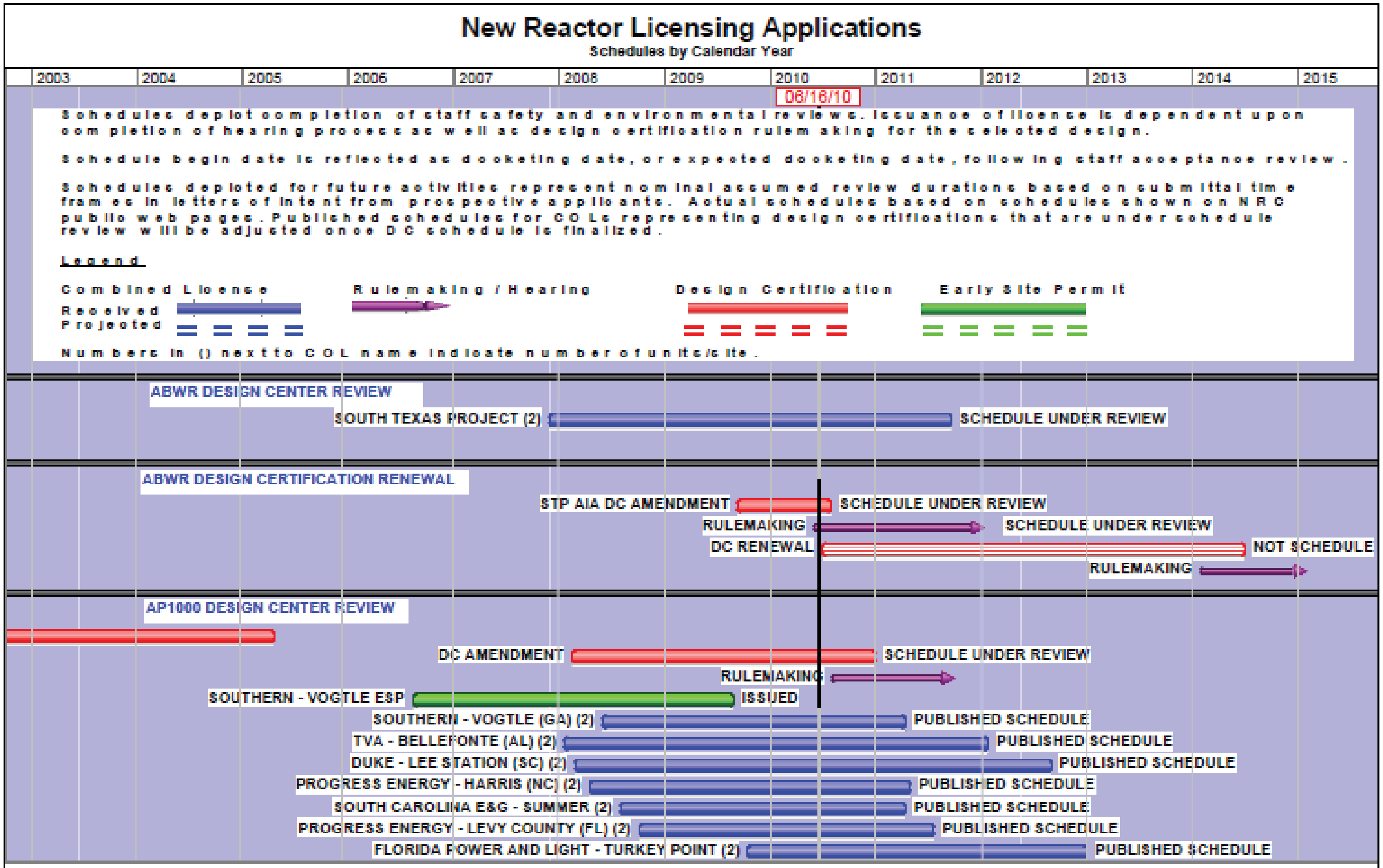
Schedule for Gen-III/III+ NNB in U.S.



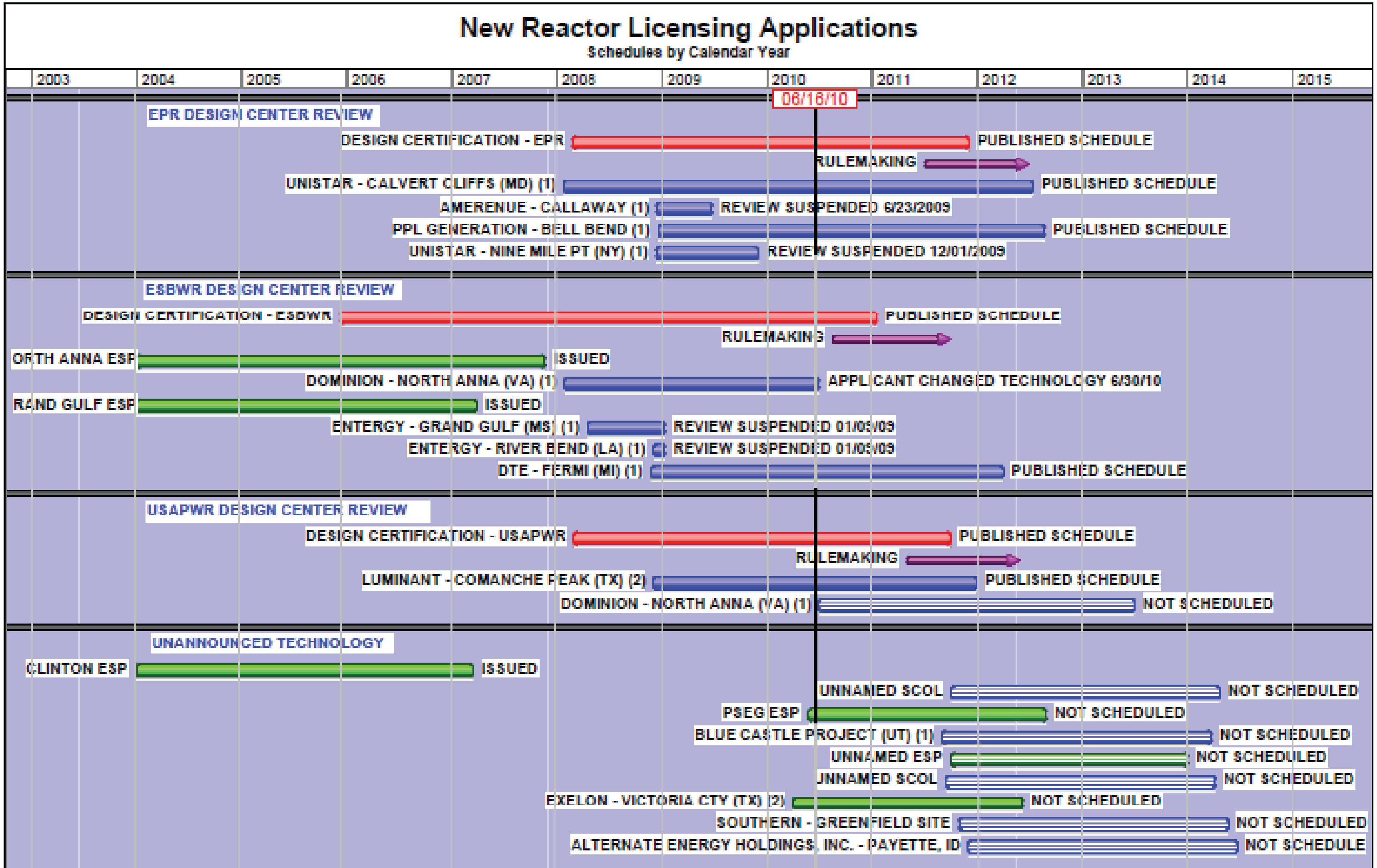
U.S. Status of NNB – Licensing

Expected New Nuclear Power Plant Applications Updated June 21, 2010								
Company (Project or Docket Numbers)	Date of Application	Design	Date Accepted	Site Under Consideration	Number of Units	State	Existing Operating Plant	Status
Calendar Year (CY) 2007 Applications								
NRG Energy (52-012/013)	09/20/07	ABWR	11/29/07	South Texas Project	2	TX	Y	Accepted/Docketed
NuStart Energy (52-014/015)	10/30/07	AP1000	01/18/08	Bellefonte	2	AL	N	Accepted/Docketed
UNISTAR (52-016)	07/13/07 (Envir.) 03/13/08 (Safety)	EPR	01/25/08 06/03/08	Calvert Cliffs	1	MD	Y	Accepted/Docketed Accepted/Docketed
Dominion (52-017)	11/27/07	ESBWR	01/28/08	North Anna	1	VA	Y	Accepted/Docketed
Duke (52-018/019)	12/13/07	AP1000	02/25/08	William Lee Nuclear Station	2	SC	N	Accepted/Docketed
2007 Total Number of Applications = 5 Total Number of Units = 8								
Calendar Year (CY) 2008 Applications								
Progress Energy (52-022/023)	02/19/08	AP1000	04/17/08	Harris	2	NC	Y	Accepted/Docketed
NuStart Energy (52-024)	02/27/08	ESBWR	04/17/08	Grand Gulf	1	MS	Y	Accepted/Docketed
Southern Nuclear Operating Co. (52-025/026)	03/31/08	AP1000	05/30/08	Vogtle	2	GA	Y	Accepted/Docketed
South Carolina Electric & Gas (52-027/028)	03/31/08	AP1000	07/31/08	Summer	2	SC	Y	Accepted/Docketed
Progress Energy (52-029/030)	07/30/08	AP1000	10/06/08	Levy County	2	FL	N	Accepted/Docketed
Detroit Edison (52-033)	09/18/08	ESBWR	11/25/08	Fermi	1	MI	Y	Accepted/Docketed
Luminant Power (52-034/035)	09/19/08	USAPWR	12/02/08	Comanche Peak	2	TX	Y	Accepted/Docketed
Entergy (52-036)	09/25/08	ESBWR	12/04/08	River Bend	1	LA	Y	Accepted/Docketed
AmerenUE (52-037)	07/24/08	EPR	12/12/08	Callaway	1	MO	Y	Accepted/Docketed
UNISTAR (52-038)	09/29/08	EPR	12/11/08	Nine Mile Point	1	NY	Y	Accepted/Docketed
PPL Generation (52-039)	10/10/08	EPR	12/19/08	Bell Bend	1	PA	Y	Accepted/Docketed
2008 Total Number of Applications = 11 Total Number of Units = 16								
Calendar Year (CY) 2009 Applications								
Florida Power and Light (763)	06/30/09	AP1000	09/04/09	Turkey Point	2	FL	Y	Accepted/Docketed
2009 Total Number of Applications = 1 Total Number of Units = 2								
Calendar Year (CY) 2010 Applications								
No Letters of Intent have been received from applicants expressing their plans to submit new COL applications in CY 2010								
2010 Total Number of Applications = 0 Total Number of Units = 0								
Calendar Year (CY) 2011 Applications								
Blue Castle Project		TBD		Utah	1	UT	N	
Southern		TBD		TBD	1		TBD	
AEHI		TBD		Payette, ID	1	ID	N	
Unnamed		TBD		TBD	1		TBD	
Unnamed		TBD		TBD	1		TBD	
2011 Total Number of Applications = 5 Total Number of Units = 5								
2007 - 2011 Total Number of Applications = 22 Total Number of Units = 31								

U.S. Status of NNB – Licensing



U.S. Status of NNB – Licensing



U.S. Status of NNB – Lead Plants

Company	Site	NPP (#Units)	COL Submittal	EXCEL activity
Constellation-Unistar	Calvert Cliffs-3	EPR	Mar 2008	developed now supporting RAIs
Constellation-Unistar	Callaway-2 Bell Bend Nine Mile Point-3 New Plant	EPR (6)	July 2008 Oct 2008 Sept 2008	supporting RAIs
Dominion	North Anna-3	ESBWR (1) APWR1700	Nov 2007 in preparation	supporting
Duke	William States Lee-1/2	AP1000 (2)	Dec 2007	supporting
Entergy	Grand Gulf-3	ESBWR (1)	Feb 2008	supporting
NRG Energy-STPNOC	South Texas-3/4	ABWR (2)	Sep 2007	supporting
Progress Energy	Harris-2/3	AP1000 (2)	Feb 2008	supporting
SC Electric & Gas	VC Summer-2/3	AP1000 (2)	Mar 2008	supporting
Southern Co	Vogtle-3/4	AP1000 (2)	Mar 2008	supporting
Luminant	Comanche Peak-3/4	APWR1700	in preparation	supporting
TVA	Bellafonte-3/4	AP1000 (2)	Oct 2007	supporting

U.S. ABWR

- Combines best BWR design features from Europe, Japan and USA
- Available from two competing Vendors (GE-Hitachi and Toshiba)
- Reactor Core has margins to uprate from 1370 MWe to 1800 MWe
- Proven Construction and Operation Costs

DCD Amendment by late 2011
Original NRC DCD approval in 1997

Updates via Departures on R-COLA

1 COLA in review in USA

Reference Plant – STP 3&4
COL in 2012, COD estimated 2017/18

OE from Toshiba Japan
4 ABWRs in operation

U.S. EPR

- Large evolutionary PWR
- Capacity ranges from 1600 – 1700 MWe
- Combination of French N4 and German Konvoi design
- 50% Cost & schedule overrun at 1st EPR in Finland is not due to EPR design

DC Application under review – Certification expected June 2012

Active Design - Standardization

(1) COLA in review

Reference Plant – Calvert Cliffs 3 – COL in late 2012 (?)

OE from Flamanville & Olkiluoto projects

AP1000

- Advanced Passive 1100 MWe PWR Design, scaled up from AP600
- Simplified systems and reduced number of systems & components
- Modular construction & Prefab reduce construction schedule uncertainties

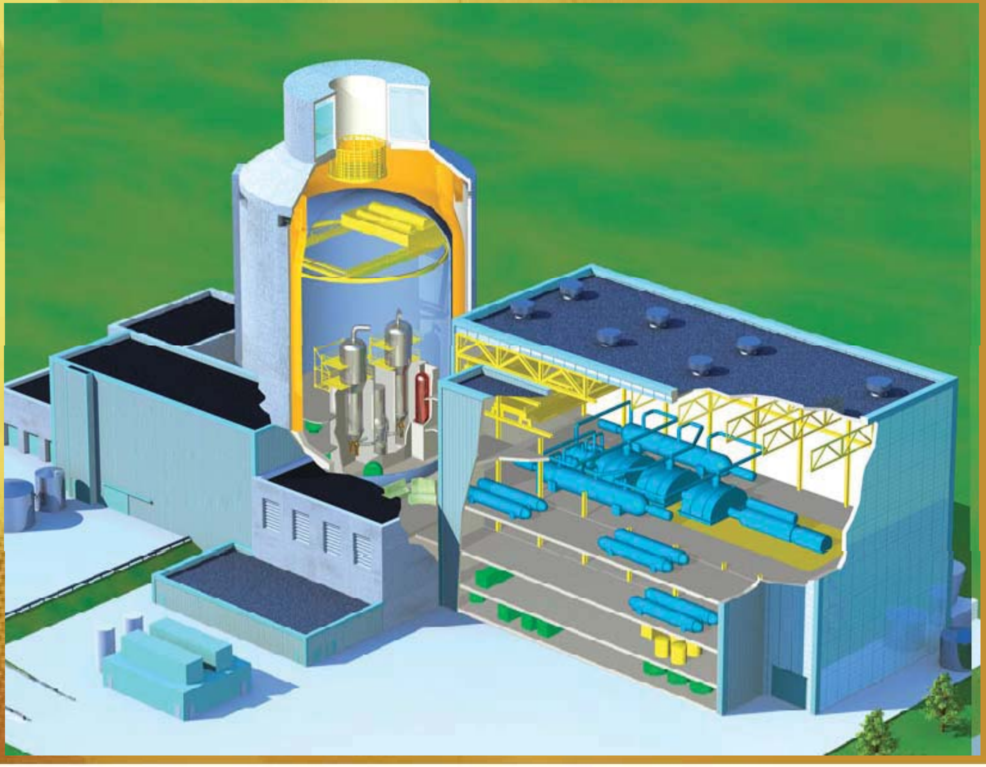
DCD Rev 17 submitted Sept 22, 2008
Certification expected Sept 2011

Passive Design – Standardization

(2) COLAs in review

Reference Plant – Vogtle 3&4 – COL expected in Nov 2011

OE from China Haiyang & Sanmen projects expected by 2015



U.S. APWR1700

- Advanced PWR developed by Westinghouse/MHI
- 1538 MWe Output in Tsuruga-3/4 in Japan startup in 2016/17
- 1700 MWe in US by increased SG / TG performance (same Thermal Power)
- Comanche Peak planned for 2017/18

Reference Plant – Comanche Peak – COL in 2012/13

DC Amendment under review – Certification expected 2012

Active Design

1 COLA in review
2nd COLA in preparation (North Anna)

OE from Tsuruga-3/4 startup in Japan2015/16

ESBWR

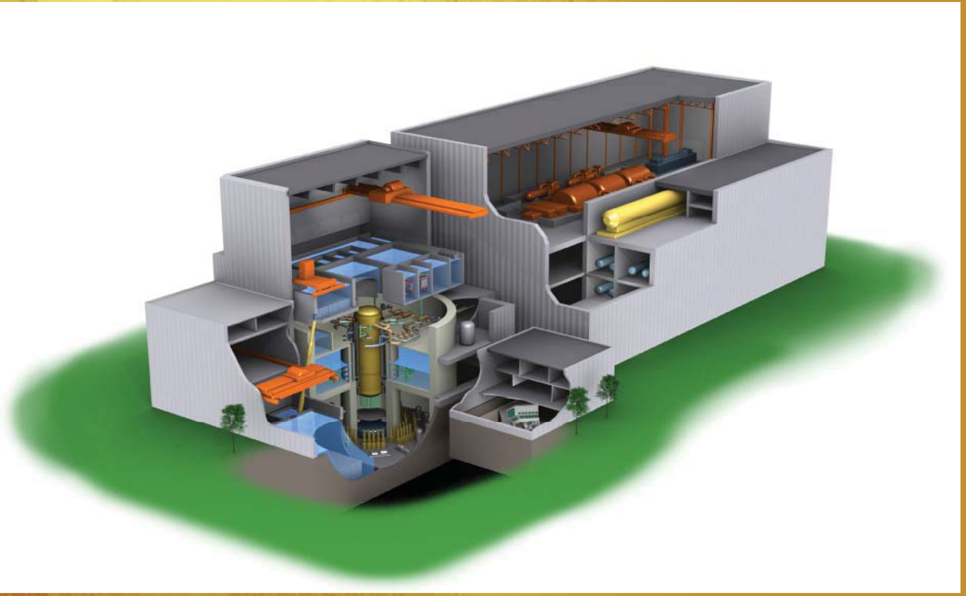
- Originally European Simplified BWR (many EU Institutions have contributed with both design and testing of components)
- Next it became Economic Simplified BWR
- Natural Circulation Boiler with largest core in the world
- 1535 MWe output at 50% of coolant flow in standard BWR
- Many passive safety features
- Greatly reduced number of systems

DC Application (Rev 6) under review – Certification expected Sept 2011

Passive Design

1 COLA in review (Detroit Edison)

Reference Plant – North Anna – COL in late 2011 (suspended)



U.S. NNB – Main Challenges

- Nuclear Renaissance in U.S. has practically stalled:
  - Financial Risks getting too high to attract Investors
  - Costs of NNB plants have increased up to $10B per reactor
  - Loan Guarantees needed for several U.S. NNB Lead Projects
  - Only (2) NNB projects are still 'moving' forward:

• **Southern Co / Vogtle-3/4**	**AP1000**
• **SC Electric & Gas / VC Summer-2/3**	**AP1000**
• **(Constellation / Calvert Cliffs-3**	**EPR … dead)**
• **(NRG / South Texas-3/4**	**ABWR … dead)**

  - **Cheap/abundant <u>Shale Gas</u> (not Fukushima) halted the Nuclear Renaissance**

U.S. Nuclear Renaissance – Restart Solutions

- Need DOE LG's near-term to keep NNB program
- Need to bring current NNB Reactor costs down quickly and dramatically (e.g., standardization)
- Need to look at Utility business model (e.g., Finland)
- Need to apply NNB Lessons Learned from:
  - NUREG-1055 (construction of US fleet of 104 reactors)
  - Construction of Gen-III/III+ NNB (Finland, France, Japan, S. Korea, and China)

Thank You!

EXCEL

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