Civil Nuclear Energy Development in China and U.S.-China Nuclear Cooperation

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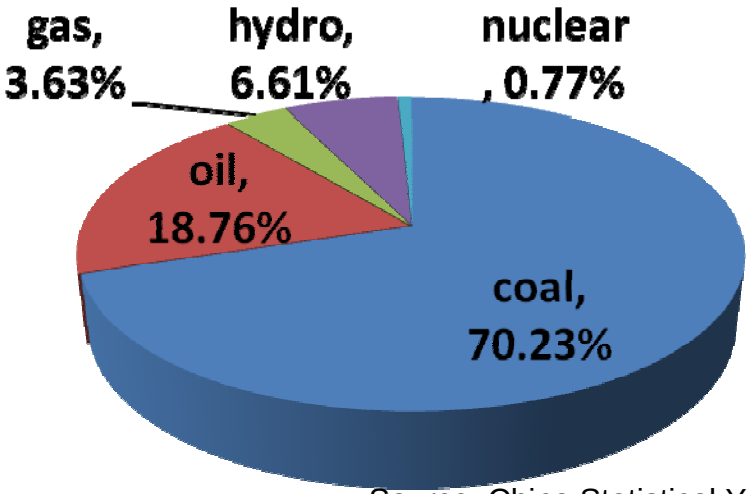
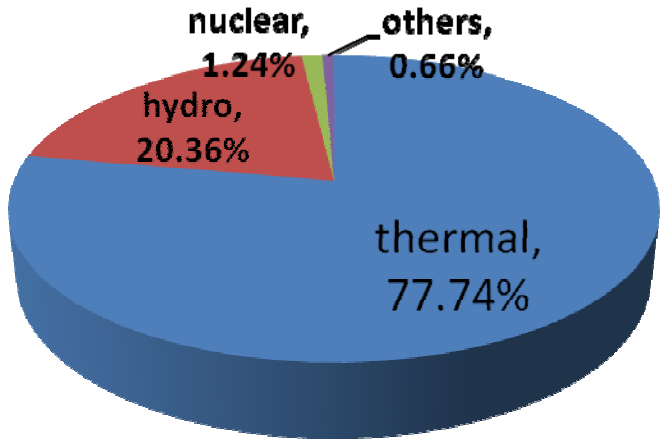
Agenda

- China’s civil nuclear development
- Projections of future development
- Challenges facing China’s nuclear expansion
- Areas for U.S.-China cooperation

Nuclear in China's energy economy (2008)





Source: China Statistical Yearbook 2009 and BP Statistical Review of World Energy, June 2009

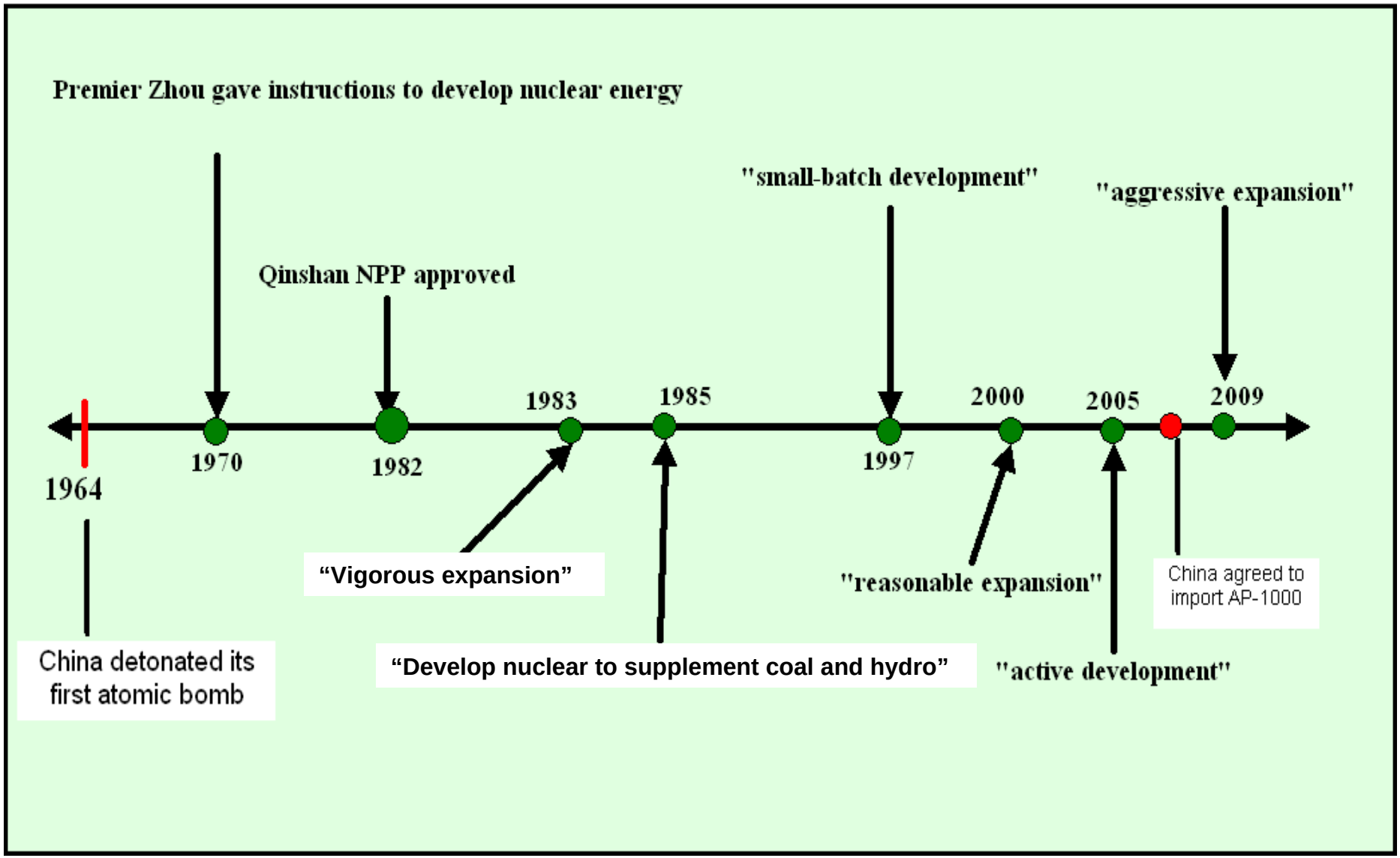
Country	Operating GW	Number of reactors	Nuclear TWH	% of E	% of world NE
US	101.1	104	809	19.7%	31%
France	63.5	59	428.3	76.2%	16.1%
Japan	46.2	53	240.5	24.9%	9.2%
Russia	21.7	31	152.1	16.9%	6%
ROK	17.7	20	144.3	35.6%	5.5%
Germany	20.3	17	140.9	28.3%	5.4%
Canada	12.7	18	88.6	14.8%	3.4%
Ukraine	13.2	15	84.3	47.4%	3.3%
China	**8.6**	**11**	**65.3**	**2.2%**	**2.5%**

Source: World Nuclear Association

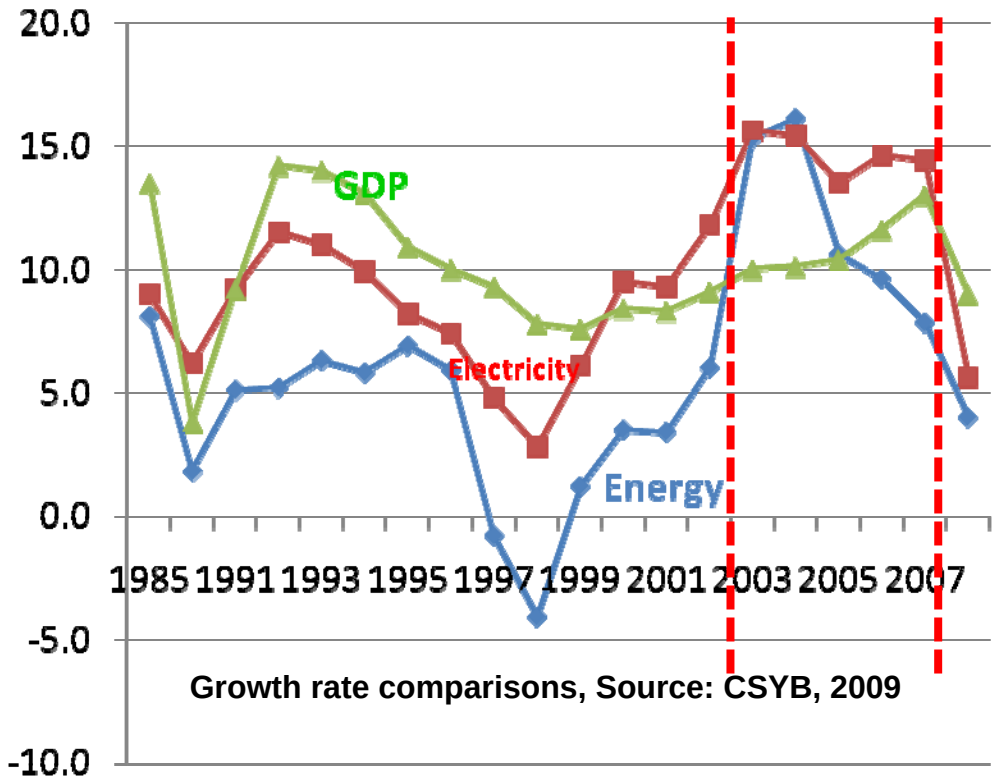
Nuclear power plants (NPPs) in China

NPP name	Developer	Type	Code	Net MW	Online Date (M-D-Y)	Construction Date (M-D-Y)	Construction Duration
QINSHAN 1	CNNC	PWR	CNP300	310	12-15-1991	3-20-1985	6.7
QINSHAN 2-1	CNNC	PWR	CNP650	650	2-6-2002	6-2-1996	5.7
QINSHAN 2-2	CNNC	PWR	CNP650	650	3-11-2004	3-23-1997	7.0
QINSHAN 3-1	CNNC	PHWR	CANDU6	700	11-19-2002	6-8-1998	4.4
QINSHAN 3-2	CNNC	PHWR	CANDU6	700	6-12-2003	9-25-1998	4.7
Daya Bay 1	CGNPC	PWR	M310	983.8	8-31-1993	8-7-1987	6.1
Daya Bay 2	CGNPC	PWR	M310	983.8	2-7-1994	4-7-1998	5.8
LINGAO 1	CGNPC	PWR	CPR1000	990.4	2-26-2002	5-15-1997	4.8
LINGAO 2	CGNPC	PWR	CPR1000	990.4	12-15-2002	11-28-1997	5.0
TIANWAN 1	CNNC	PWR	AES-91	1060	5-12-2006	10-20-1999	6.6
TIANWAN 2	CNNC	PWR	AES-91	1060	5-14-2007	9-20-2000	6.7
LINGAO 2-1	**CGNPC**	**PWR**	**CPR-1000**	**1080**	**7-15-2010**		
Total (12)				**1,158.4**		**Average Time**	**5.8**

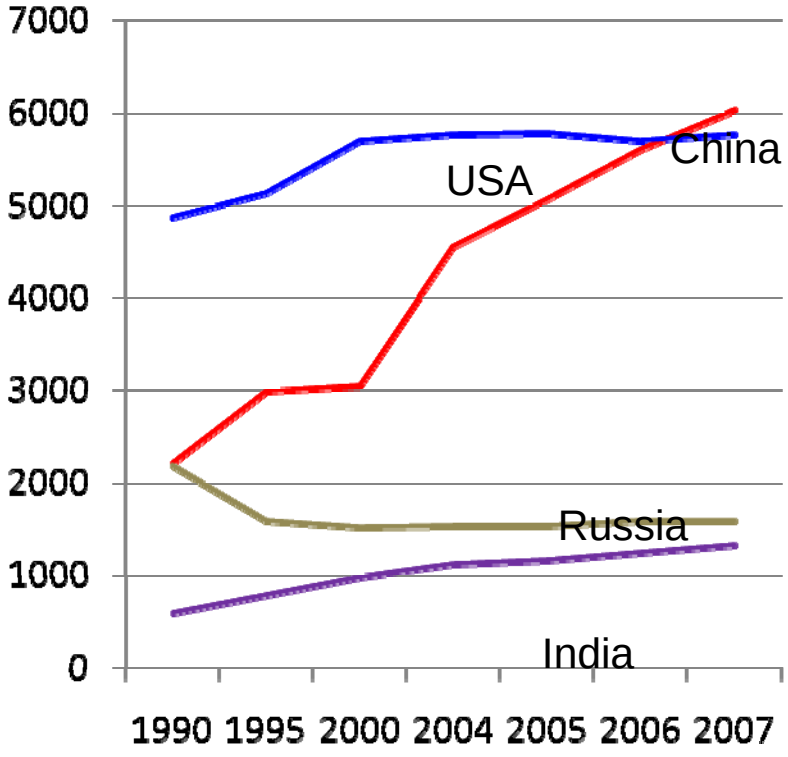
Evolution of China's civil nuclear energy policy



A “perfect storm” for nuclear expansion in China



Growth rate comparisons, Source: CSYB, 2009



Million tons of CO2 Emissions, Source: IEA, 2009

1. **Policy pressure: energy intensity and carbon intensity reduction**
2. **Policy target: 15% renewable energy by 2010**
3. **Uranium supplies: acquisitions in Kazakhstan, Uzbekistan, Niger, and Australia and aggressive purchases**

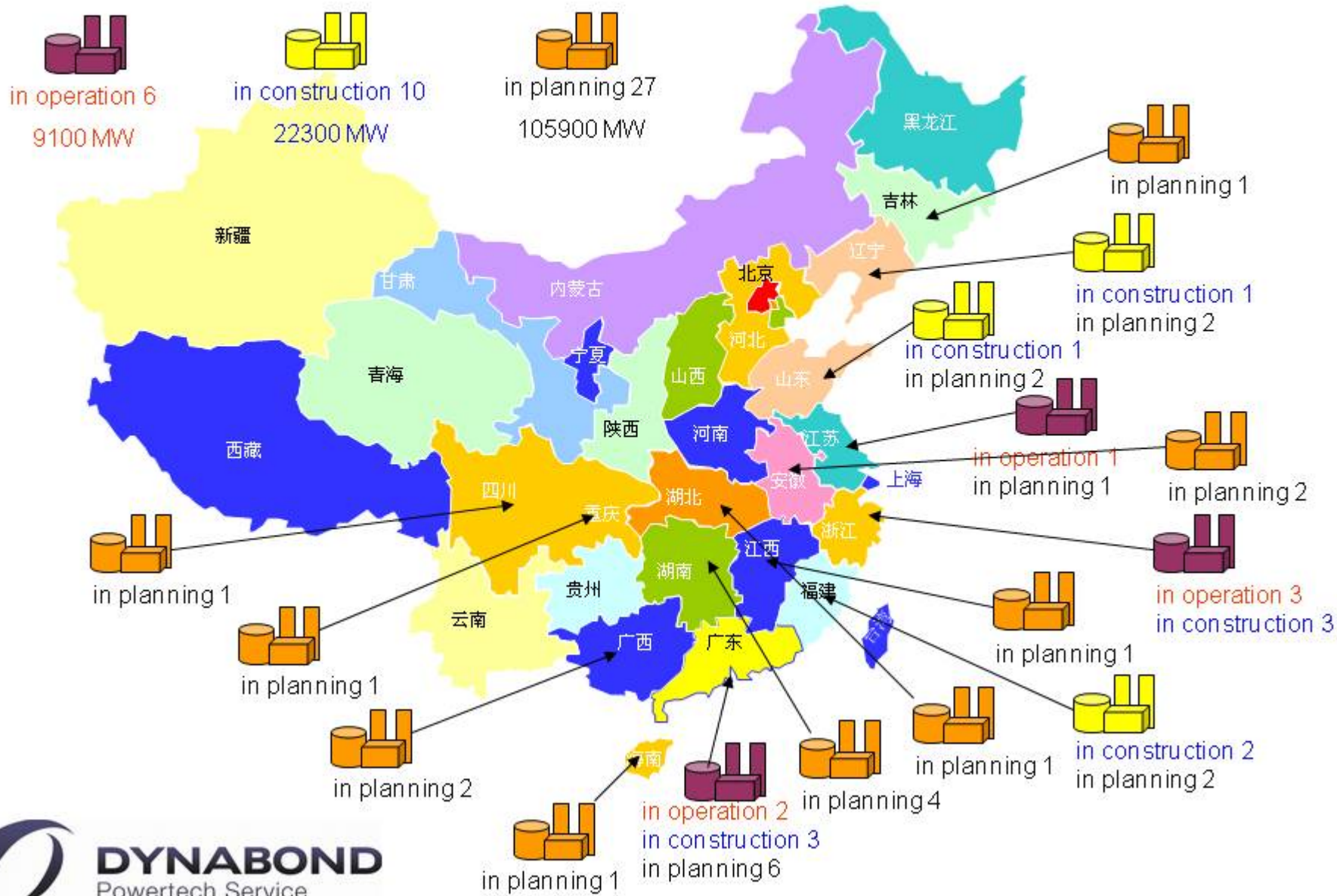
China leads the world in NPP construction

Reactor	FCD Starting date	Gross MW	TYPE	Projected completion
FANGJIASHAN 1	12/26/2008	1080	CPR-1000	9/14/2014
FANGJIASHAN 2	7/17/2009	1080	CPR-1000	4/5/2015
FUQING 1	11/21/2008	1080	CPR-1000	8/10/2014
FUQING 2	6/17/2009	1080	CPR-1000	3/6/2015
QINSHAN 2-3	4/28/2006	650	CNP-600	12/15/2011
QINSHAN 2-4	1/28/2007	650	CNP-600	10/16/2012
SANMEN 1	4/19/2009	1250	AP-1000	3/29/2013
HAIYANG 1	9/30/2009	1100	AP-1000	9/9/2013
HONGYANHE 1	8/18/2007	1080	CPR-1000	5/6/2013
HONGYANHE 2	3/28/2008	1080	CPR-1000	12/15/2013
HONGYANHE 3	3/7/2009	1080	CPR-1000	11/24/2014
HONGYANHE 4	8/15/2009	1080	CPR-1000	5/4/2015
LINGAO 3	12/15/2005	1080	CPR-1000	9/3/2011
LINGAO 4	6/15/2006	1080	CPR-1000	3/3/2012
NINGDE 1	2/18/2008	1080	CPR-1000	11/6/2013
NINGDE 2	11/12/2008	1080	CPR-1000	8/1/2014
YANGJIANG 1	12/16/2008	1080	CPR-1000	9/4/2014
YANGJIANG 2	6/4/2009	1080	CPR-1000	2/21/2015
TAISHAN-1	11/17/2009	1750	EPR (CEPR)	Aug. 2014
TAISHAN-2	4/18/2010	1750	EPR (CEPR)	April 2015
CHANGJIANG	4/25/2010	650	CNP-600	Dec. 2014
SANMEN-2	5/16/2010	1100	AP-1000	Dec. 2014
HAIYANG-2	6/20/2010	1100	AP-1000	
FANGCHENGGANG	7/30/2010	1080	CPR-1000	
Total (24 units)		**26,200**		

Policy targets offer certainty of nuclear expansion

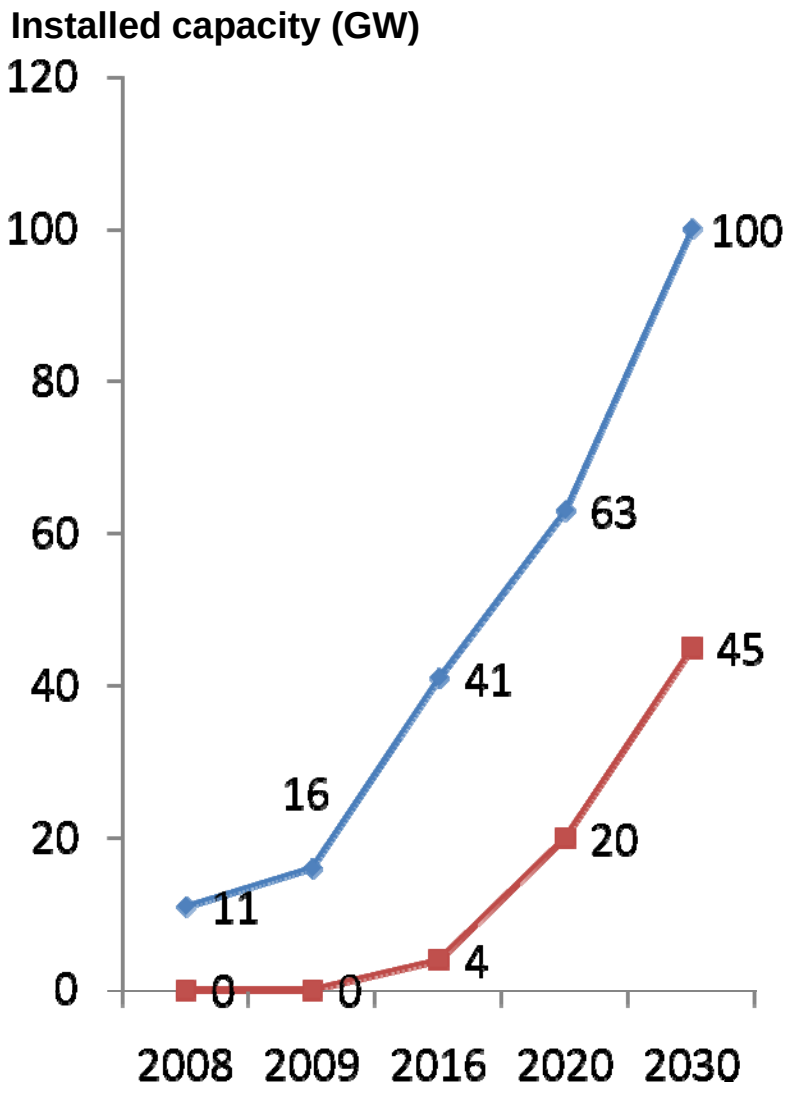
- *The Medium- and Long-term Nuclear Power Development Plan* (2007) targets 40GW of installed capacity and 18 GW under construction by 2020.
- **REALITY**: operational (11GW)+ construction (26GW)+ approved (15GW) =52GW
- New target—60GW or 75GW by 2020
- *Industrial Development Plan of China's Renewable Energy* : 12 GW by 2011 and **86GW by 2020**

NPP Distribution in China

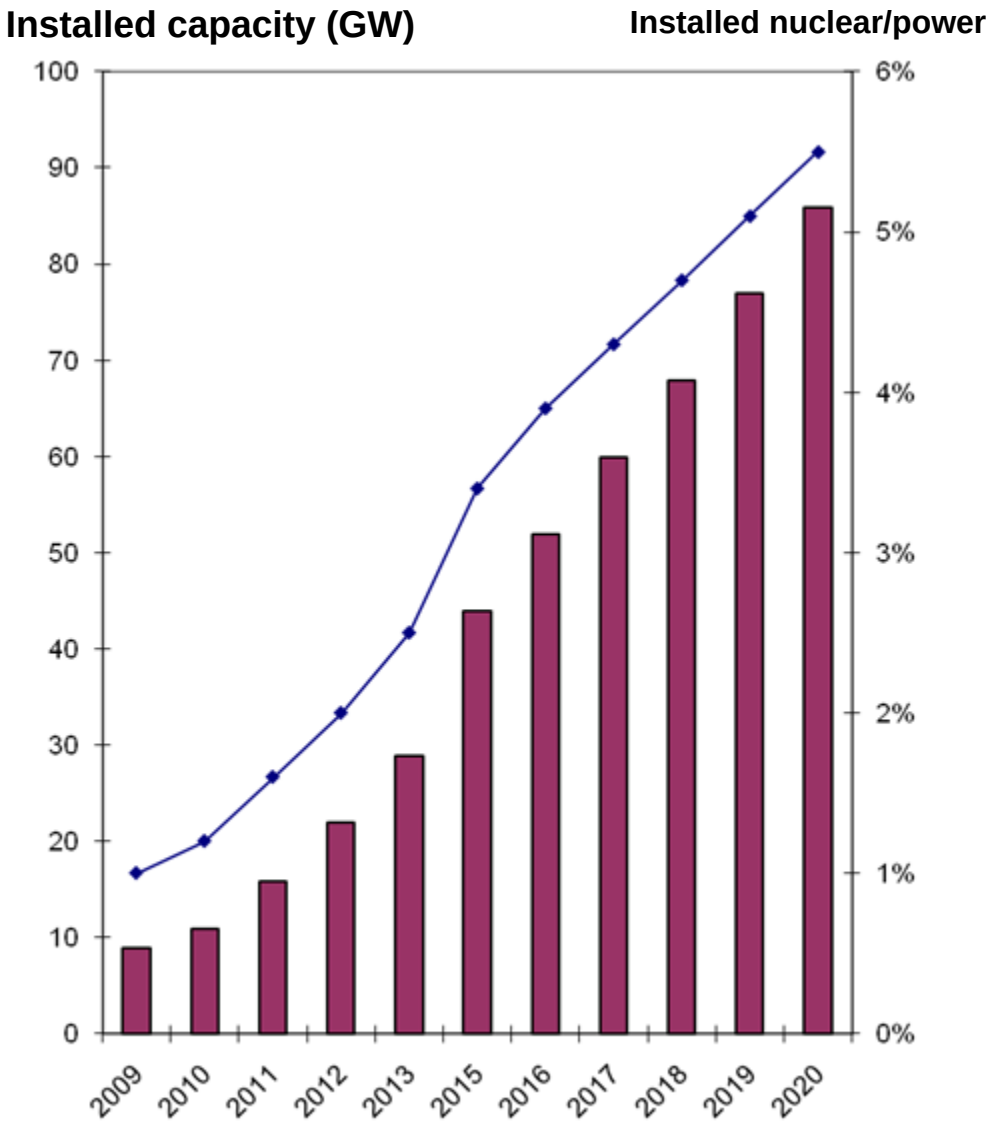


DYNABOND
Powertech Service

“Nuclear spring” in China

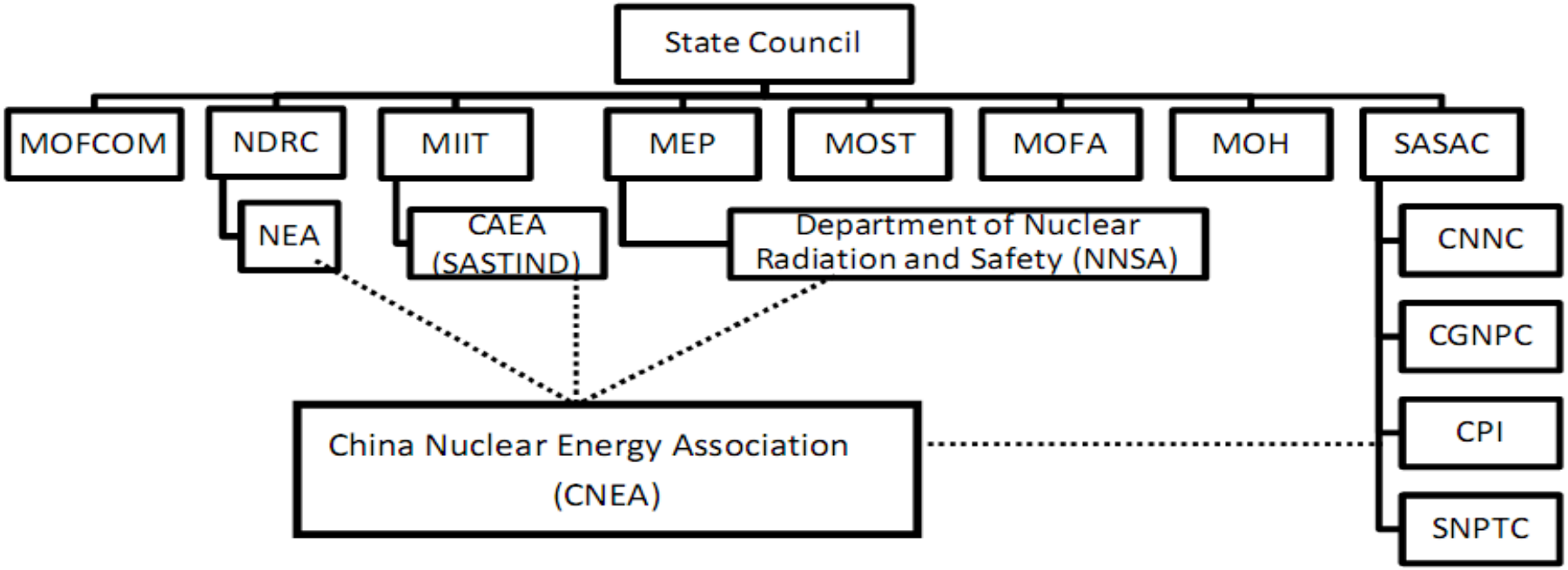


Source: Dynabond Powertech Service



Source: Sinolink Securities, April 2010

Regulatory and institutional challenges



- **Fragmentation of governance**
- **Lack of regulatory independence**
- **Regulatory personnel shortage (40 staff for NNSA and 300 countrywide, NRC 3709—104 reactors) (US, France, Japan--36 staff/GW)**
- **Budget constraint (US, France, Japan--$11 million/GW)**
- **No Atomic Energy Law and some regulations are dated**

Human capital challenges

Nuclear talent demand survey 2004-2005

Type of personnel needed	# of personnel needed
reactor engineering	2600
radiation chemistry engineering and radiation chemistry	2600
nuclear fuel engineering	1500
Nuclear technology application and nuclear science	2400
radiation and environmental protection	1300
nuclear physics	1300
nuclear geology and uranium mining and metallurgy	1300
Total nuclear personnel needed	13000
2004-2010	6000
2010-2020	7000

CAEA 2009 estimate: by 2020, China needs 25,000 additional nuclear talents, but Chinese universities recruited 750 per year in 2004.

Source: Guo Yongji, China Atomic Energy Authority (CAEA), 2004 and CAEA, 2009.

Safety and technical challenges

- Current expansion overstretches the regulatory capacity;
- Risks of reckless expansion and corner-cutting;
- Low indigenization rate for G3 reactors: 90% for G2, 70% for G2+, but 50% for G3;
- G2+ likely to crowd out G3;
- Multiple technologies in use complicate regulation, standardization, and certification process.

Nuclear security challenges

- No inventory of nuclear material has been established
- Implementation of the MPC&A system is unverified
- Illegal uranium mining activities raise worries
- Haven't defined DBT and nuclear protection systems for all
- Nuclear security remains to be updated
- Radioactive sources are poorly regulated

Potential areas of U.S.-China nuclear cooperation

- Joint expansion in a third country
- Capacity building: regulatory and human capital
- Exchange programs and data sharing
- NPP life extension
- Join work on advanced fuel cycles and waste management
- Security of nuclear material, facility and radioactive sources (e.g. Center for Nuclear Excellence)