The World's **NEW** Energy Imperative

Implications For Discovery Investors

Michael A. Berry, PhD

April 9, 2011

Tombstones and Tsunamis?

“We left it to the experts … they researched old documents for information on how many tombstones had toppled over and such.”

Masatoshi Toyoda, a Tokyo Electric
Vice President who oversaw
the construction of the plant.
NYT, March 26, 2011

“Does Technology Fly In The Face Of God?”

"I cannot imagine any condition which would cause a ship to founder. I cannot conceive of any vital disaster happening to this vessel.

Modern ship building has gone beyond that."

Captain Edward J. Smith,
Commander RMS Titanic
January 1912

It seems to me that the disaster about to occur was the event that not only made the world rub it's eyes and awake but woke it with a start … **To my mind the world of today awoke April 15th, 1912."**

-

Jack B. Thayer, Titanic Survivor

Was Fukushima 2011: Flying in the Face of God?

- **I believe that the energy world of today awoke March 11th, 2011. This event was the 3/11 of this decade.**
- **The disaster that occurred to Japan’s reactors can only be rationalized ex post -**
- **We call this “if only” analysis.**

The “IF ONLY’S” **of** Fukushima 3-11-11

- **IF ONLY**:
  1. Fukushima’s triple backup cooling system had been waterproofed.

  2. Spent nuclear fuel had been recycled or stored off site.

  3. A flare system for interior H_2 gas had been in place.

  4. Sea walls had been designed for a Tsunami like that of 869 AD. The hubris of Gaussian thinking.

Fukushima 3-11-11: The **“IF ONLY’S”** **(A Few)**

- **IF ONLY**:

  5. Inspectors had listened to whistle blower Mitsuhiko Tanaka’s concerns on reactor 3.

  6. Adequately sized containment vessels had been in place.

  7. Fukushima had not been built on a geological fault.

  8. Builders had not relied on inadequate, earthquake history (tombstone analysis).

The Persistence of Human Fatal Flaws Embedded in Technology Implementation

- Titanic: Poor grade iron bolts, inadequate lifeboats, poorly designed water tight compartments ….

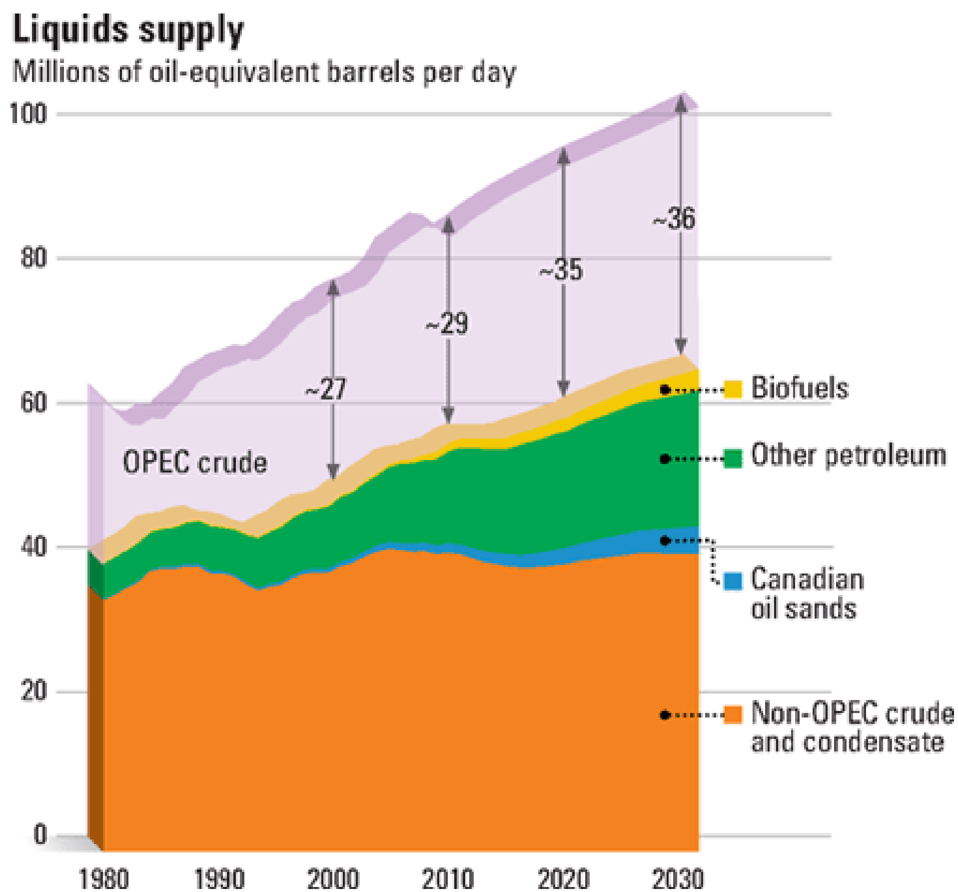
- Fukushima: re licensing of 40 year old reactors, loss of coolant, small suppression chambers, inadequate tsunami protection, inadequate spent fuel storage ….

New US Energy Imperatives as a Result of Fukushima

Instantaneous realization of 30 to 50 years of continued US dependence on fossil fuels.

Still sourced primarily from foreign deposits.

“Peak Oil: Running Flat Out”



Energy Prices Must Rise

Peak Oil Production May Already be Here
Science Vol. 331 March 25 2011,
PP 1510 1511

The world and the nuclear community has been dealt a serious blow to the "clean energy bridge."

Nevertheless we advocate that nuclear energy, produced from newer, safer technology is necessary and will ultimately prevail for QOL sustenance.

Surely Japan's energy plight from 1930 forward has proved this.

Big nuclear accidents are rare, but their psychological effect is immense in terms of sowing fear in the population.

“Radiation is something you can’t see, can’t smell, can’t taste.”

but ....

it can kill (added).

Dale Klein, a former chairman of the Nuclear Regulatory Commission

“Japanese Rules for Nuclear Plants Relied on Old Science”

March 26, 2011

“Fukushima: Mark 1 Reactor Design Caused GE Scientists to Quit in Protest”

NYT March 15, 2011

“Mitsuhiko Tanaka, an engineer who worked on the design of the reactors at the Fukushima Daiichi plant, said the reactors there were outdated, particularly their small suppression chambers, which increased the risk that pressure would build up within the reactor, a fault eliminated in newer reactors.”

NYT, March 27 2011

Scientific Advances Have Changed 1960s Mark 1 Nuclear Designs and Build out

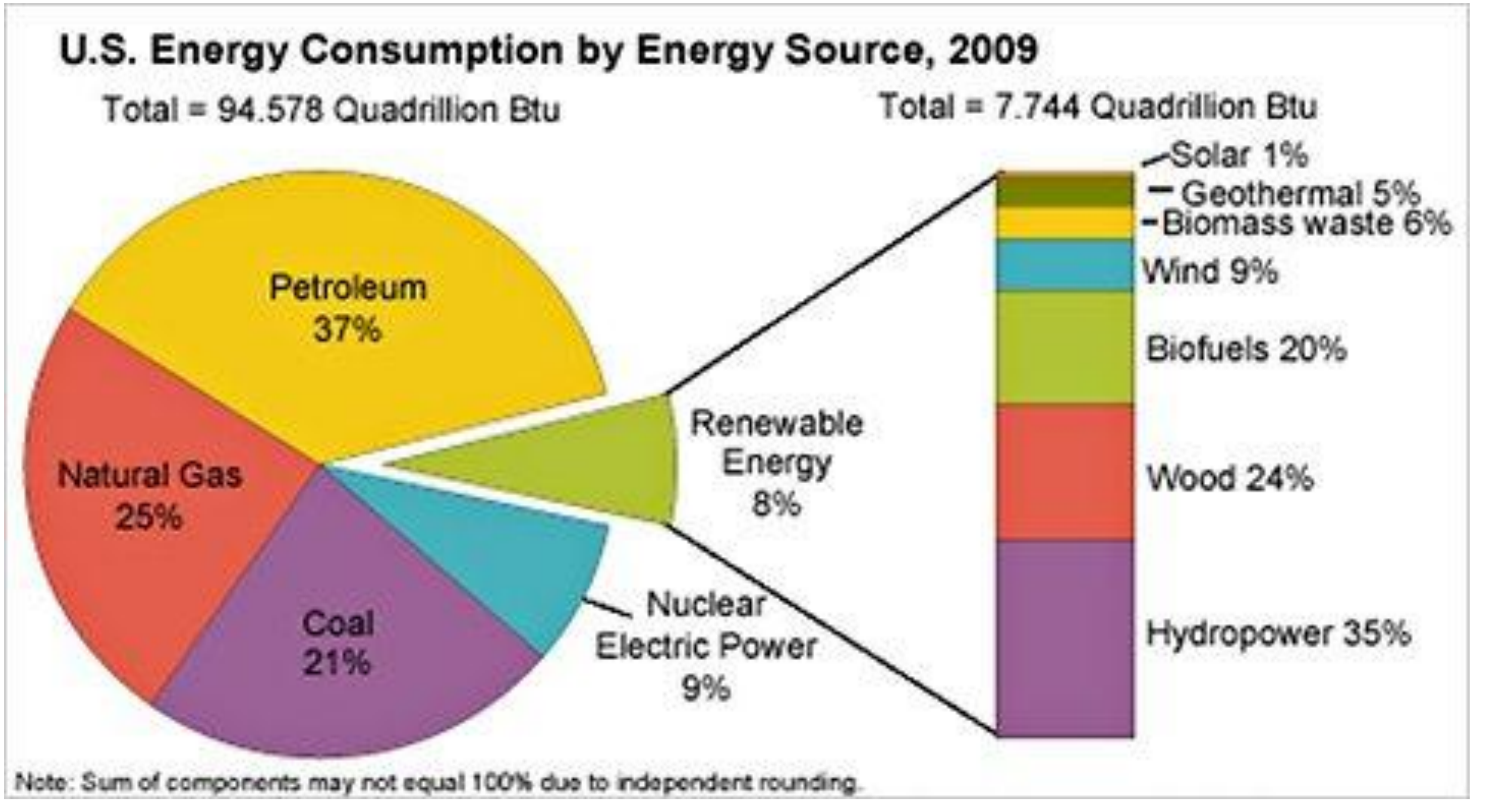
- In **seismology** particularly tsunami research.
- In **geological** understanding of fault structures.
- In **metallurgy** and **reactor construction**.
- In **digital** computation.
- In **fuel design** and spent fuel handling.

Artifact 1: Germany's Move and Impact on the New Energy Imperative

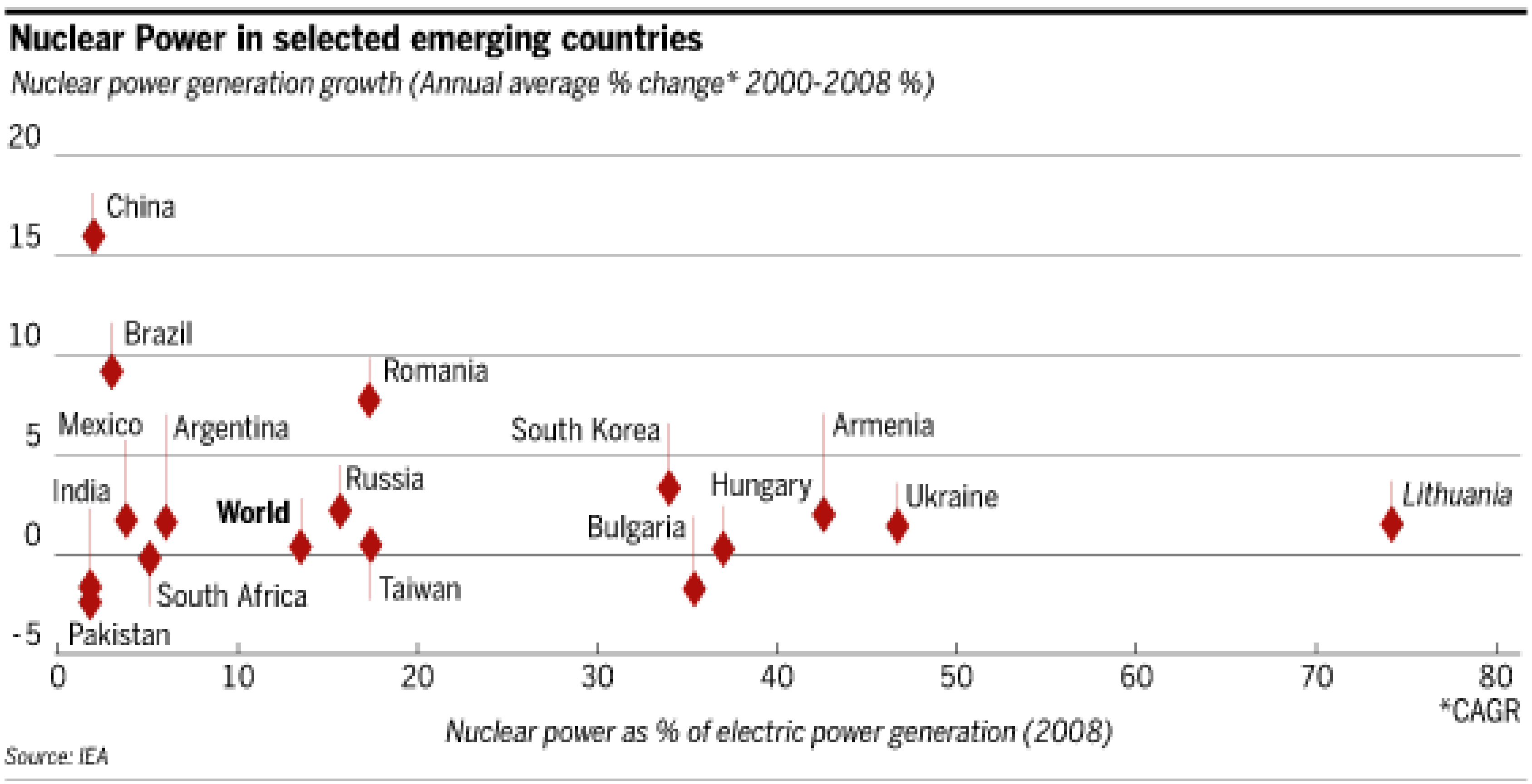
- The Green's in Germany have seized on the Fukushima disaster; it appears that Germany will completely eschew nuclear energy.
- The Toronto Globe and Mail reported (4/9/11) that The German Utilities Association forbade use of nuclear (old or new).

Artifact 2: Can Renewable Energy Replace Nuclear Now)?

(New York Times, March 26, 2011



Artifact 3: A Significant Investment in Gen 3+ Nuclear Energy in The Emerging World (2000 -2008)



The Most Critical Imperative:

NEW NUKE

Nine Necessities of New Nuke in the New Energy Imperative

- Increased **Safety**
- **Clean** across the supply chain (ground to grid)
- **Cheaper** to build and cheaper product.
- High **availability** (base load, fuel and grid)
- **Long Lived** infrastructure

Nine Necessities of New Nuke in the New Energy Imperative

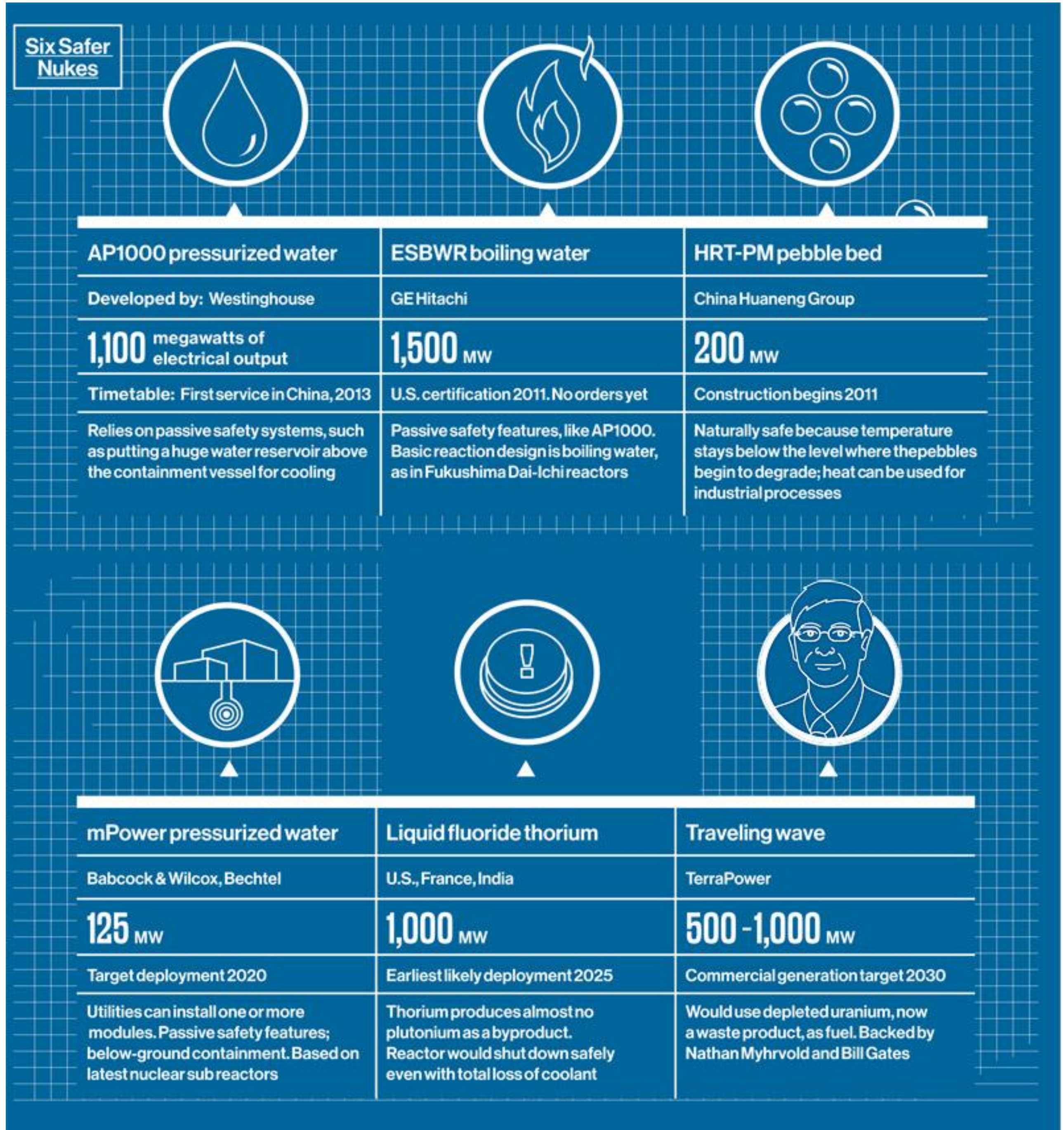
- **Recyclable** and Re-usable
- Expedient fault **Recovery**
- Ease of **Decommissioning**
- **Standardization** and Modularity

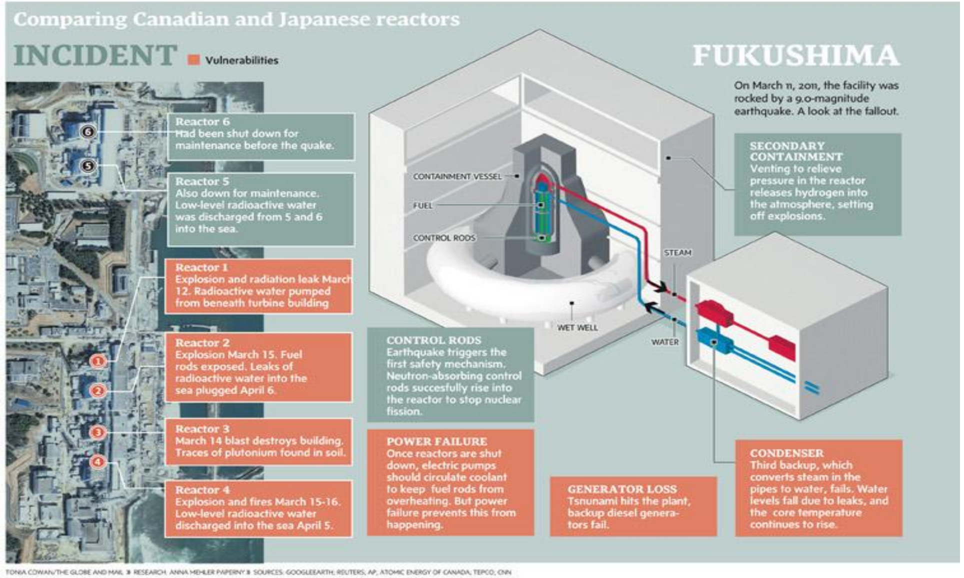
New Nuke Architecture / Availability

- **Gen**eration 4 Nuclear (2030)
- Pebble Bed (Chinese test bed 2011)
- Travelling Wave (Gates, Areva 2030)
- Candu (The Avro Arrow Phenomenon ?)
- Modular Systems (Babcock and Wilcox 2020)
- Passive Cooling (AP 1000 Today)
- Thorium, Beryllium/ Uranium, MOX (IBC R&D 2015)
- Helium cooling in place of water.

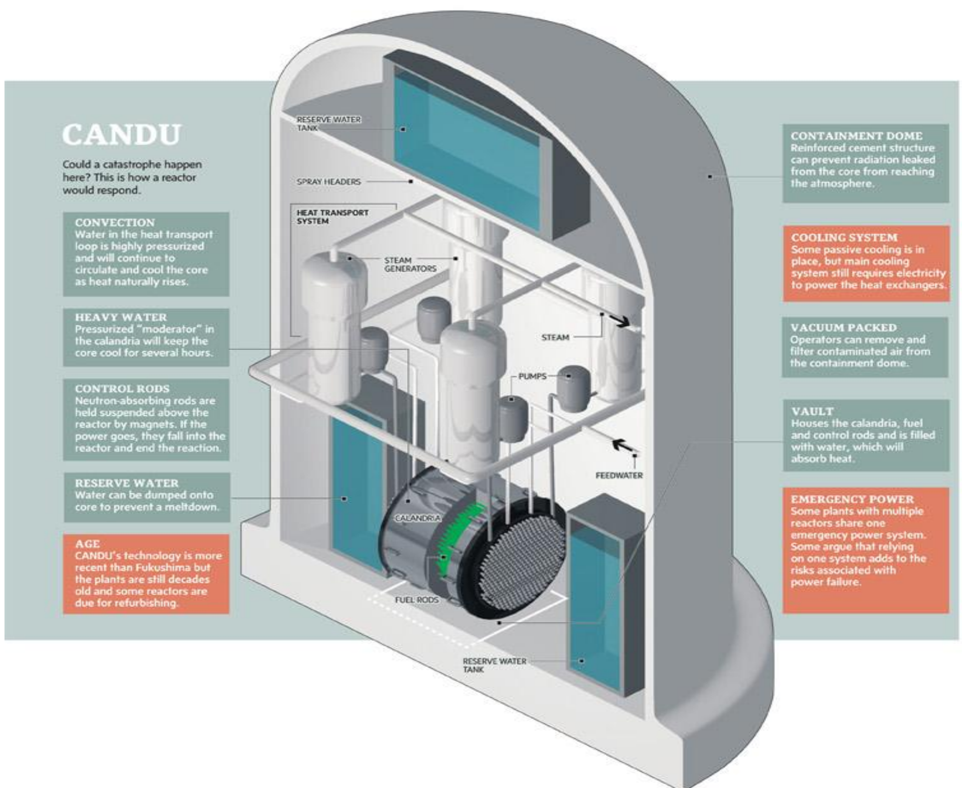
Six Safer Nukes:

1. AP1000
2. ESBWR
3. Pebble Bed
4. mPower
5. Liquid Fluoride Thorium
6. Travelling Wave





Canada's Gen 3 Candu nuclear technology appears significantly safer. So why hasn't Canada continued to develop it?



Toronto Globe and Mail
April 9, 2011

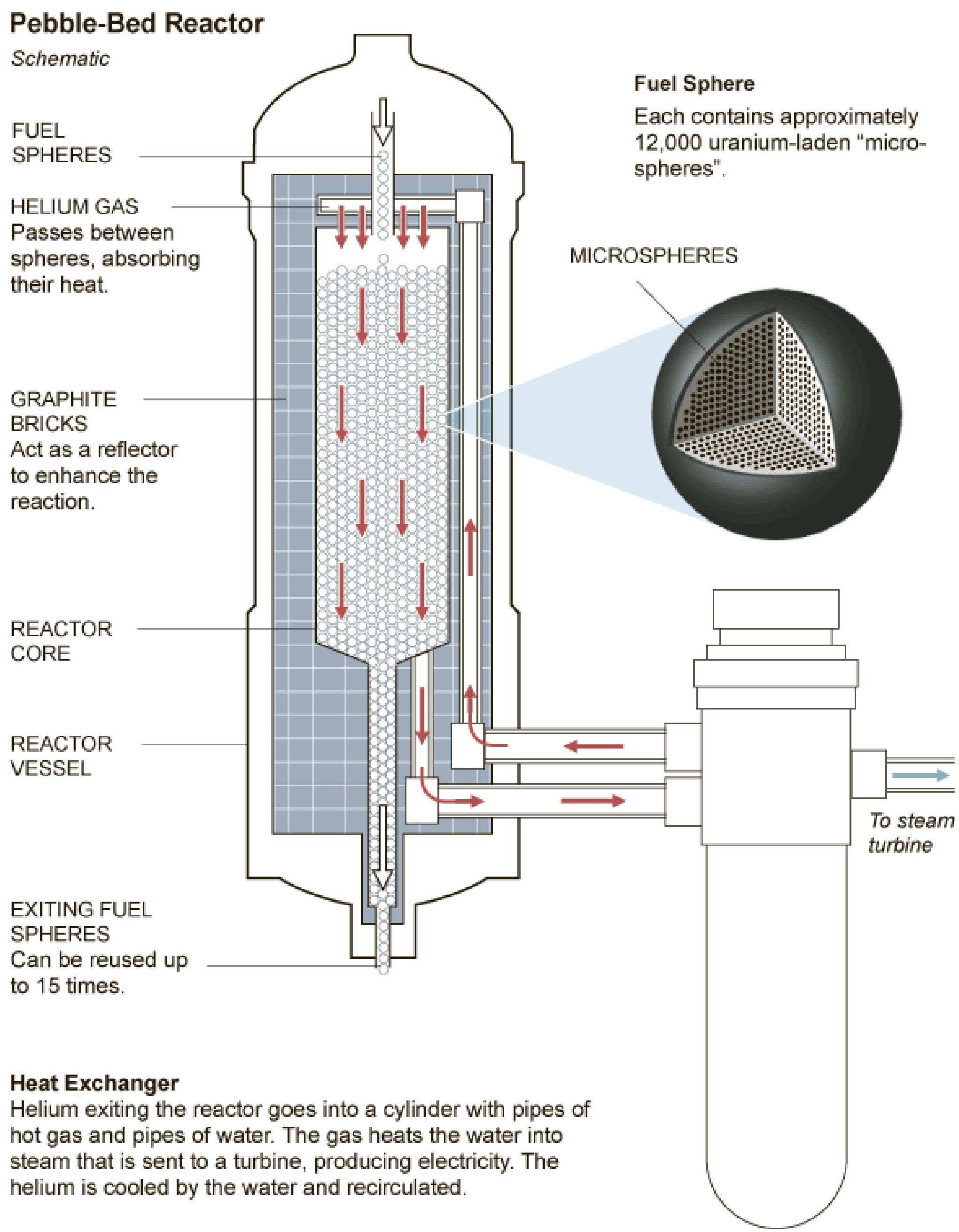
Pebble Bed: A Different, Safer Nuclear Reactor in China?

- Rather than using fuel rods encased in water, engineers in China are building pebble-bed reactors that use billiard ball-size fuel spheres, pebbles.

- Amassing these pebbles inside the reactor creates nuclear fission, which heats a gas (helium). The gas in turn heats water into steam, driving a turbine.

- The reactor core consists of 420,000 of these fuel spheres, and every 15 seconds one is removed and replaced by another one.

China's Pebble Bed Technology



Troubling Energy Imperatives 2030 - 2050

- All man made systems have failure modalities (BP oil spill, West Virginia Coal disaster, Fukushima, Apollo 13).
- Nuclear technology, circa 1970, poses obvious failure risks. Can China build safe Gen 3 + nuclear technology?
- There is no Gaussian analytic that provides designers with sufficient safety. Ongoing “Black Swans” await.
- We must accept failure potentiality in the energy space as emerging world growth increases.

Discovery Investing in Nuclear Technology

- Thorium, Uranium, Beryllium / Uranium, Helium, Graphite and high temperature materials qualification.

  (See Next Generation Nuclear Plant Report to Congress, April 2010)

- Spent Fuel Recycling Technology Travelling Wave (Areva).

- Canadian Nuclear technology - significantly safer?

- Standardized Reactor Design.

- Domestic Nuclear Energy Supply Chain Development

  (Babcock and Wilcox, Bechtel).

New Nuke - Gen 4 Circa 2030

- Will come to the fore. Post Fukushima timing is much less certain.
- Commercial infusion 20 to 30 years away.
- Old Nuke re-licensing should be reconsidered / cancelled. What machine do you know that works safely for 60 years?
- Nuclear standardization is a necessary and sufficient condition.
- Decommissioning, reclamation, spent fuel management a priority. Questions must be answered by authorities.

But A NOW Delayed New Nuke Is Also

"The World's New Energy Imperative"

It is the Most Likely Outcome Of The Most Recent of Three Nuclear Accidents

Traditional Global Energy Imperatives

- Cleaner, cheaper, more accessible energy.
- Increased electrification of economic activity, to 2050.
- Energy self-reliance / independence.
- Development of enhanced battery technology.
- Development of 2^{nd} generation “smart” electrical grid.

The World's New Energy Imperative 2011 – 2050 - Development of:

- Conventional / Shale Gas and Oil, LNG and CBM + Combined cycle gas electric generation.
- Natural gas to diesel (GTL) infrastructure.
- Advanced battery technology: lithium, vanadium, manganese.
- Supplemental oil and coal resources.
- Materials R&D on bio diesel, solar, geothermal and wind.
- Superconductivity + Second Gen electrical grid build out.

The World's New Energy Reality 2011 - 2050 , Development of:

- Increased global demand for coal - thermal / coke.

  "**Chinese Group Makes Billion-dollar Bet On B.C. Coal"** **Globe and Mail, March 30, 2011**)

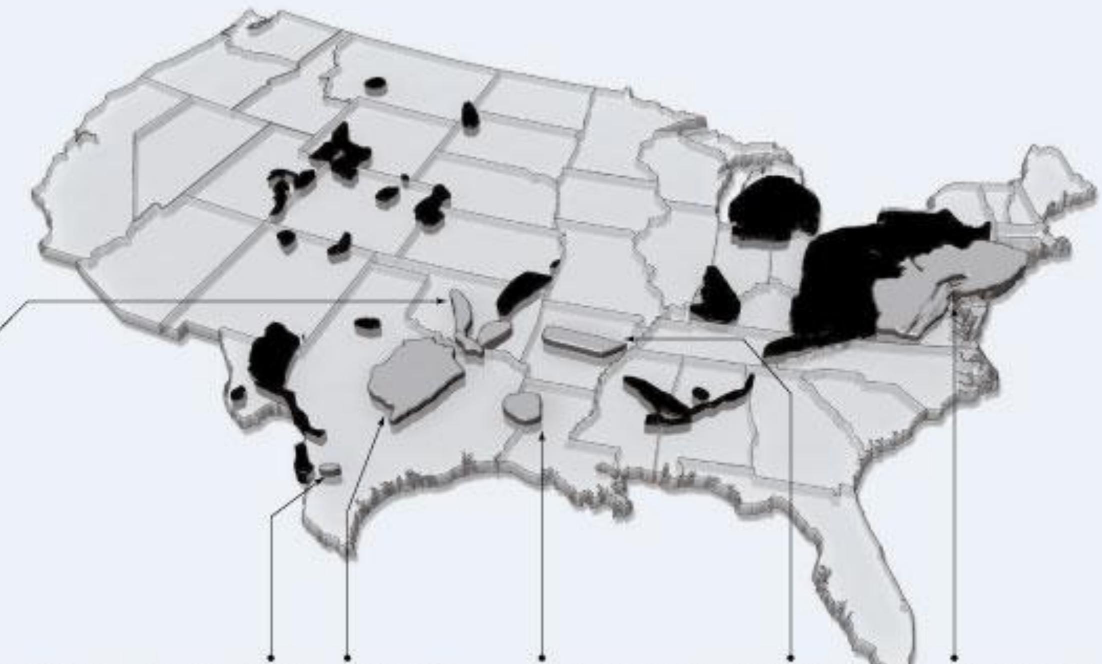
- Oil sands and Shale oils (Eagle Ford, Marcellus, Bakken).

- Lithium, graphite, manganese and a number of resource infrastructure developments including coal to liquids (CTL) as in Saskatchewan and China and GTL .

Stepping on the Gas

Drilling Down

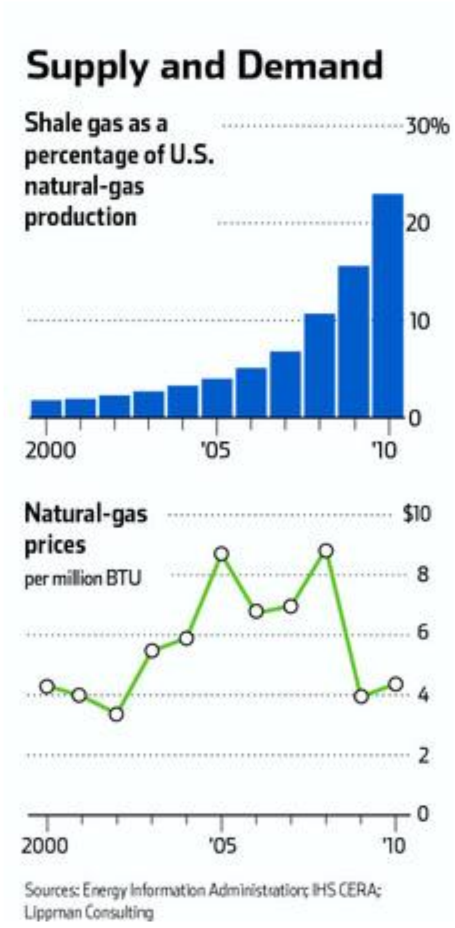
A look at shale formations in the U.S., with data on the six largest.



	Woodford	Eagle Ford	Barnett	Haynesville	Fayetteville	Marcellus
BILLION CUBIC FEET PER DAY (2010)	0.96	0.28	5.16	3.81	2.10	1.27
NUMBER OF WELLS COMPLETED (2010)	**274**	**396**	**585**	**703**	**662**	**792**

Sources: Energy Information Administration; IHS CERA; Lippman Consulting

Shale Gas


Supply and Demand
Shale gas as a percentage of U.S. natural-gas production
30%
20
10
0
2000
'05
'10
Natural-gas prices
per million BTU
$10
8
6
4
2
0
2000
'05
'10
Sources: Energy Information Administration; IHS CERA; Lippman Consulting

COAL-FIRED B.C.

- The rising price of coking coal made coal the province's most important export material buoyed by new demand in Japan / China.
- **$5.1-billion:** Value of B.C. coal exports in 2010
- **86%:** B.C.'s share of Canada's $6-billion of coal exports 2010
- **106%:** Increase in value of B.C.'s exports since 2007
- **$804-million:** B.C. coal exports to mainland China in 2010, (15 times more than $54-million annual average 2003-07)
- **B.C. coal exports to China:**

  2010: $804-million
  2009: $560-million
  2008: $121-million
  2007: $13-million

US Energy Independence: The Endless Chimera

- If it could have been done, it would have been done by now.

- "Anybody who's talking about energy independence is smoking pot …. There's no way we're going to get to energy independence as long as we depend on the internal combustion engine."

James Schlesinger, former Secretary of Energy bluntly to Politics, March 2011

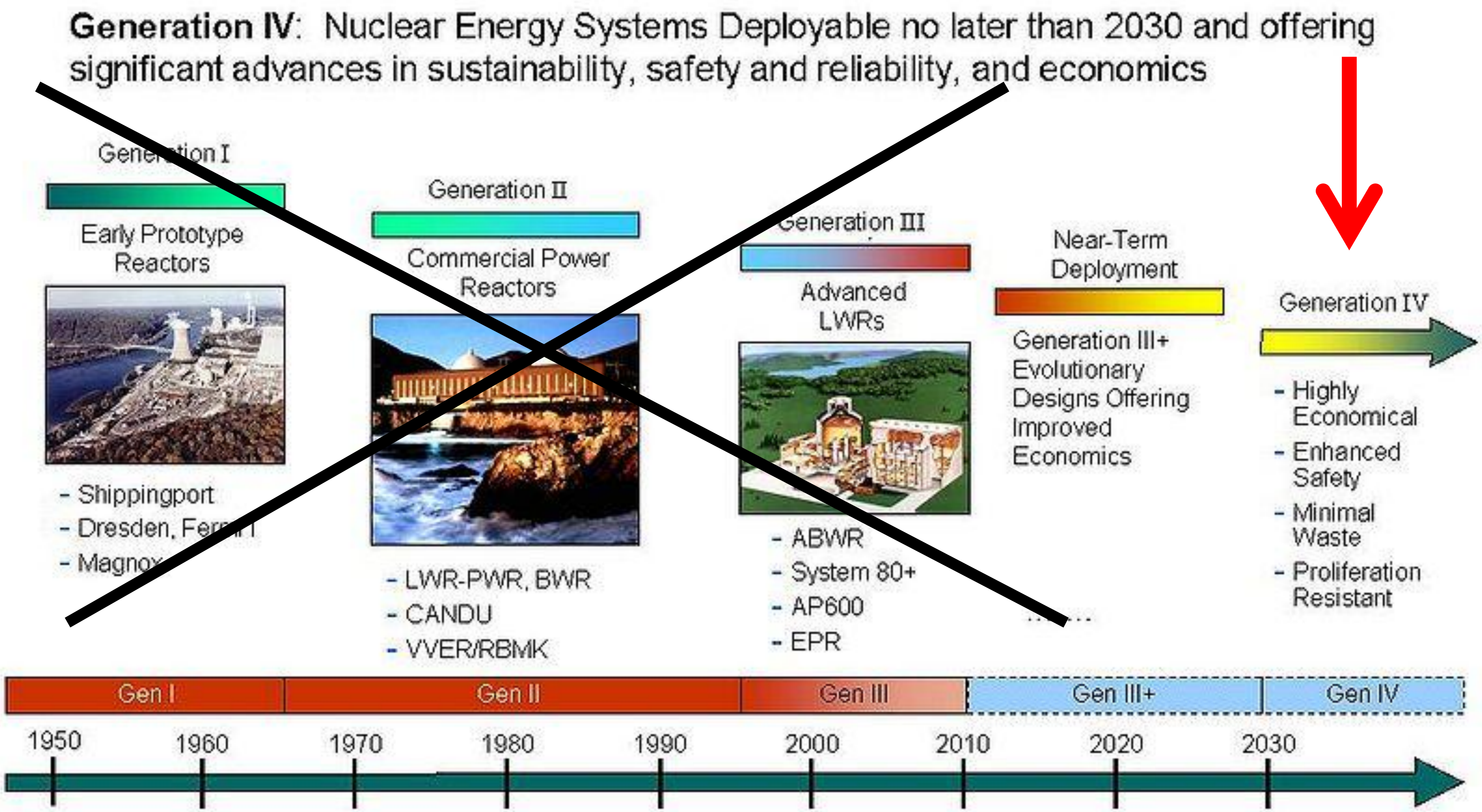
Carbon Contention, Another Chimera in The World's New Energy Imperative

"We are now about to find out just how strongly the world believes that our carbon and fossil fuel dependence is seriously deleterious to humanity's quality of life."

The New Energy Future

- Eventually, safe and cheap nuclear – New Nuke
- Intermediate power from coal, shale gas, oil sands, shale oil and LNG.
- Ironically the electric car mania forces increased global reliance on coal, particularly in China.

Artifact 4: The Critical Move to Gen 4 Nuclear



DEVASTATION IN JAPAN

Nuclear Power's Global Fallout

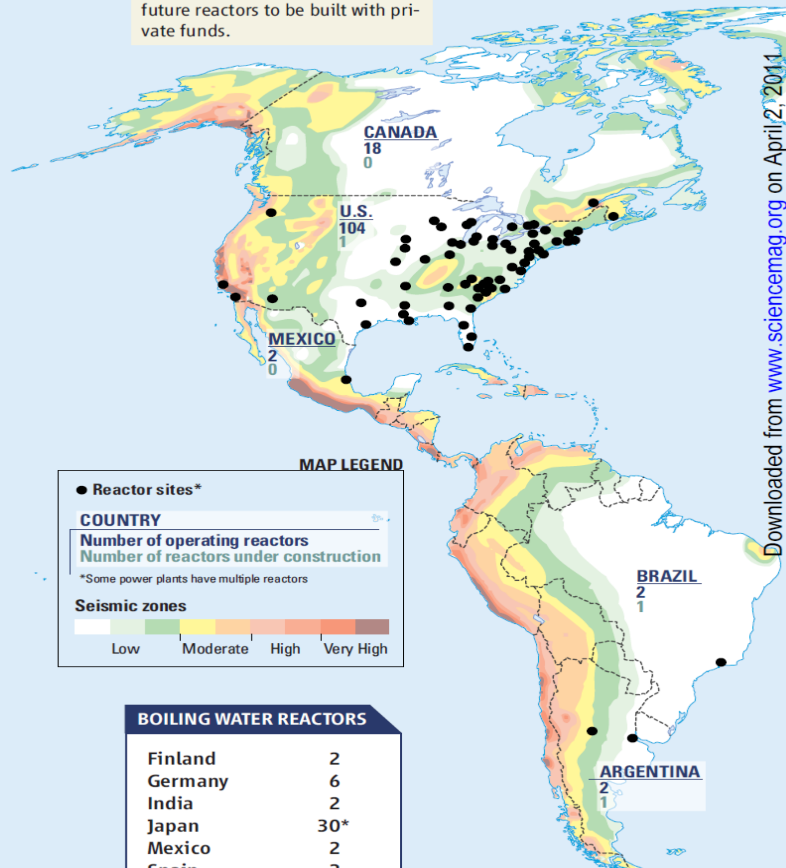
The crisis at the Fukushima Daiichi nuclear power plant, like the accidents at Three Mile Island and Chernobyl, is prompting countries around the world to reassess the safety of their plants and their nuclear aspirations. The map on this page provides a snapshot of the number of nuclear reactors in operation (dark blue) and under construction (green), locations of power plants in relation to seismic hazard zones, and reactions to events in Japan in some countries. The following pages examine what we have learned about radiation risks from previous exposures (p. 1504), improvements in safety since the boiling water designs at Fukushima (p. 1506), what to do with the wrecked reactors (p. 1507), and damage to research facilities from the earthquake (p. 1509). **—NEWS STAFF**

UNITED KINGDOM

The government has asked its chief nuclear inspector to compile a report on the implications of the Fukushima accident for Britain's current and future nuclear plants. Energy and climate change secretary Chris Huhne said: "We should not rush to judgment. It is important that we have the full facts at our disposal." Current policy is for future reactors to be built with private funds.

FRANCE

The French government has promised a safety audit of the country's 58 nuclear reactors. But the government has made clear that nuclear energy will remain the cornerstone of France's 40-year-old policy of energy independence and has rejected calls for a referendum on atomic energy. France generates over 75% of its electricity with nuclear power, more than any other country in the world.



UNITED STATES

The United States is the world's largest producer of nuclear power, but no new reactor has been built there for 3 decades. The Nuclear Regulatory Commission has ordered a safety review of the 104 existing U.S. plants, some of which are in seismically active areas. The Obama Administration has proposed expanding nuclear capacity largely by stimulating new construction with loan guarantees; opposition to that plan is likely to strengthen.

BRAZIL

Mines and Energy Minister Edison Lobão said Brazil's federal government will review security at the country's twin nuclear reactors at Angra and halt construction of a third, due to go on line in 2015, until the review is completed. The Fukushima crisis has renewed calls to create an independent regulatory agency for nuclear power in Brazil.

ARGENTINA

Events in Japan have reopened debate over Argentina's aging reactors. Its oldest plant dates to 1974, and another has been under construction since 1981 but is not yet complete. Critics call it a "Model T."

BOILING WATER REACTORS

Finland	2
Germany	6
India	2
Japan	30*
Mexico	2
Spain	2
Sweden	7
Switzerland	2
Taiwan	4
United States	35

*4 are advanced boiling water reactors

MAP SOURCE: GLOBAL SEISMIC HAZARD ASSESSMENT PROGRAM; REACTOR TOTALS: EUROPEAN NUCLEAR SOCIETY; BOILING WATER REACTOR TABLE: IAEA

GERMANY

Chancellor Angela Merkel suspended for 3 months a newly enacted law that postponed Germany's planned phase out of nuclear power. Several older reactors, which got a reprieve under the law, are now being shut down, and some are unlikely to come back on line. During the 3-month moratorium, the government will reassess the safety of all 17 reactors and is expected to propose amendments to the new law in accordance with the findings.

BELGIUM

The Belgian government decided in 2003 to phase out the country's seven nuclear reactors, which produce half of Belgium's electricity. But the first phase, shutting the three oldest reactors by 2015, was recently pushed back 10 years. Environmental groups hope the Fukushima disaster will swing the pendulum back in their direction.

SWITZERLAND

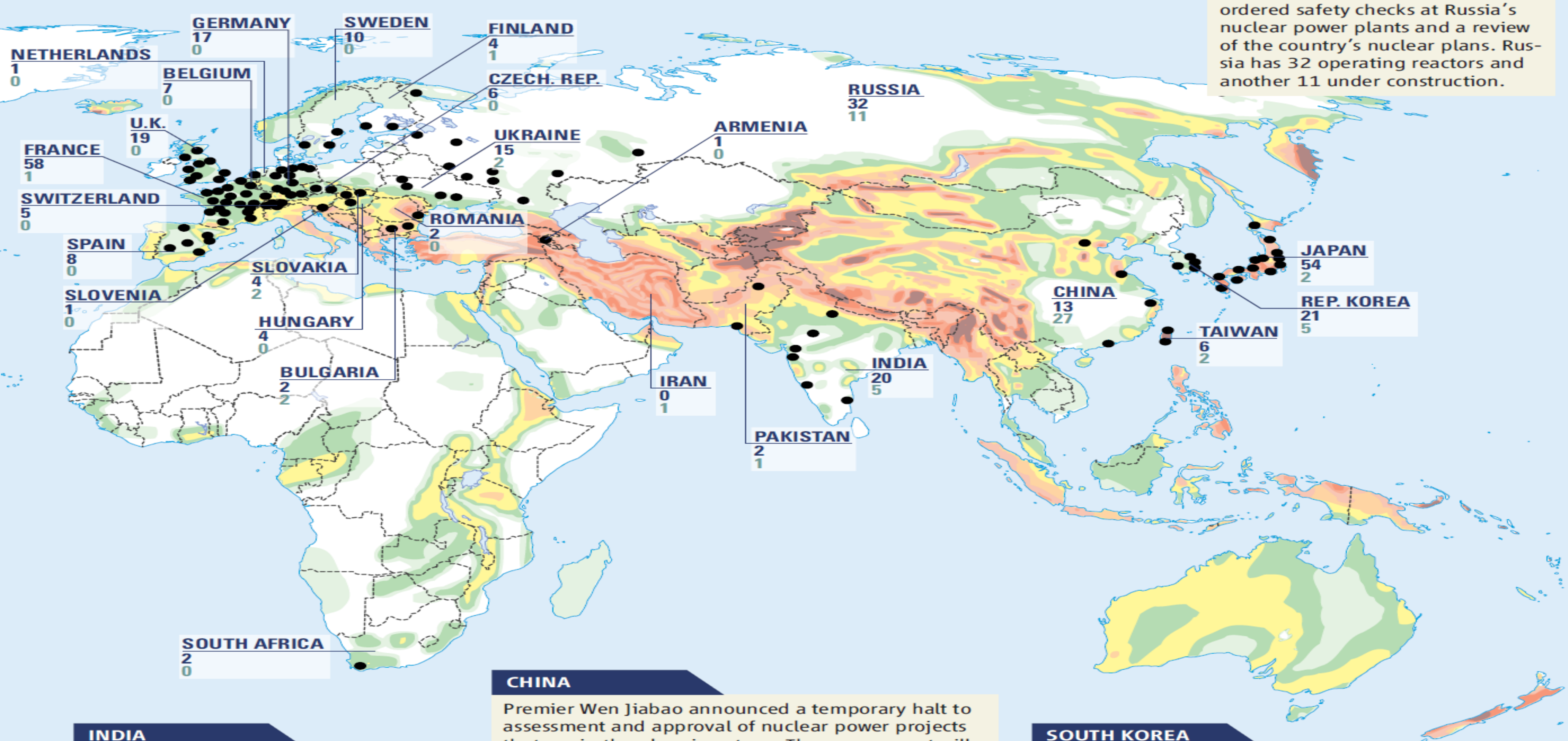
Switzerland generates 40% of its electricity with its five nuclear reactors. Last week, the government suspended feasibility studies for three potential reactors, and politicians across the political spectrum have spoken in favor of a nuclear power phaseout, though most have been vague about a timeline.

ITALY

A 1987 referendum, influenced by the Chernobyl disaster, led to Italy shutting down its four nuclear power plants between 1987 and 1990. Silvio Berlusconi's government has supported plans to build at least four new reactors, starting in 2013. A referendum this spring could block those plans.

RUSSIA

Prime Minister Vladimir Putin ordered safety checks at Russia's nuclear power plants and a review of the country's nuclear plans. Russia has 32 operating reactors and another 11 under construction.



CHINA

Premier Wen Jiabao announced a temporary halt to assessment and approval of nuclear power projects that are in the planning stage. The government will conduct a comprehensive review of all nuclear facilities, draw up nuclear safety regulations, and adjust its 15-year nuclear power–development plan. China has the world's most ambitious nuclear power program, with 13 reactors in commercial operation, 27 under construction, and as many as 50 more in the pipeline. The temporary halt applies only to projects yet to be approved; China's growing reliance on nuclear power is expected to continue.

INDIA

Prime Minister Manmohan Singh ordered a safety review of India's 20 operating nuclear reactors. In an interview with *Science*, Srikumar Banerjee, chair of India's Atomic Energy Commission, said no shutdowns are planned. India has five plants under construction and aims to produce 25% of its electricity from nuclear power by 2050.

SOUTH KOREA

South Korean President Lee Myung-bak ordered safety reviews of the country's nuclear reactors as well as procedures for handling emergencies. The country's 21st nuclear reactor started commercial power production at the end of February, another five reactors are under construction, and further expansion is planned. Knowledge Economy Minister Choi Joong-kyung said now is not the time to review the country's nuclear power policy.