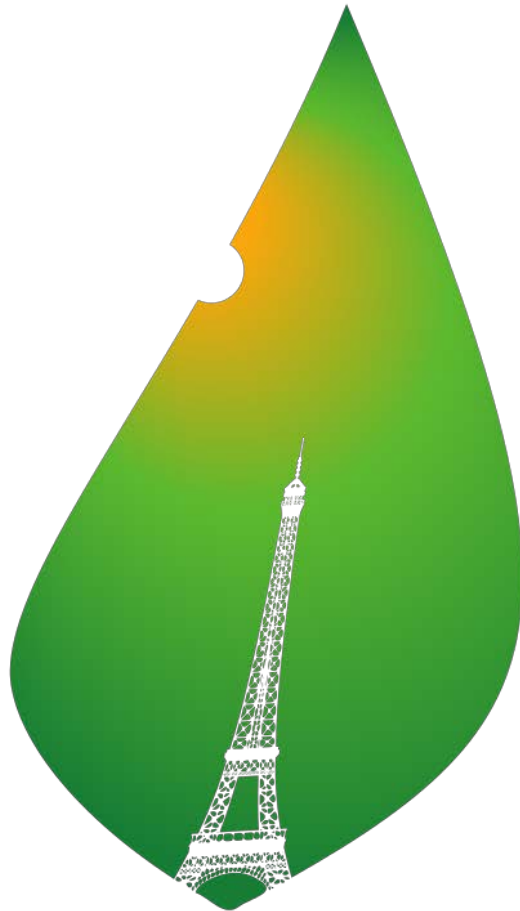


**WHY NUCLEAR?**

**WHAT NUCLEAR?**



**PARIS AGREEMENT  
NOW IN LEGAL  
FORCE:**

**LIMIT WARMING TO  
“WELL BELOW” 2  
DEGREES C AND  
“PURSUE EFFORTS”  
TO LIMIT WARMING TO  
1.5 DEGREES C**

**PARIS2015**  
UN CLIMATE CHANGE CONFERENCE  
**COP21·CMP11**

**WHAT DOES THAT MEAN?**

**A ZERO CARBON ENERGY SYSTEM**

**ELECTRICITY, TRANSPORT AND  
INDUSTRY**

**WITHIN 40-50 YEARS**

**AS GLOBAL ENERGY DEMAND  
DOUBLES**

**WHAT ARE OUR  
OPTIONS?**

**REDUCE DEMAND VIA EFFICIENCY**

**ADOPT ZERO CARBON RENEWABLE  
ENERGY (E.G. WIND, SOLAR)**

**SCRUB THE CARBON OUT OF  
FOSSIL ENERGY OR FROM THE  
ATMOSPHERE**

**NUCLEAR ENERGY**

**EACH OF THESE  
OPTIONS HAS  
CHALLENGES AT SCALE**

# **EFFICIENCY CHALLENGES:**

**UNDERLYING DEMAND FOR LIGHT,  
HEAT AND MOTION WILL GROW AS  
THE WORLD GETS RICHER – WE CAN  
MITIGATE BUT NOT ELIMINATE  
GROWTH**

**EX: 50 MILLION NEW AIR  
CONDITIONING UNITS/YEAR IN  
CHINA**

# **NUCLEAR CHALLENGES:**

**COSTS MORE THAN GAS AND COAL**

**SLOW TO BUILD (4-5 YEARS/UNIT)**

**PUBLIC ACCEPTANCE – ACCIDENT  
RISK, WASTE, PROLIFERATION**



# **CCS CHALLENGES:**

**ADDS TO FOSSIL FUEL COSTS  
DIRECTLY AND VIA LOAD TO  
OPERATE SCRUBBING EQUIPMENT**

**MUST CONSTRUCT AND OPERATE  
SUBSTANTIAL UNDERGROUND  
PIPELINE AND STORAGE  
INFRASTRUCTURE**

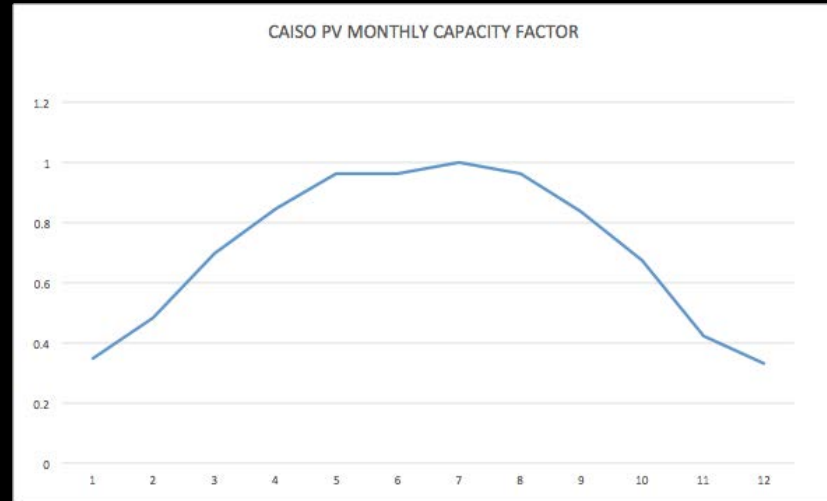
# **RENEWABLES CHALLENGES:**

**DIRECT COST OF PRODUCTION IN MOST CASES HIGHER THAN FOSSIL**

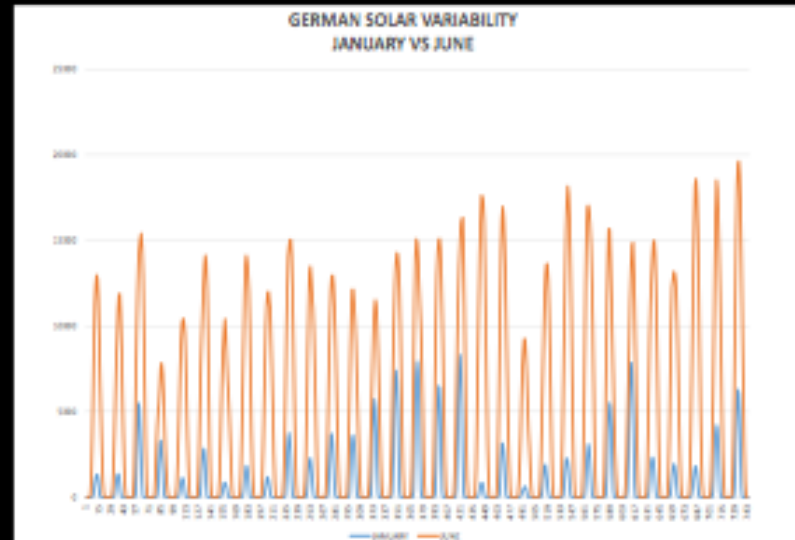
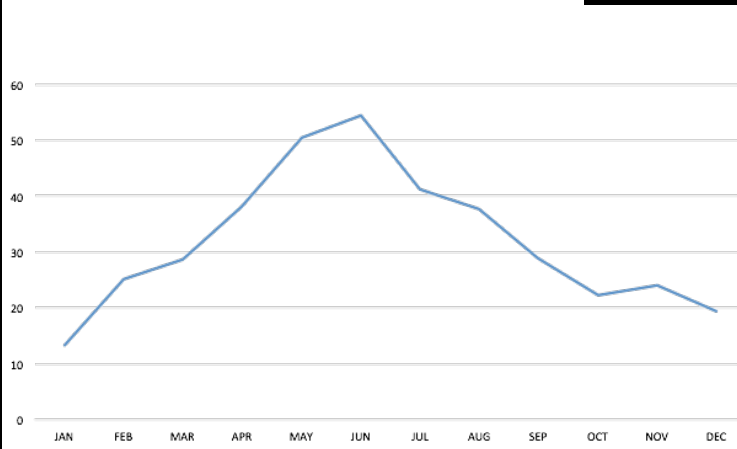
**SEASONAL INTERMITTENCY THAT CANNOT BE ADDRESSED BY DAILY STORAGE**

**SUBSTANTIAL INFRASTRUCTURE BUILDOUT – GENERATION AND TRANSMISSION**

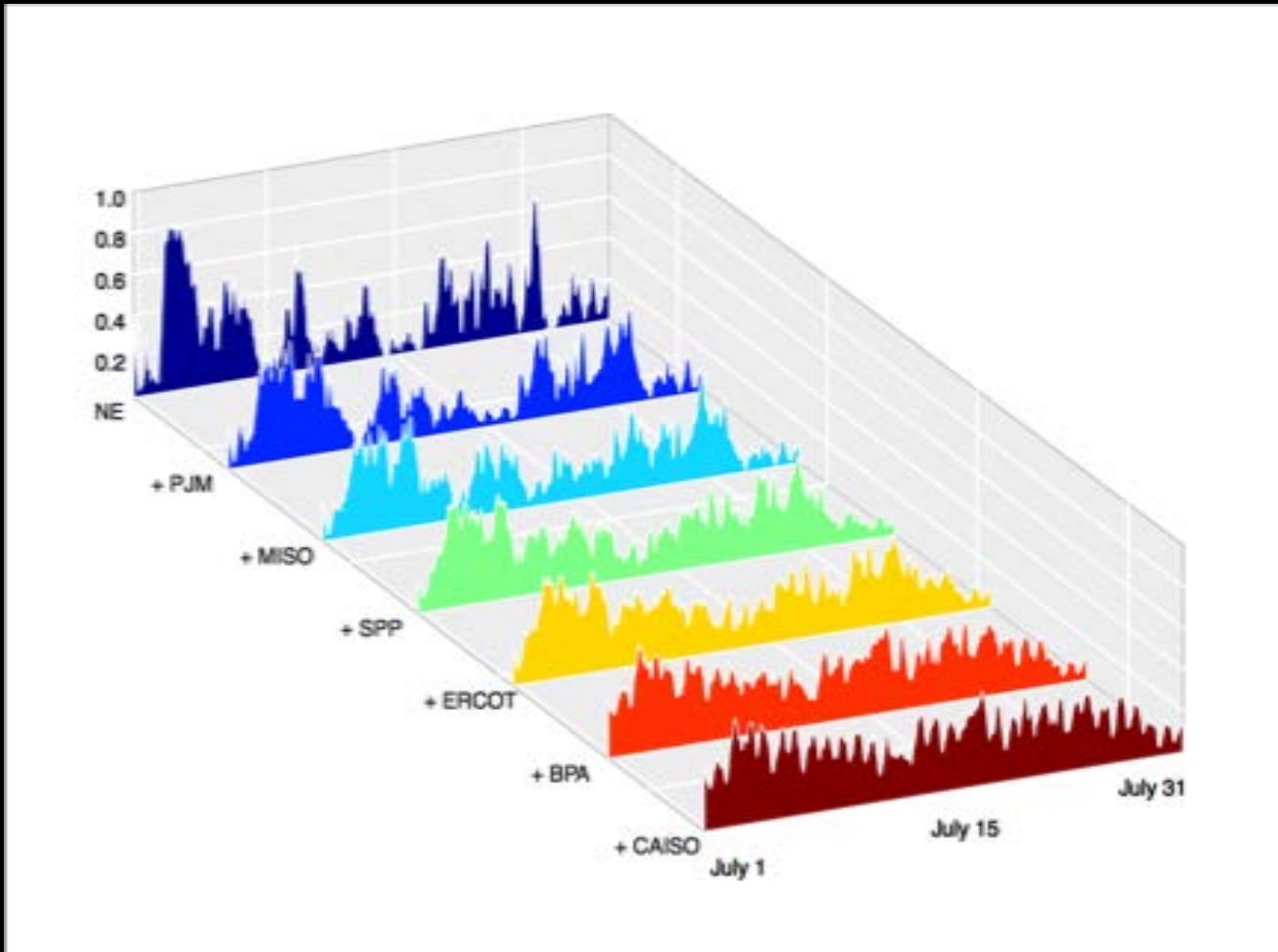
# WIND AND SUN ARE HIGHLY VARIABLE ACROSS MULTI-WEEK AND SEASONAL PERIODS



CA Wind Monthly Capacity Factor

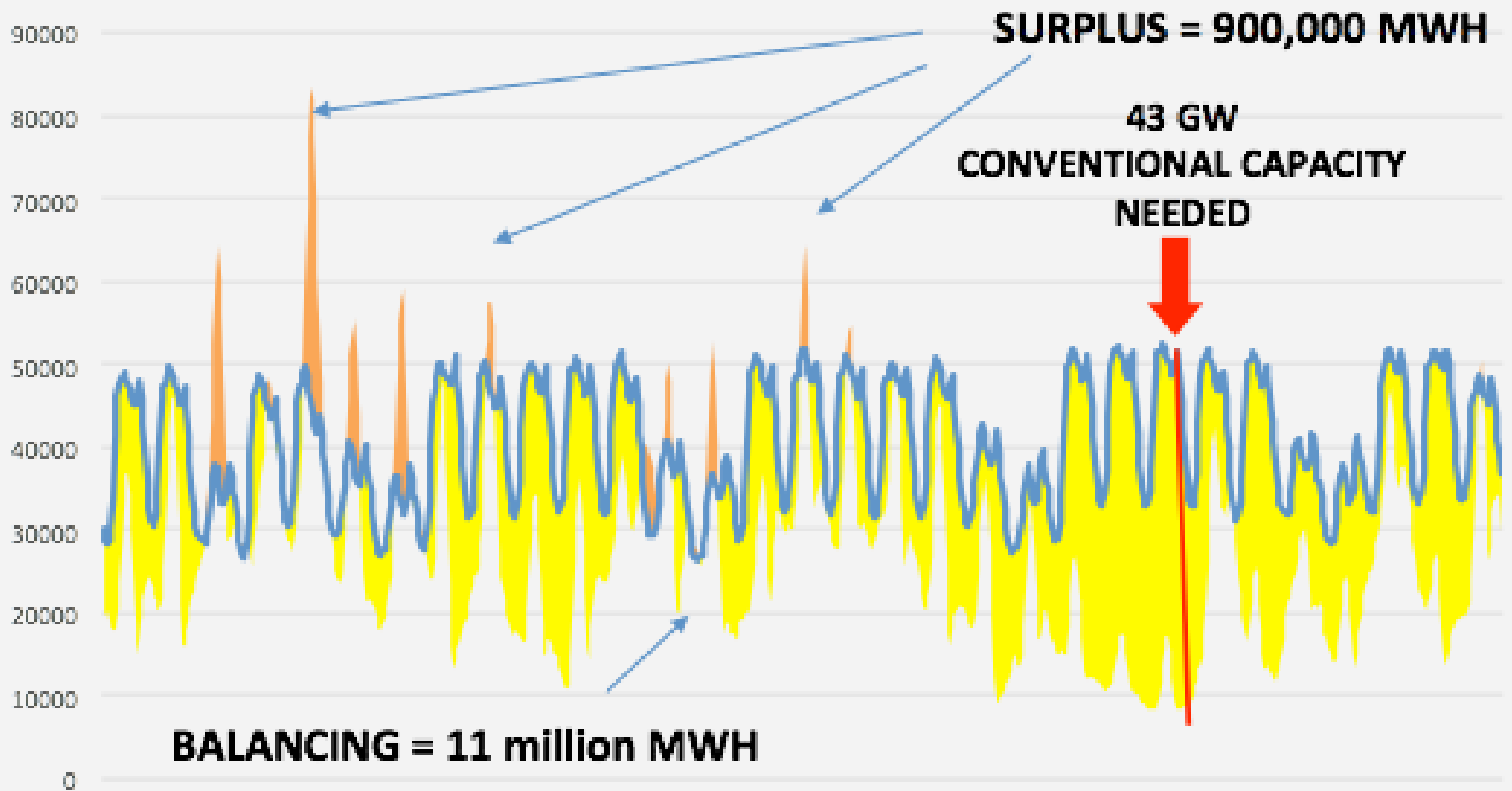


# WIND IS HIGHLY CORRELATED ACROSS CONTINENTAL SCALE



**BATTERY STORAGE WILL  
NOT SOLVE THE PROBLEM**

OCTOBER 2050  
GERMAN POLICY SCENARIO  
TOTAL GERMAN STORAGE TODAY = 37,000 MWH



**YOU NEED DISPATCHABLE  
CAPACITY NEARLY EQUAL  
TO PEAK DEMAND**

**OR SEASONAL STORAGE  
CAPACITY IN THE SAME  
RANGE AS PEAK DEMAND**



SCALING  
TOWARDS AN  
ALL-RENEWABLE  
ENERGY SYSTEM  
BY 2050-2070  
ALSO  
CHALLENGES  
CREDIBILITY



**22 OF THE NATION'S LARGEST WIND FARMS IN EVERY STATE**

**41 OF THE WORLD'S LARGEST OFFSHORE WINDFARMS FOR EVERY COASTAL STATE, INCLUDING THE GREAT LAKES STATES**

**1,200X MORE CENTRAL SOLAR PV PLANTS THAN EXIST TODAY**

**SEASONAL STORAGE TWICE THE SIZE OF THE US ELECTRIC SYSTEM, USING TECHNOLOGIES THAT HAVE NOT BEEN COMMERCIALY DEMONSTRATED AT SCALE**

**ABILITY TO RAMP DOWN 60% OF INDUSTRY DEMAND FREQUENTLY FOR EIGHT HOURS**

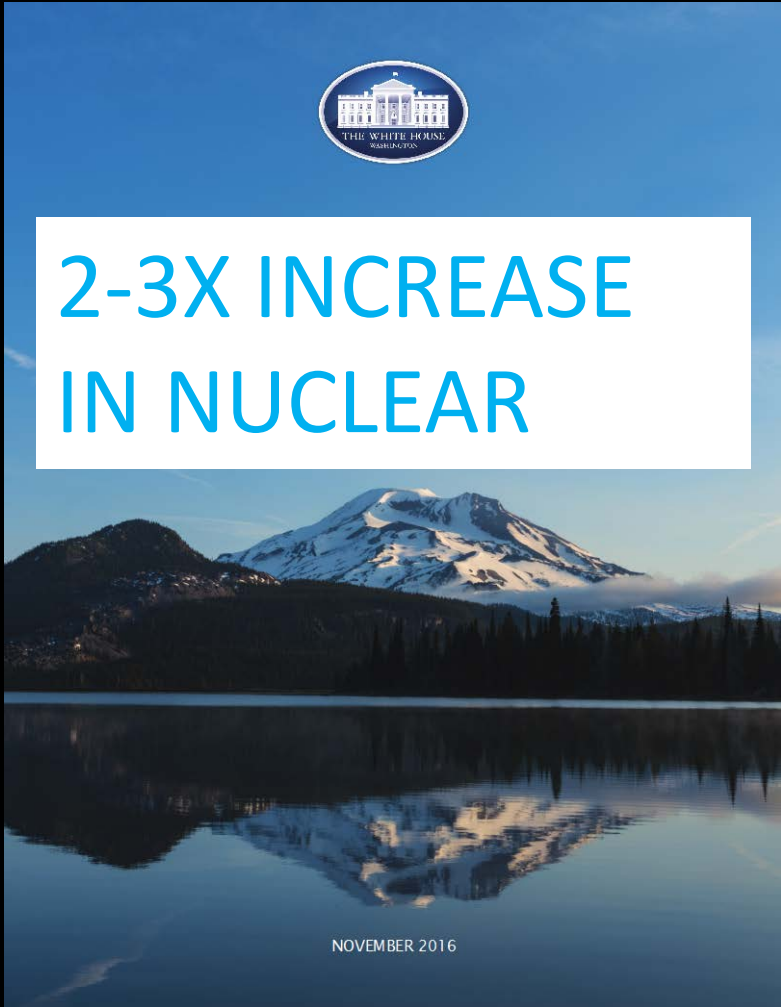
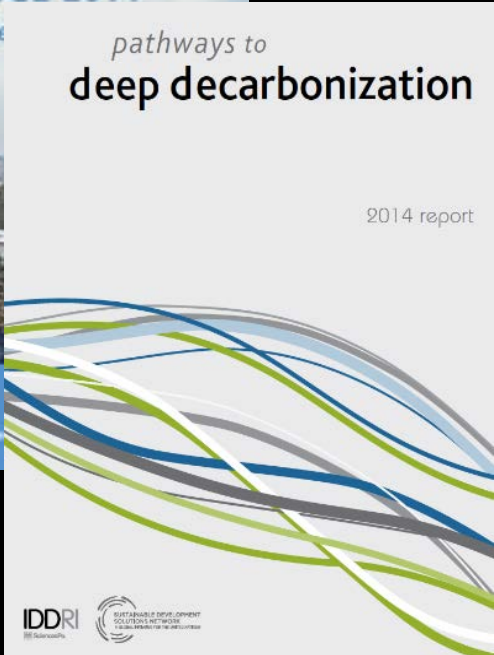
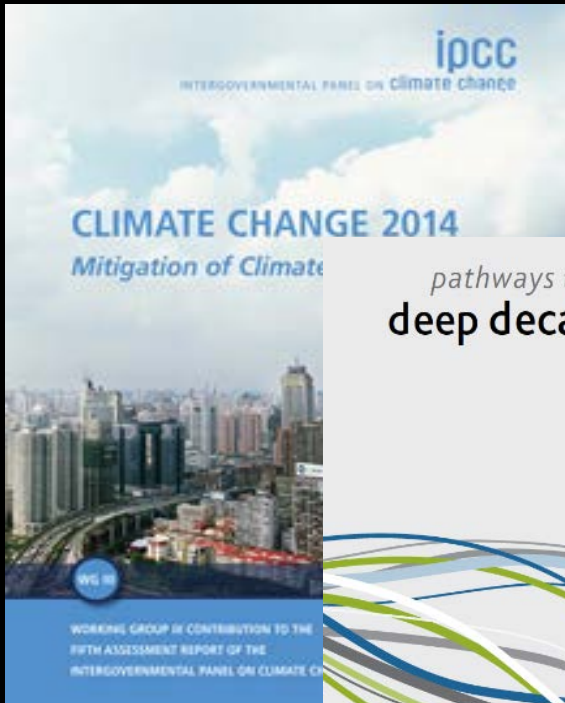
**DOUBLE SIZE OF TRANSMISSION ETC ETC**

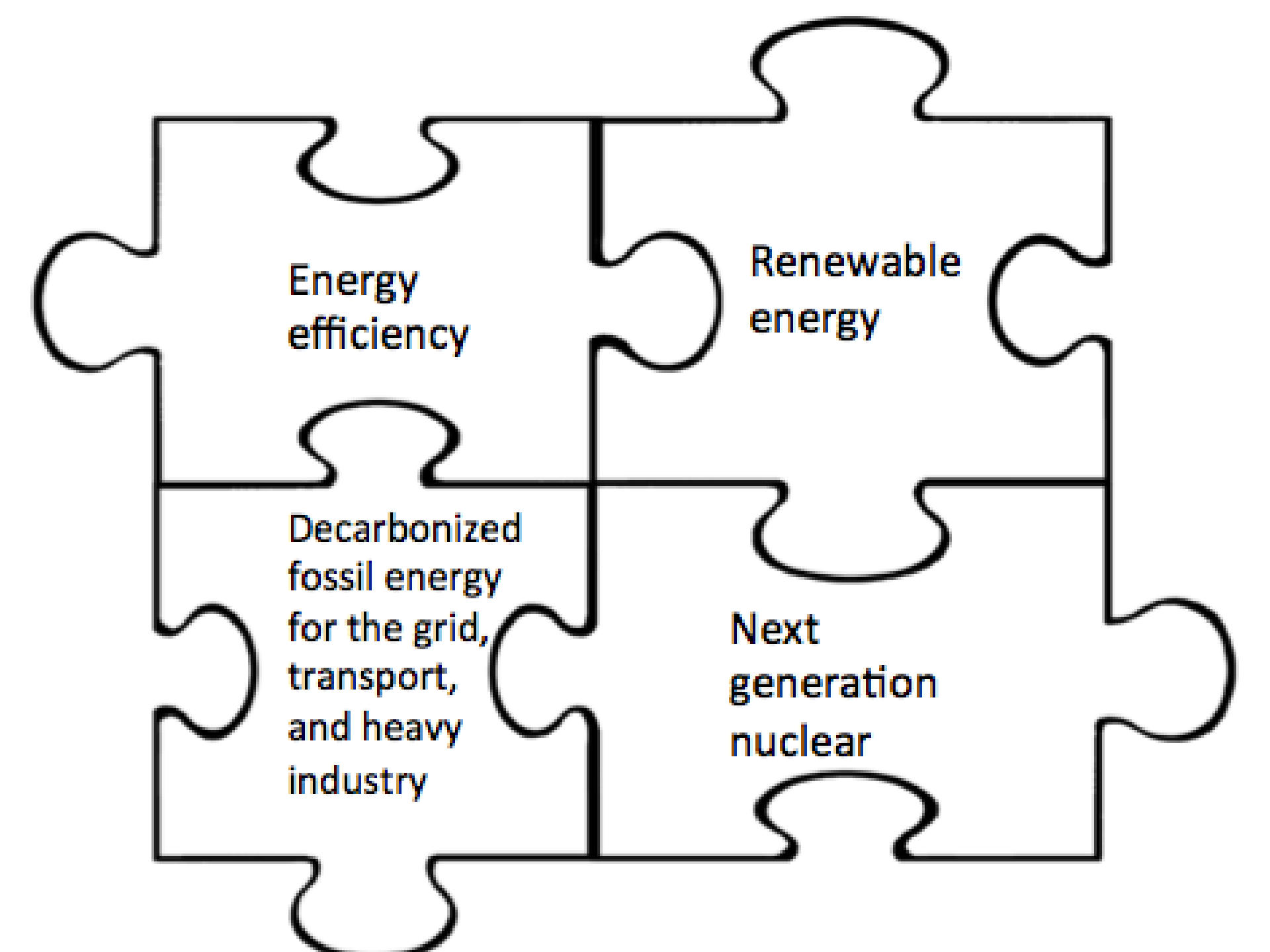
**DOABLE THEORETICALLY?**

**MAYBE**

**HIGHLY RISKY AS A SOLE STRATEGY  
IN THE REAL WORLD?**

**MOST DEFINITELY**





Energy  
efficiency

Renewable  
energy

Decarbonized  
fossil energy  
for the grid,  
transport,  
and heavy  
industry

Next  
generation  
nuclear

**BUT WE NEED BETTER  
NUCLEAR**

**CAN WE GET IT?**

**ELIMINATE WATER FROM THE EQUATION  
USING COOLANTS WITH MUCH HIGHER  
PHASE CHANGE POINTS:**

**RADICALLY REDUCED ACCIDENT  
RISK/OFFSITE IMPACTS**

**OPERATE AT ATMOSPHERIC PRESSURE->  
ELIMINATE NEED FOR PRESSURIZED  
CONTAINMENT → REDUCED COST AND  
SHORTER AND PREDICTABLE  
CONSTRUCTION TIMES**

# 50 start-ups in the US, CAN, UK, EU

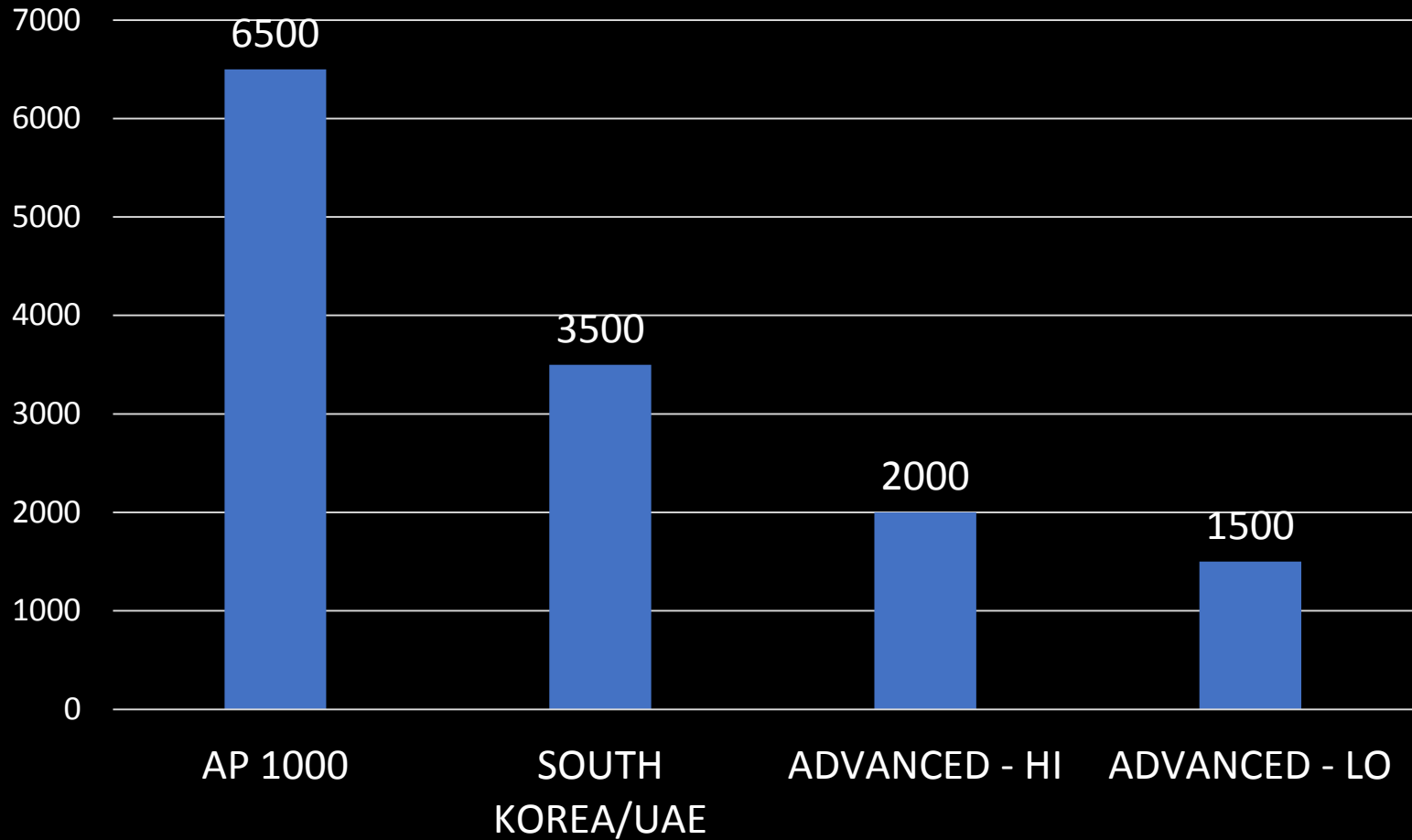


## Reactor Design Types

- Molten Salt Reactor
- Fluoride Salt-cooled High Temperature Reactor
- Liquid Metal-cooled Fast Reactor
- High Temperature Gas Reactor
- Pebble Bed Reactor
- Nuclear Battery Reactor
- Designs Advanced Nuclear Fuels
- Small Modular Reactor
- Fusion Reactor
- Super-Critical CO<sub>2</sub> Reactor

Graphic from: Third Way, 2015

# OVERNIGHT NUCLEAR COSTS





**CONCLUSION:**

**MORE OPTIONS →**

**INCREASE OUR CHANCE  
OF SUCCESS**

**NUCLEAR IS A KEY OPTION**

MORE AT

<http://www.catf.us/resources/publications/view/232>

# ADDITIONAL SLIDES

# FACTORY OR SHIPYARD BUILT

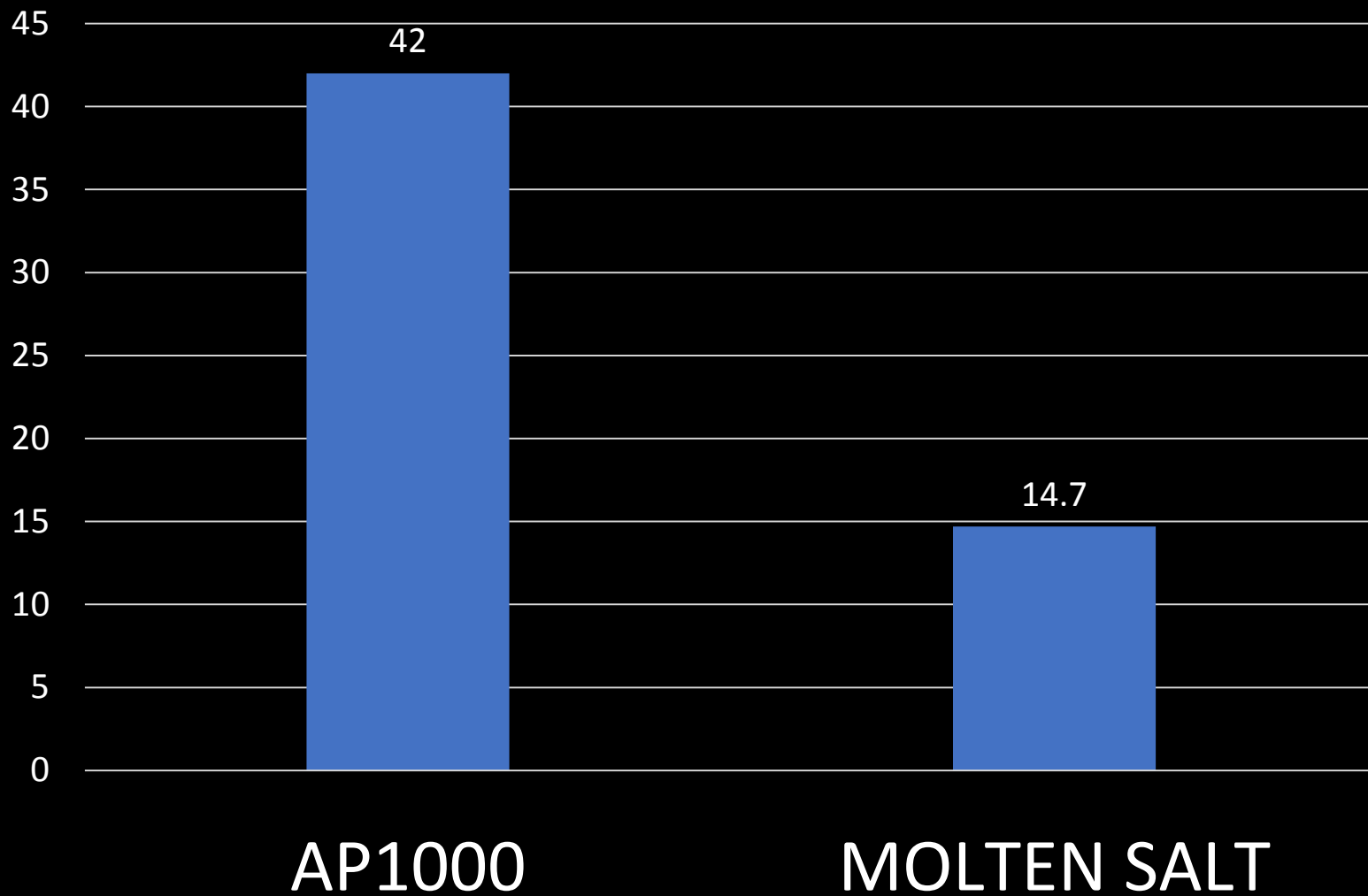


reactor.

of steel plate into more  
On average, these ships  
a 1 GWe advanced

# INTERNATIONAL STANDARIZED LICENSE

# Metric Tons of Steel Per MW



**HIGHER TEMPERATURE → INDUSTRIAL  
HEAT AND FUEL SYNTHESIS**

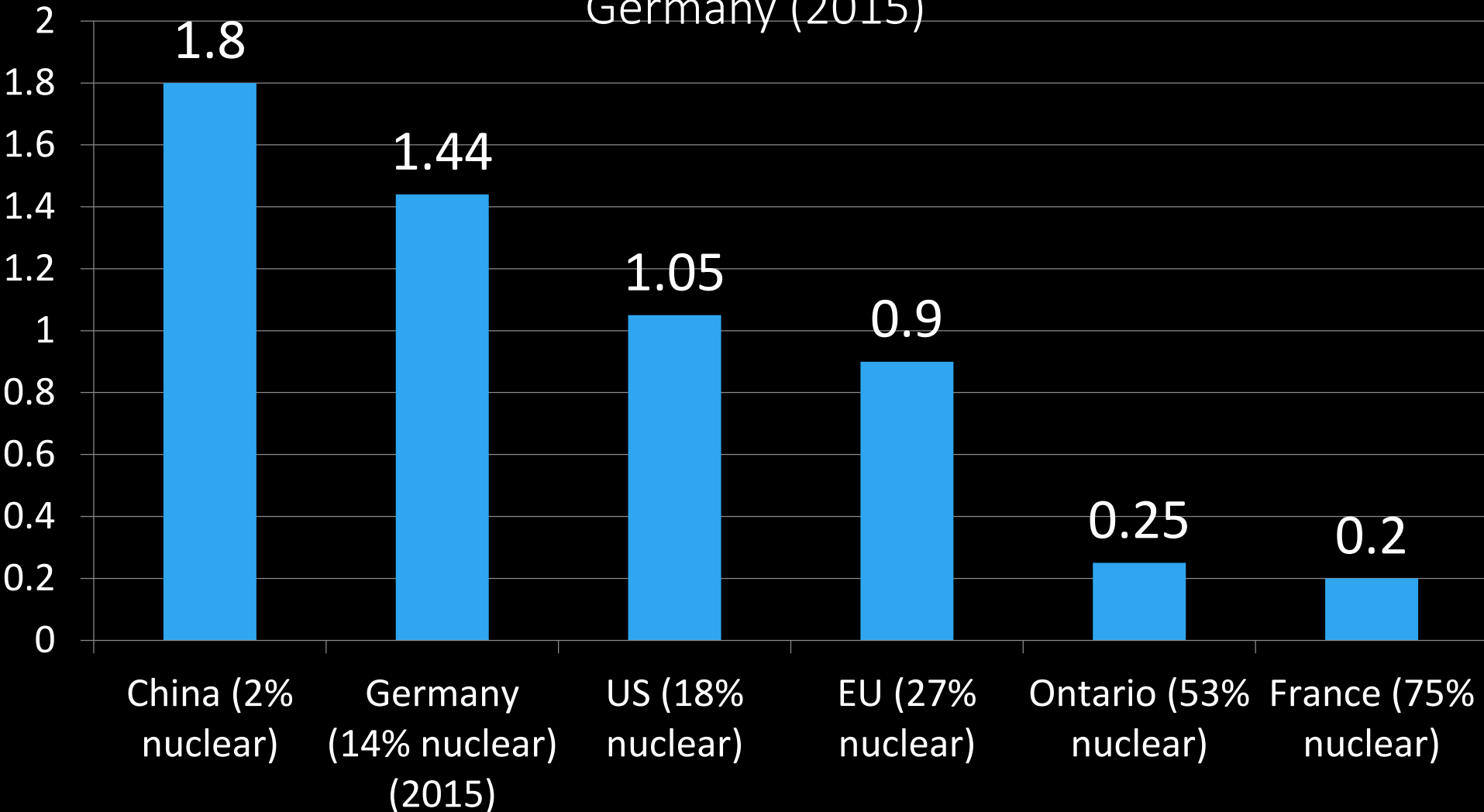
**HIGHER UTILIZATION AND RECYCLING OF  
FUEL, REDUCING PROLIFERATION RISK**

**REDUCE OR ELIMINATE COOLING WATER  
REQUIREMENTS**

**“BUILD - OWN - OPERATE - REMOVE”  
BUSINESS MODEL ALLOWS SAFER  
GLOBAL OPERATION**

# History: the most decarbonized grids are high nuclear

Carbon intensity of electricity (lbs CO2/kwh)- 2012 ex Germany (2015)



Source: IHS CERA; Germany 2015 data from German Environment Ministry and Agora EnergieWende

# DIABLO CANYON REPLACEMENT OPTIONS (MWH)

