# China's Civilian Reprocessing Programs

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# China's nuclear power plans

--by Feb 2016 , operating 30 reactors (28 GWe) +24 (27 GWe) reactor under construction.

--by 2020: operation 58 GWe +30 GWe under construction

--by 2030: 110-150 GWe

--by 2050: 240-400 GWe

**Main drivers**

-- air pollution,

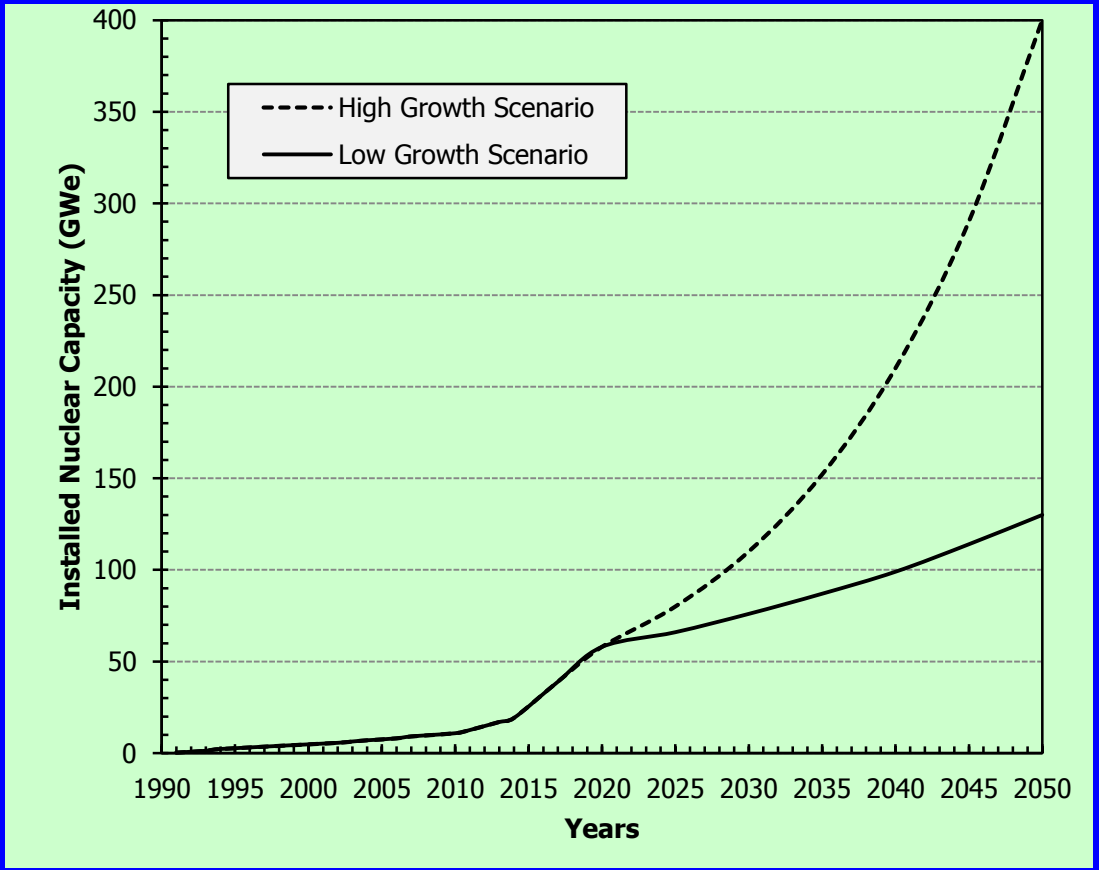
--climate change,

--energy security

# China's Growing Nuclear Power

- **High-growth scenario: 20 GWe (2014) – 58 GWe (2020)-- 400 GWe (2050)**
- **Low-growth scenario: 20 GWe (2014) – 58 GWe(2020)-- 130 GWe (2050)**

**Projected nuclear generation capacity (GWe) for two scenarios**



# China's plans on reprocessing

**In the mid 1980s, China selected a closed fuel cycle strategy to reprocess spent fuel and has recently speed up development of this strategy.**

## Motivations

**---Full use of uranium resources; Reducing cost of mining, milling and enrichment uranium**

**---Provide MOX fuel ; Development of FBR;**

**---Energy security concerns;**

**---Reduce the waste repository volume**

**---minimizing radioactive toxicity, disposal of radwast safely;**

**---Reducing the burden of spent fuel at reactor pools**

# The reprocessing pilot plant

--Capacity: 50 tHM/year; Jiuquan nuclear complex, Gansu;

--Project approved July 1986; construction commenced July 1997;

--Successful hot test Dec 21, 2010, operating about 10 days, producing 13.8kg Pu. Later: 25.4 kg

--problem: MUF ; high waste volume,

--Capital cost : about 3.2 billion RMB in 2014; several times more than earlier estimates.

--Long delay: from projected approval to hot test =14 year, then operating only 10 days.

--Resume operation recently

## 200 tHM/yr reprocessing plant

-- approval July 2015, site preparation
--operational 2020?

## 800 tHM/yr reprocessing plant

--Since 2007 negotiation with AREVA – disputes over price,

--Finished first stage ( technical) and second stage ( business) since 2015

-- CNNC plans to start construction 2020

# China's experimental fast reactor

--Construction started May 2000

--Completed in July 2010

--Design capacity: 25 MWe

--Operations:

- 1st criticality 7/2010, 40% power;
- 26 hours in 2011,
- no operation 2012 &13;
- 72 hours Dec. 2014 (100% power)
- since then for R&D

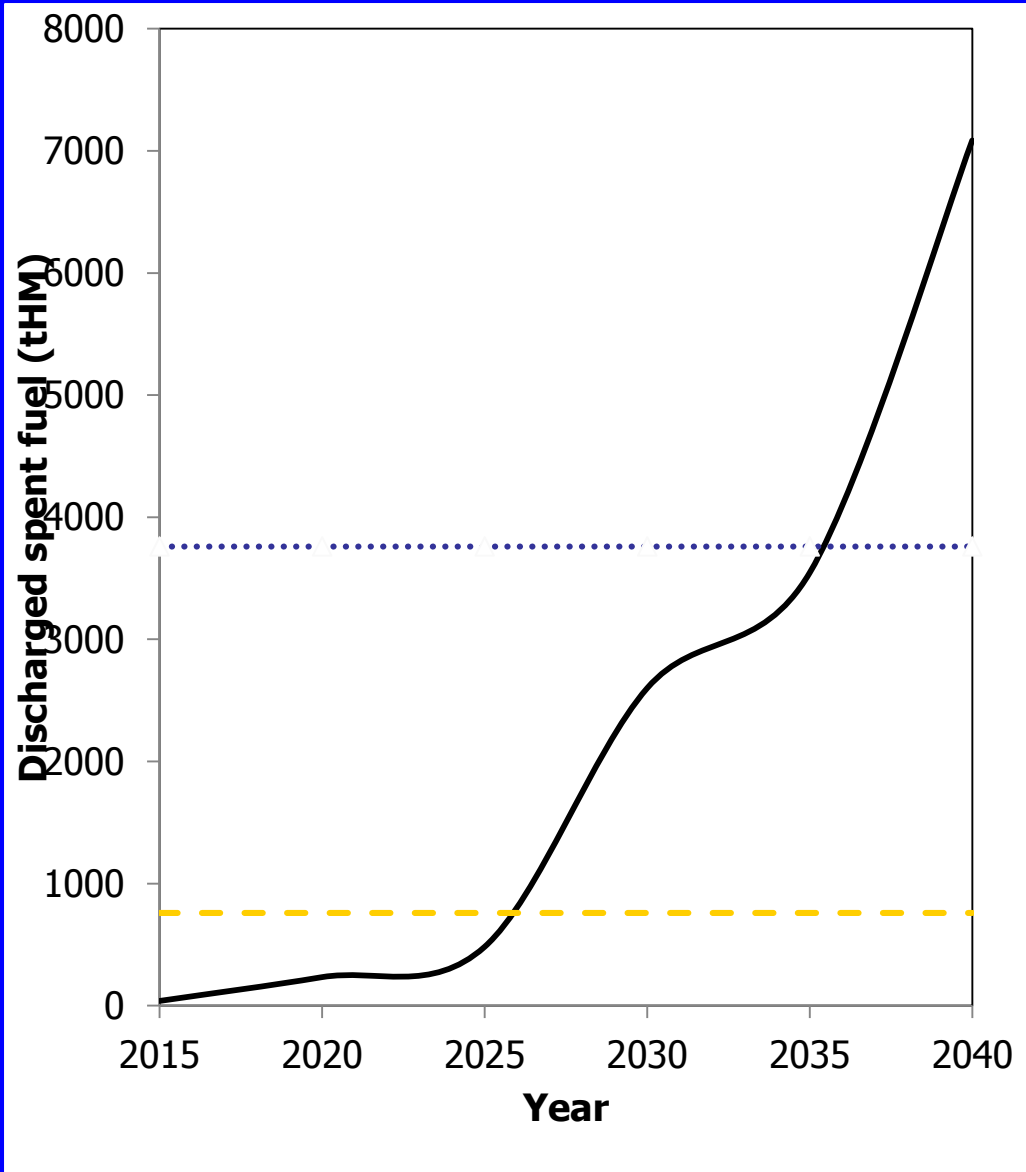
| | |
|---|---|
| Location | 35km from Beijng |
| Floor surface of building | 43731 $m^2$ |
| Main building size | 78m x 68m x 57m |
| Water supply | 4500 ton/day |
| Power supply | 3000 kw |
| Thermal power | 65 MW |
| Electric power | 20 MW |
| Plant life | 30 yrs |

# CIAE's Proposed China FBR Development Strategy

| | | Reactor type | Power (MWe) | Commissioning |
|---|---|---|---|---|
| Experimental Stage | | CEFR | 20 | 2010 |
| Demonstration Stage | Pre-2013 Plans | CDFR (e.g.BN-800)<br>CDFBR | 600～900<br>1000～1500 | 2018~2020<br>2028 |
| | Post-2013 Plans | CFR-600 (confirmed plan by CIAE )<br>BN-800? | 600<br>800 | 2023<br>? |
| Commercialize Stage | Pre-2013 Plans | CCFR<br>CCFBR | Nx800～900<br>1000～1500 | 2030<br>2030～2031 |
| | Post-2013 Plans | CFR-1000 | 1000 | 2034-2044? |

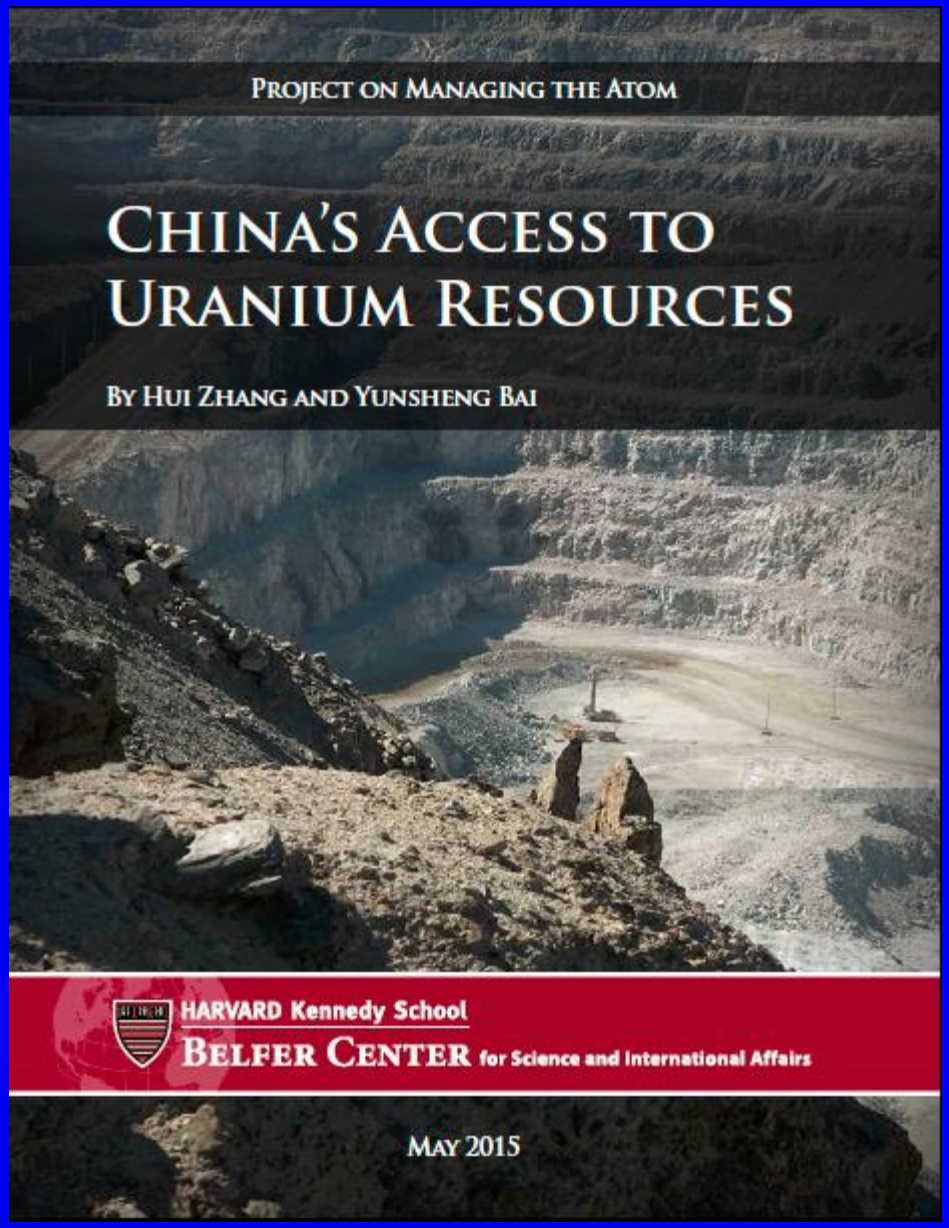
# Cumulative additional storage demand

| Offsite storage space (tons) | Estimate of when the storage will reach full capacity |
|---|---|
| 500 | 2017 |
| +760 | 2027 |
| +3000 | 2035 |

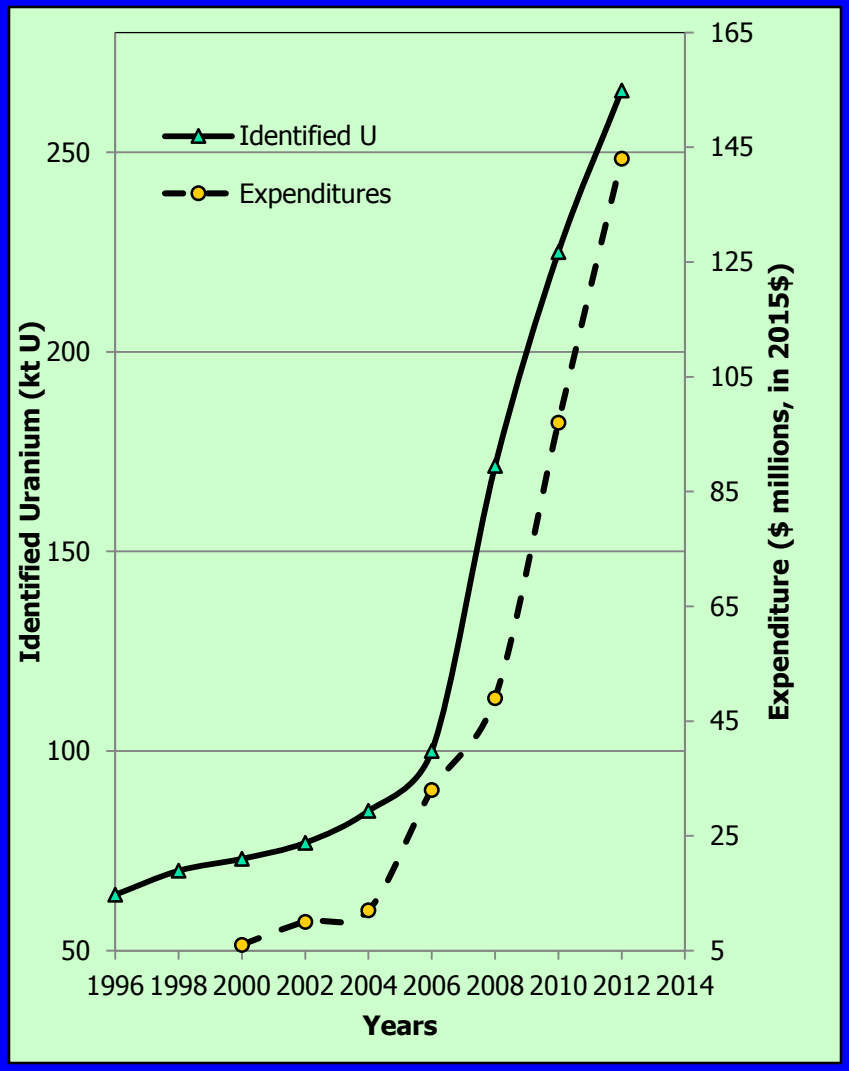


---One third policy : domestic uranium, international market, overseas mining

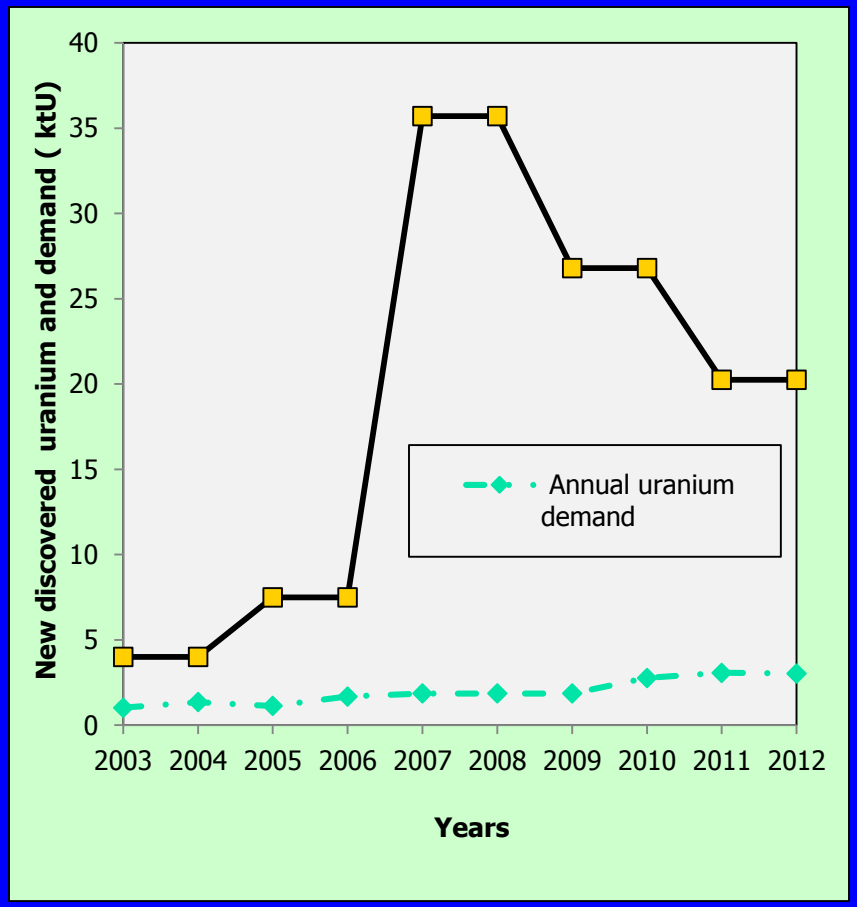
---uranium supply enough for 2050, even under the most ambitious scenarios.



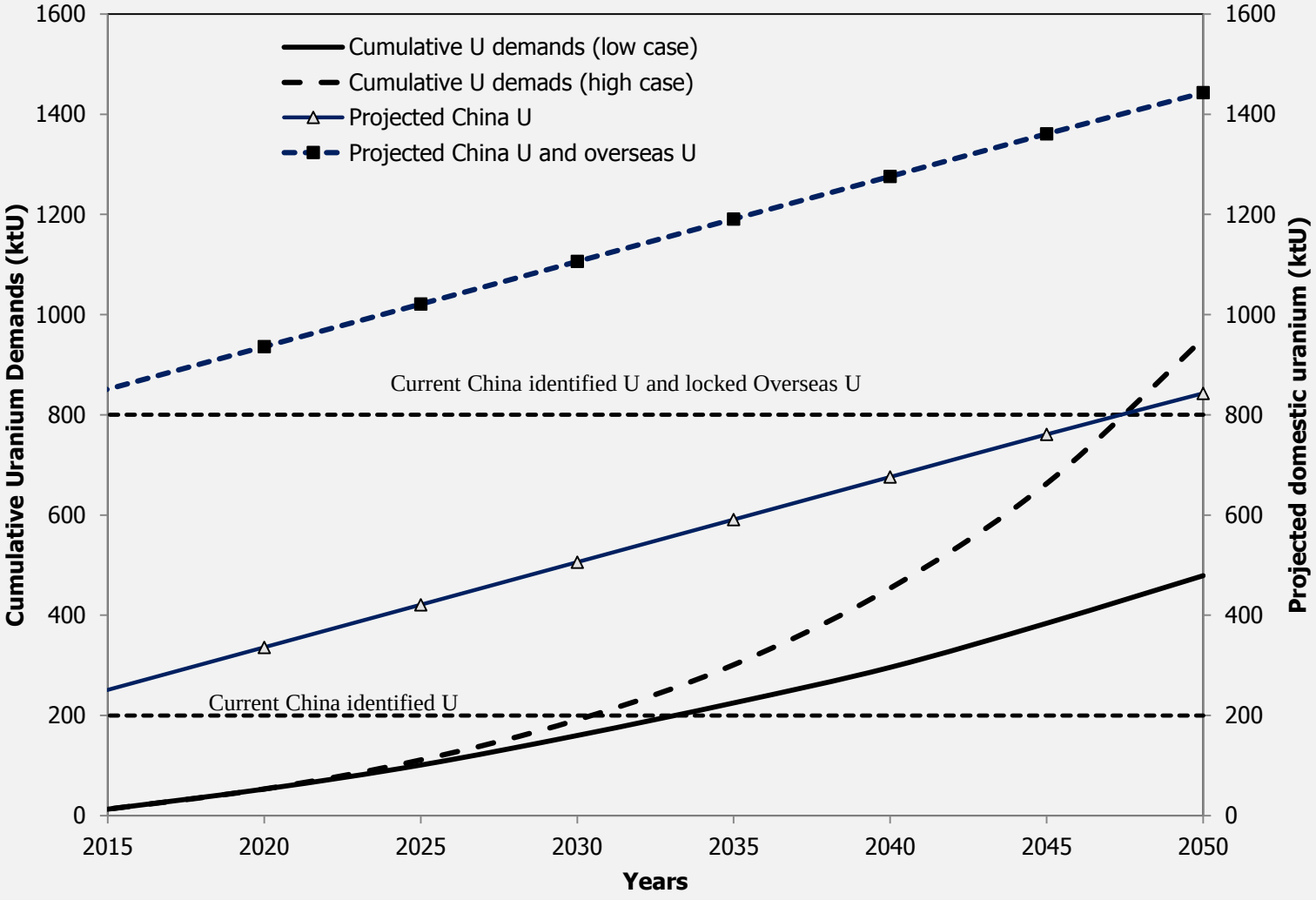
**China's identified uranium resources increased rapidly as exploration expenditures increased from 2004.**




**China's new discovered uranium resources per year and annual uranium demand**

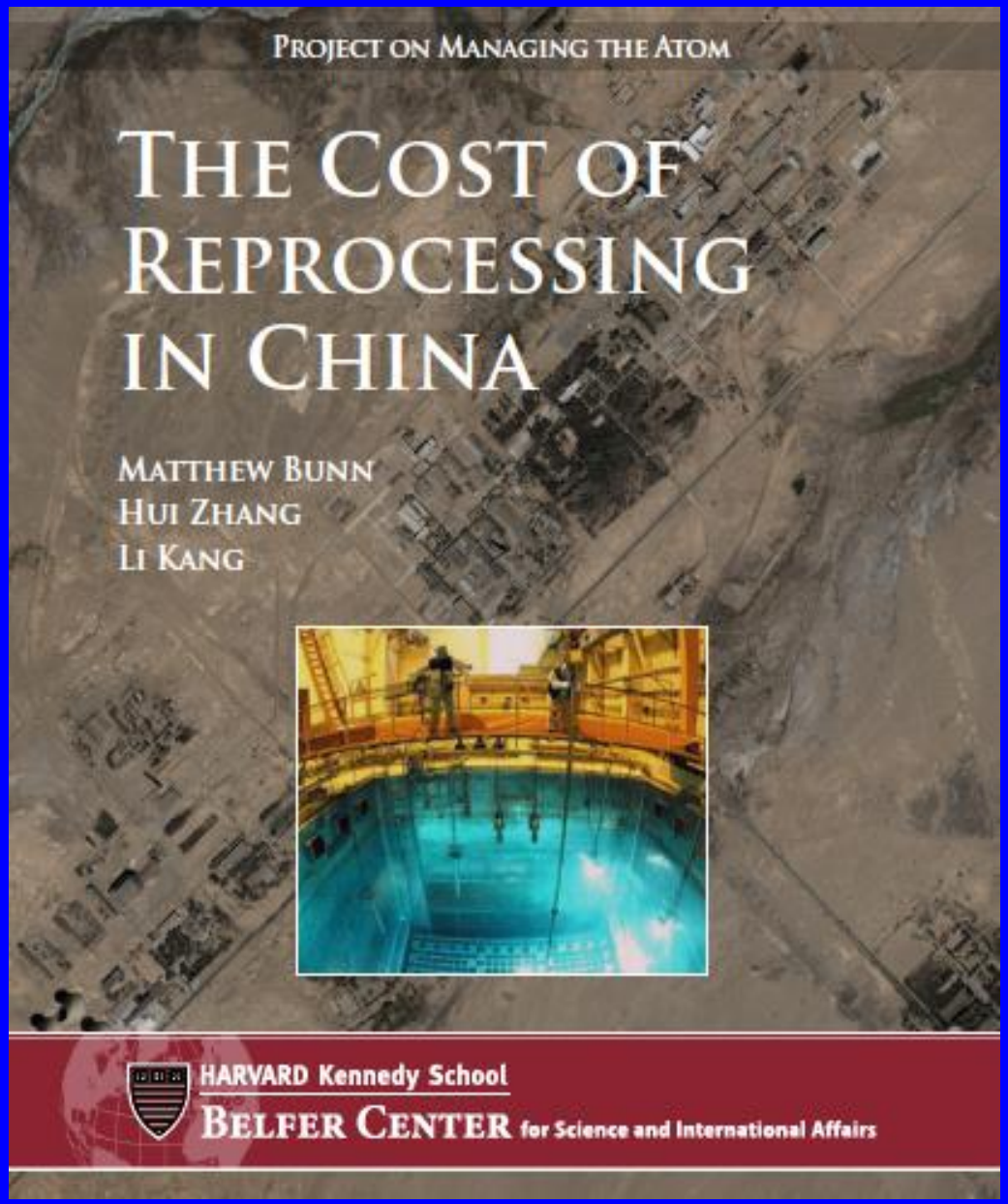


# China's projected cumulative uranium demand



---A new report on the cost of China's reprocessing 2016

---China could save many billions by storing spent fuel rather than reprocessing it




http://belfercenter.ksg.harvard.edu/publication/26158/

# Cost for reprocessing & dry cask storage: high and low estimates

| *Plant* | Capital cost | Operating cost | 40-year cost (no financing) | 40-year dry storage cost |
|---|---|---|---|---|
| 200 tHM/yr, Low | $3.20 B | $0.19 B | $10.80 B | $1.60 B |
| 200 tHM/yr, High | $5.70 B | $0.34 B | $19.30 B | $1.60 B |
| 800 tHM/yr, Low | $8.00 B | $0.48 B | $27.20 B | $6.40 B |
| 800 tHM/yr High | $20.00 B | $1.50 B | $80.00 B | $6.40 B |

Even without financing costs :

---Even low estimate for 800 tHM/yr plant operated at full capacity throughout 40-year life--save over $20B by dry casks for that period

-->$9B savings for low estimate of 200 tHM/yr plant

# Per-kilogram reprocessing costs: high and low estimates: 800 tHM/yr plant

| Plant | Capital Cost | IDC | Decom. | Capital+ IDC+ Decom. | FCR | Capital Charge/ kg | Operating (annual) | Operating (per kg) | Total cost/ kg |
|---|---|---|---|---|---|---|---|---|---|
| 800 tHM/yr Low 0% | $8B | 0 | .04 | $8.4B | 0.025 | $330 | $480 M | $750 | $1,100 |
| 800 tHM/yr Low 3% | $8B | 0.19 | .04 | $9.9B | 0.043 | $670 | $480 M | $750 | $1,400 |
| 800 tHM/yr Low 6% | $8B | 0.42 | .04 | $11.7B | 0.066 | $1,220 | $480 M | $750 | $2,000 |
| 800 tHM/yr High 0% | $20B | 0 | .04 | $20.8B | 0.025 | $810 | $1.5 B | $2,340 | $3,200 |
| 800 tHM/yr High 3% | $20B | 0.19 | .04 | $24.7B | 0.043 | $1,670 | $1.5 B | $2,340 | $4,000 |
| 800 tHM/yr High 6% | $20B | 0.42 | .04 | $29.3B | 0.066 | $3,040 | $1.5 B | $2,340 | $5,400 |

# Conclusions

- **Our new study shows that China's reprocessing and plutonium recycle is much more costly than LWR once-through cycle.**
- **Enough U for many decades, even under the most ambitious scenarios. To secure long-term uranium supplies for its fast-growing nuclear power industry, China should continue maintaining its one-third policy: domestic uranium, international market, overseas mining**
- **Should postpone the large reprocessing plant, and take an interim storage approach, which offers a safe, flexible ,and cost-effective near term approach to spent fuel management.**
- **The postponing approach will give China a substantial opportunity to carefully develop a long-term policy for the nuclear fuel cycle.**