THE OUTLOOK FOR UNCONVENTIONAL FUELS

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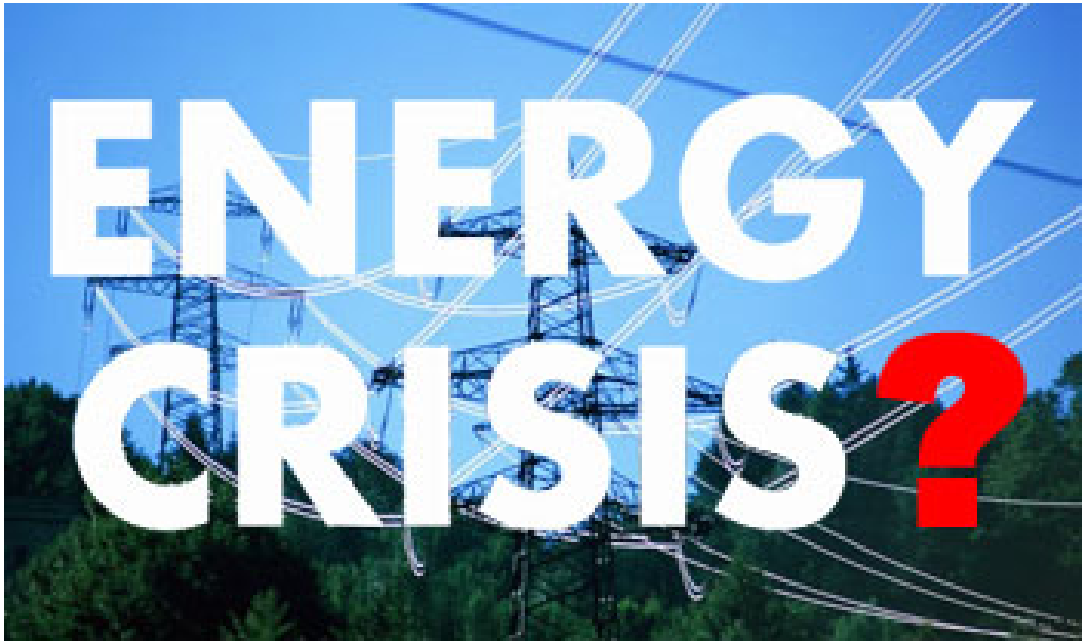
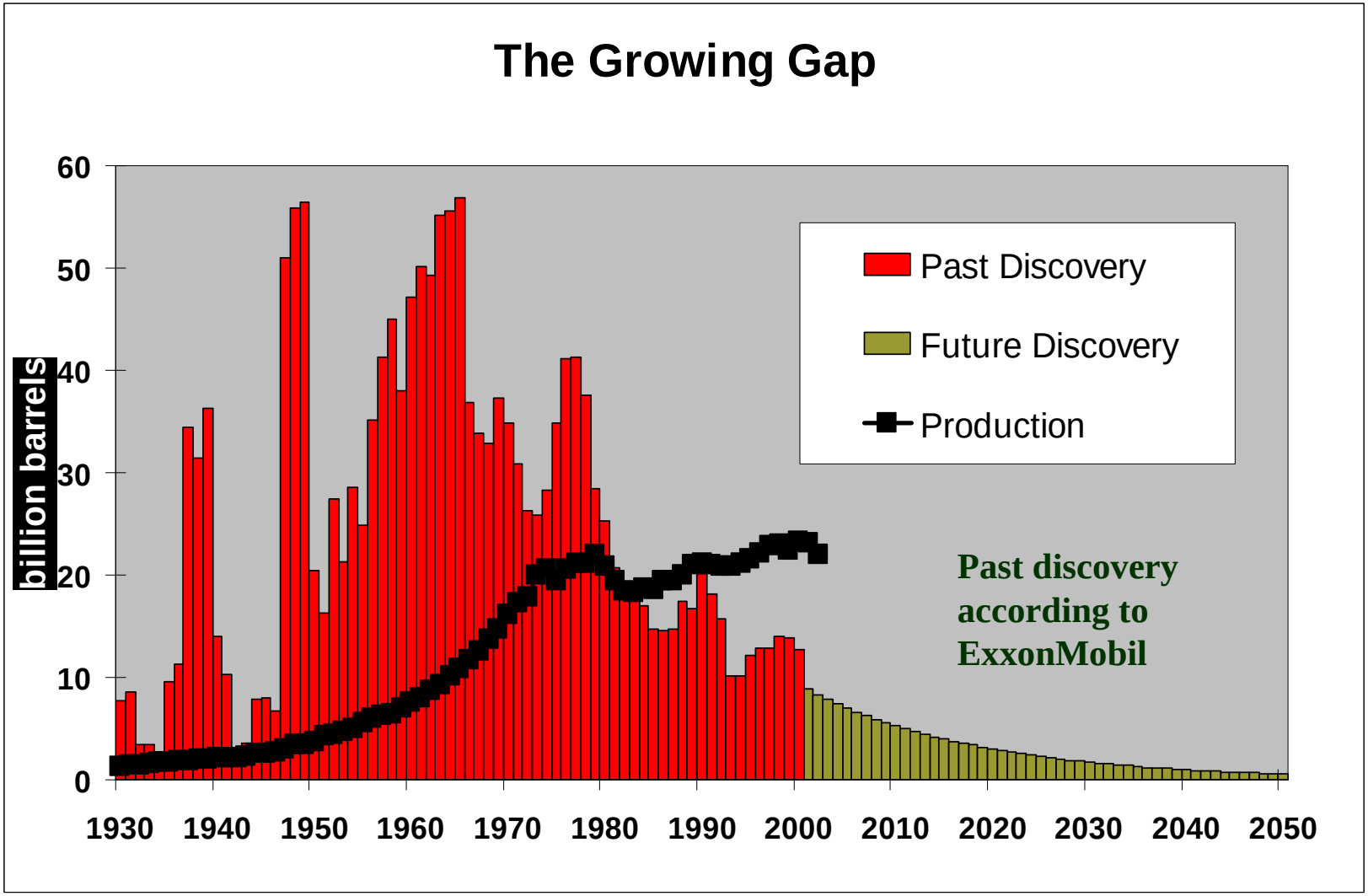


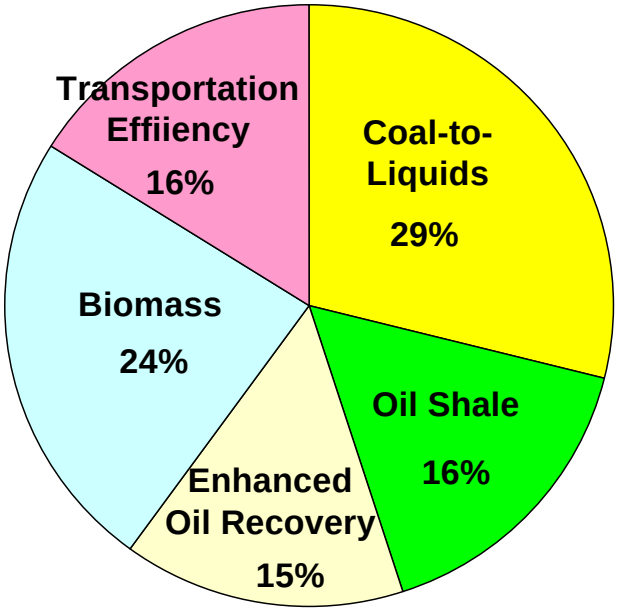
No, we're facing a liquid fuels crisis

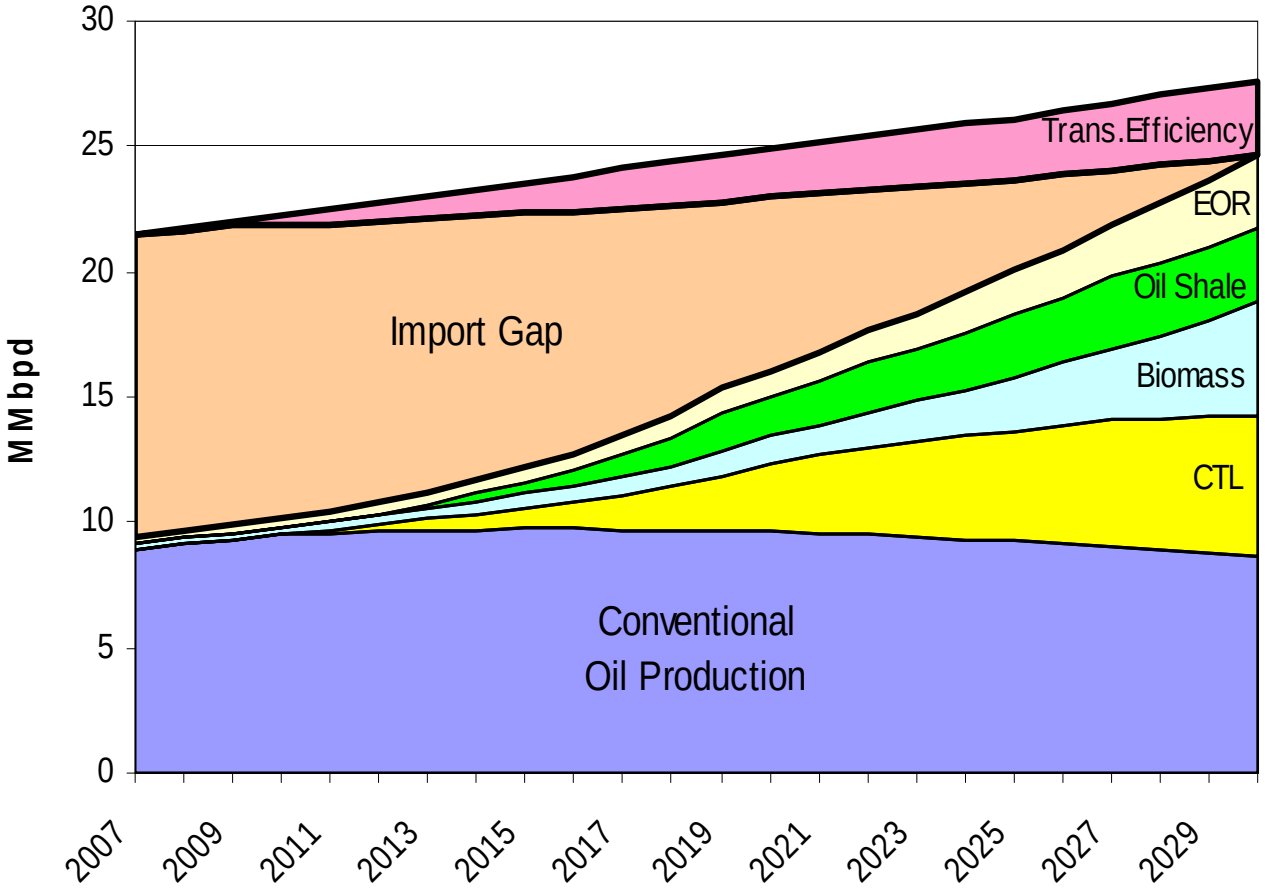
WORLD HAS BEEN CONSUMING MUCH MORE OIL THAN IT HAS BEEN FINDING



ARE UNCONVENTIONAL FUELS THE ANSWER?

Eliminating U.S. oil imports by 2030 – Southern States Energy Board, 2006

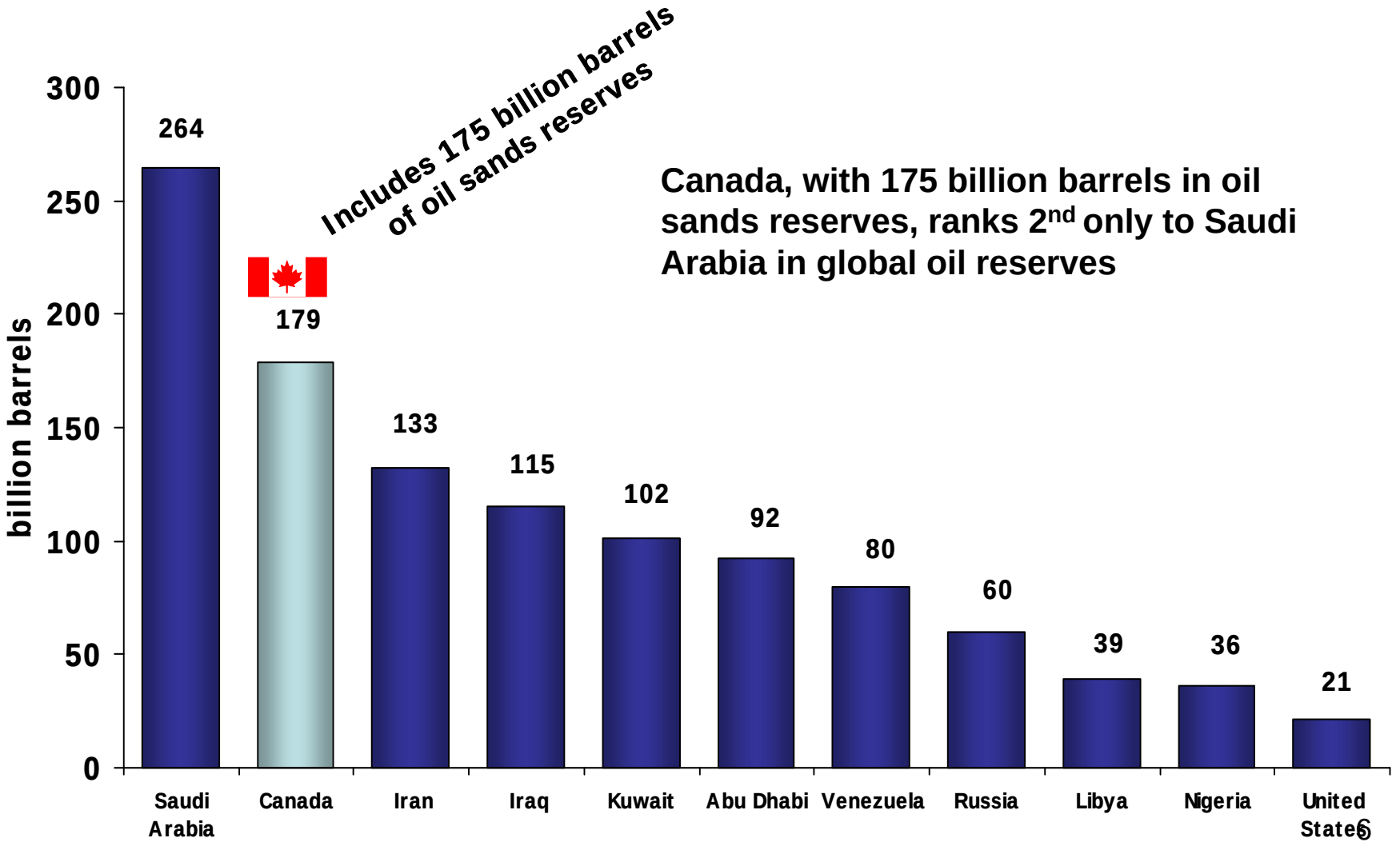




OIL SANDS

- Immense resource
- No exploration costs
- No decline curve
- Capital access
- Politically stable
- 40 yrs. development
- Challenges
  - -- Capital costs
  - -- Labor
  - -- Natural gas
  - -- Water
  - -- Climate
  - -- Environmental

GLOBAL CRUDE OIL RESERVES BY COUNTRY

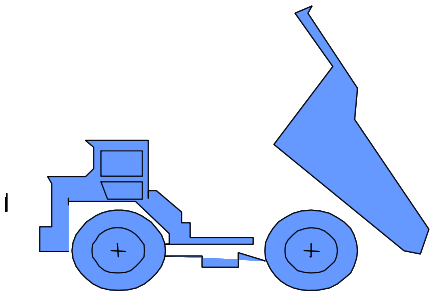


Canada, with 175 billion barrels in oil sands reserves, ranks 2nd only to Saudi Arabia in global oil reserves

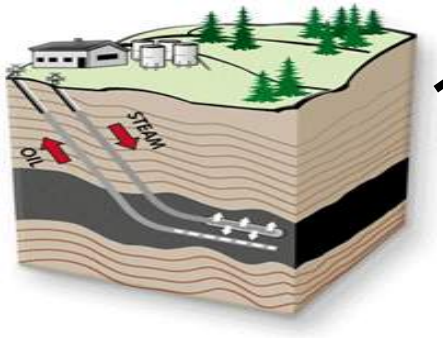
Source: Oil & Gas Journal Dec. 2005

TWO EXTRACTION METHODS: MINING & IN-SITU

Extraction **Upgrading** **Refining**



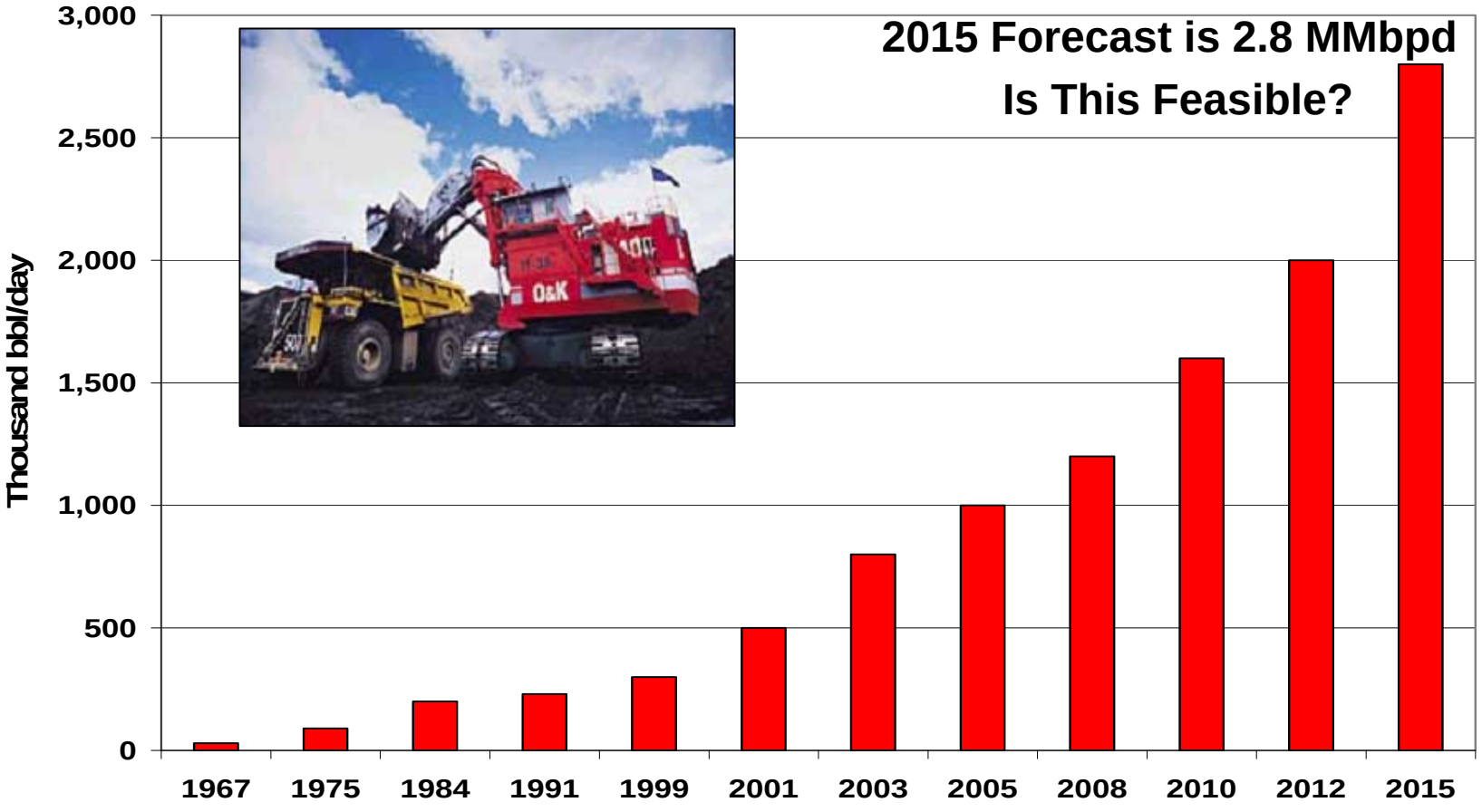
Mineable



In-Situ

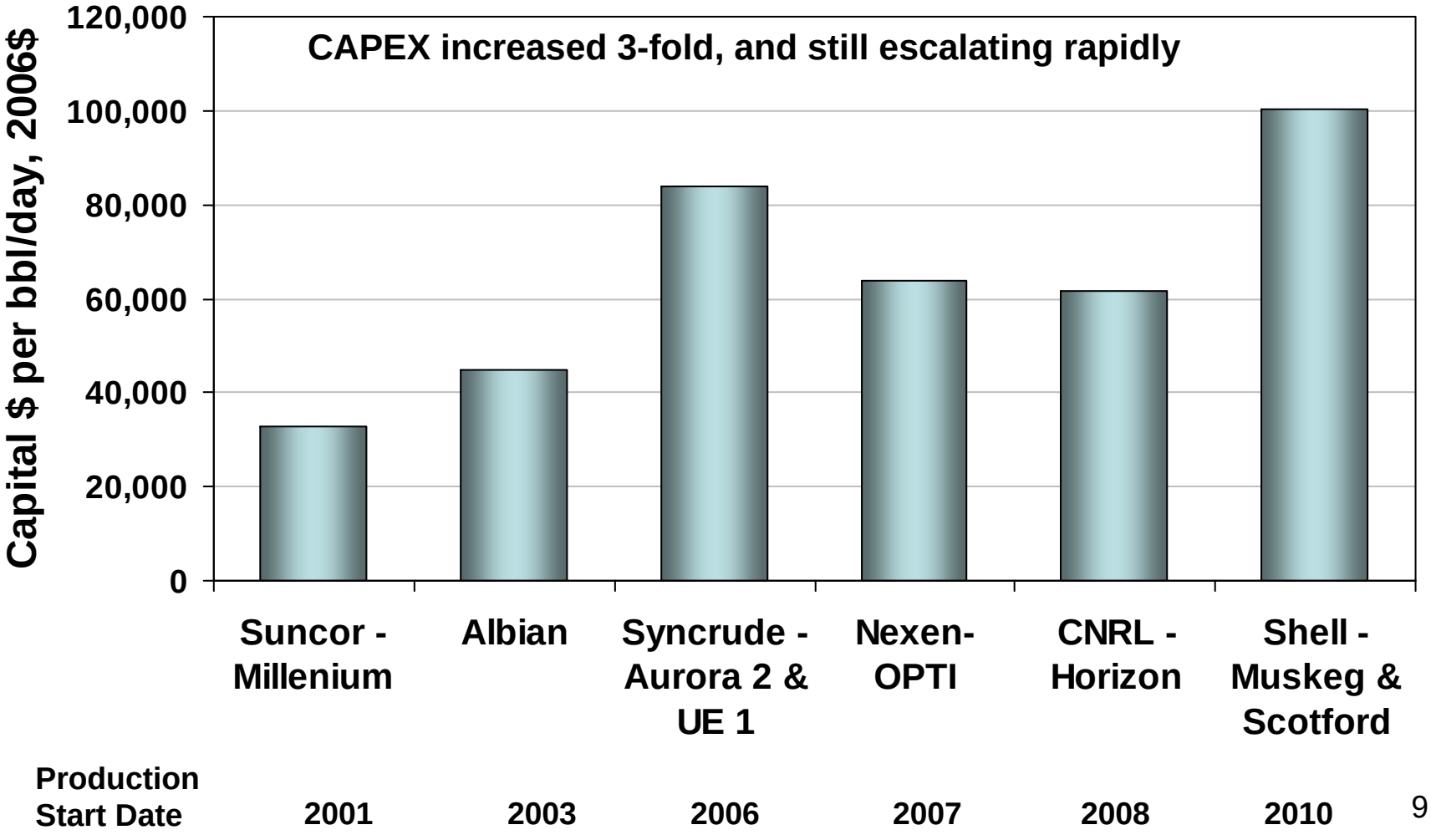
OIL SANDS CURRENTLY PRODUCING 1.1 MMBPD

But it Has Taken 40 Years to Reach This Level!



OIL SANDS CAPITAL COSTS INCREASES

But Cost Increases are Global for all Energy



LIQUID FUELS FROM COAL

U.S. Could Be the New Middle East

1.55 Trillion Barrels of Coal Synfuel

Old Middle East

Saudi Arabia:	261.8 Billion Barrels
Iraq:	112.5 Billion Barrels
UAE:	97.8 Billion Barrels
Kuwait:	96.5 Billion Barrels
Iran:	89.7 Billion Barrels
Qatar:	15.2 Billion Barrels
Oman:	5.5 Billion Barrels
Yemen:	4.0 Billion Barrels
Syria:	2.5 Billion Barrels

TOTAL 686 Billion Barrels

U.S. Domestic Coal

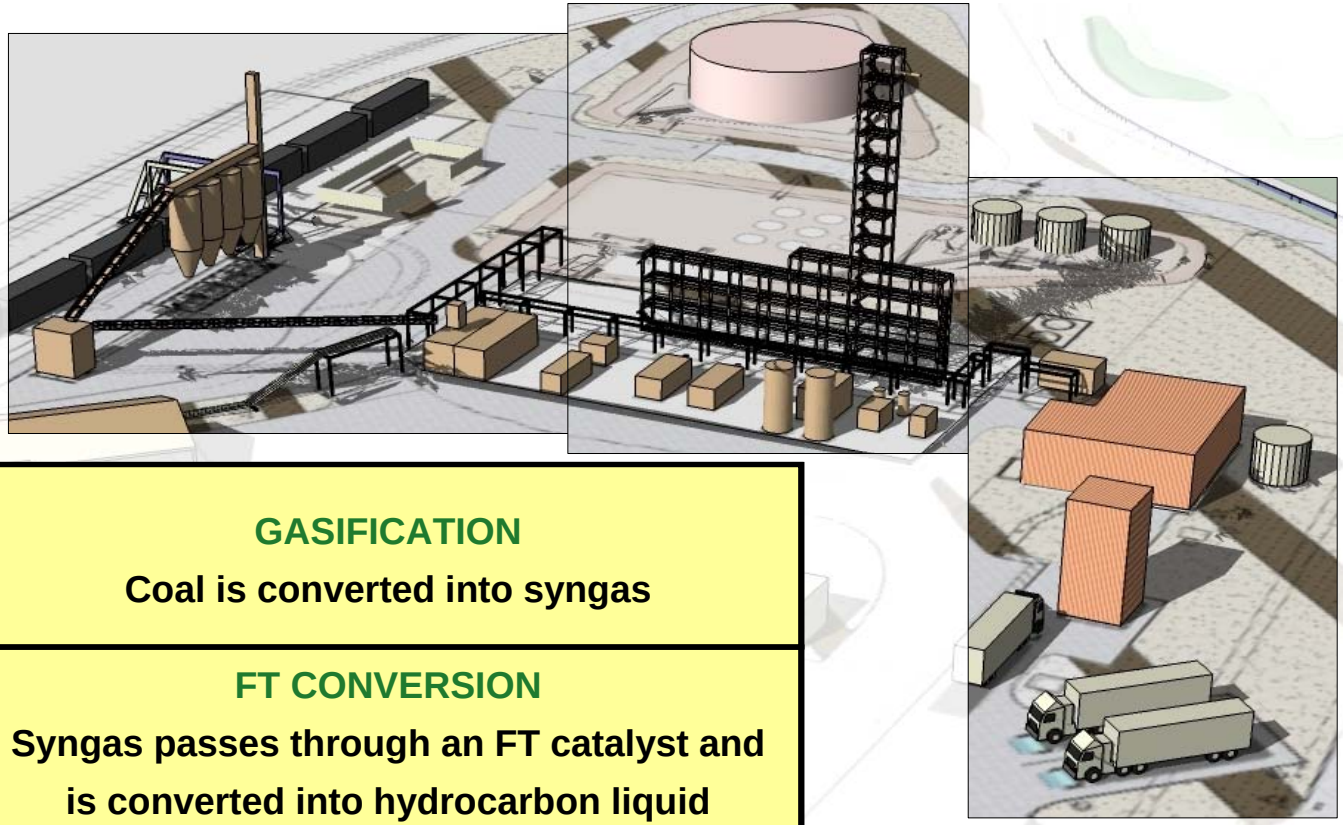
(oil equivalent)

Recoverable reserves	0.55 T Bbls
Demonstrated reserve base	1.0 T Bbls

TOTAL 1.55 T Bbls Equivalent

COAL-TO-LIQUIDS TECHNOLOGY

A Proven Technology Currently in Use World-Wide



1	**GASIFICATION** Coal is converted into syngas
2	**FT CONVERSION** Syngas passes through an FT catalyst and is converted into hydrocarbon liquid
3	**UPGRADE** The FT liquid produced is upgraded into ultra clean synthetic fuels

ESTIMATES OF U.S. CTL POTENTIAL

Bottom Line*: *All studies indicate huge potential for CTL

BARRIERS TO CTL

- Technical: Integrated operations of advanced CTL technologies
- Economic:
  - Uncertainties about future WOP
  - High capital and operations costs
  - Investment risks
  - Competition for equipment and engineering skills
- Environmental:
  - CO_2 and criteria pollutants emissions
  - Expansion of coal production
  - Water requirements
- Social: NIMBY & public resistance to coal use

HYPOTHETICAL CTL PLANT EXAMPLE
(26,000 barrels/day)

Expenditures:

- Capital (plant): $3.2 billion
- O&M: $114 million/yr
- CO_2 sequestration: @$15/ton CO_2, $98 million/yr

Revenues/Returns:

- Net revenues: $700 million/yr
- Return on investment (ROI): 16%

Bottom Line:

- Net cash-flow is positive by year 7 of project
- Plant is profitable during year 13 of project
- CTL plant competes with oil at $61/bbl

OIL SHALE BASICS

- Hydrocarbon bearing rock
- Enormous resource: 2.6 trillion BOE; about = world oil reserves
- Advantages:
  - -- 2 trillion+ in U.S.; most in CO, UT, WY
  - -- Well specified
  - -- Extensive RD&D conducted
- Issues:
  - -- Huge CAPEX
  - -- Never been commercialized
  - -- Requires huge energy input
  - -- Environmental problems: water, waste, CO_2, etc.
  - -- Infrastructure: roads, facilities, labor, etc.

EASTERN & WESTERN OIL SHALE RESERVES

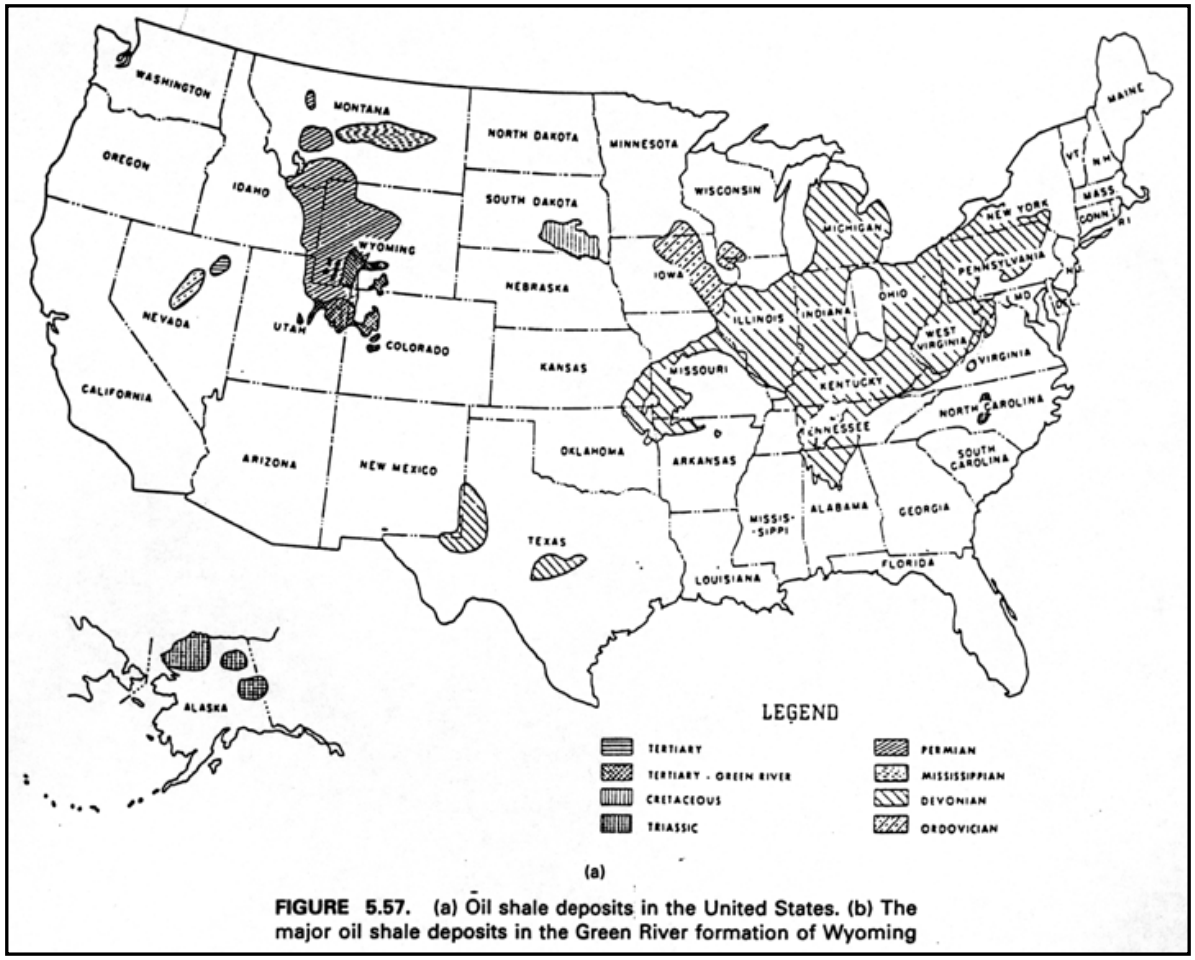


FIGURE 5.57. (a) Oil shale deposits in the United States. (b) The major oil shale deposits in the Green River formation of Wyoming

U.S. Geological Survey's Reserve Estimate: *2.1 Trillion Barrels*

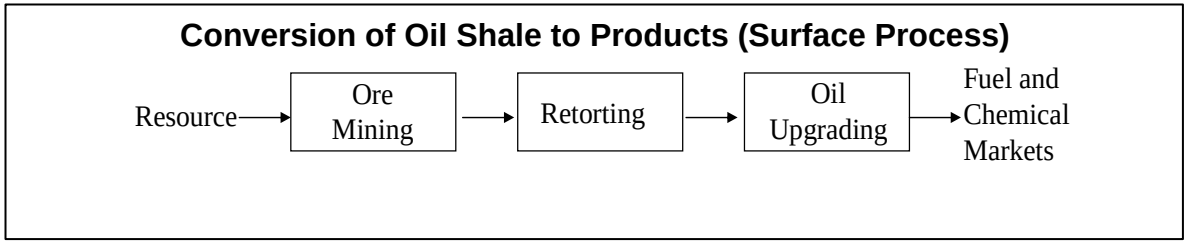
OIL SHALE TECHNOLOGIES

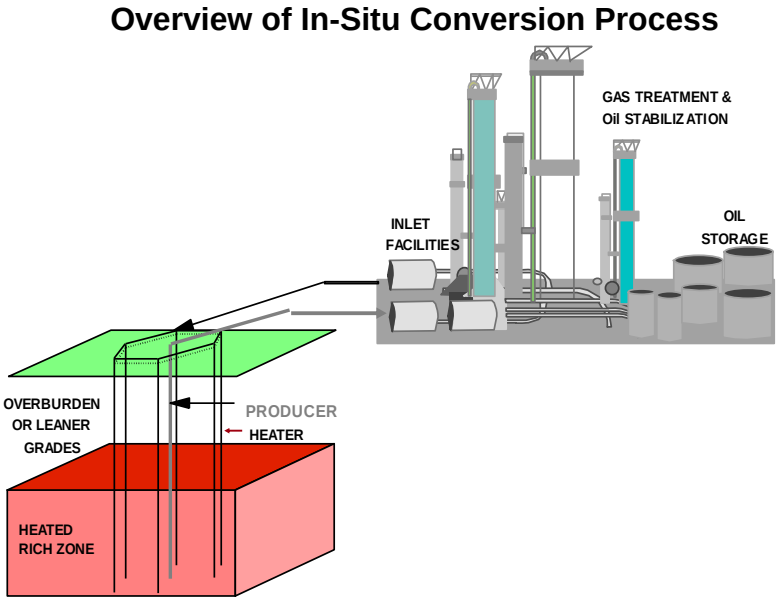
Two basic processes:

- Mining followed by surface retorting
- In-situ retorting

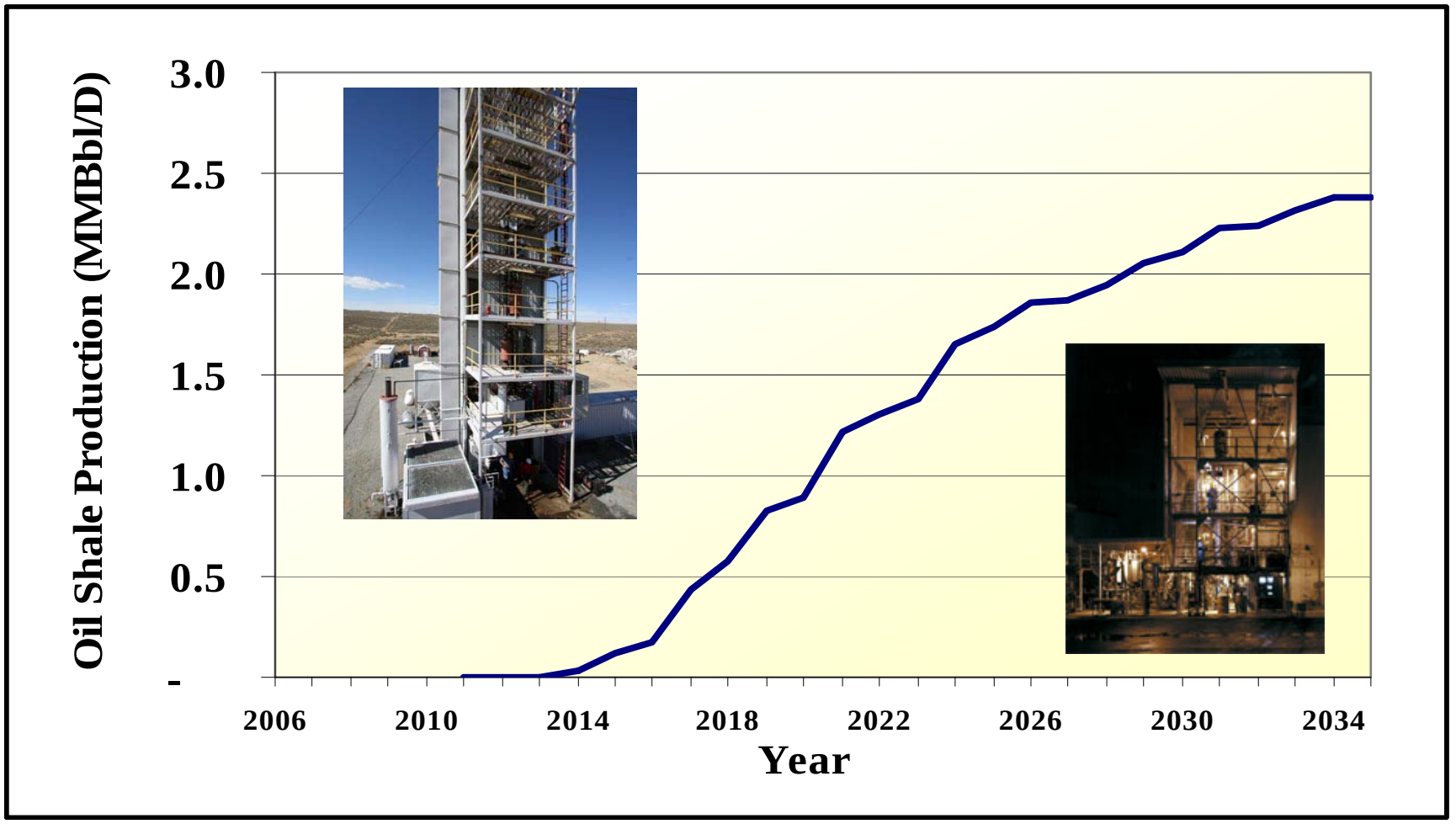
Shell modified in-situ process (ICP) most viable

However, energy input is enormous: e.g., 250K bpd would require all Colorado electricity

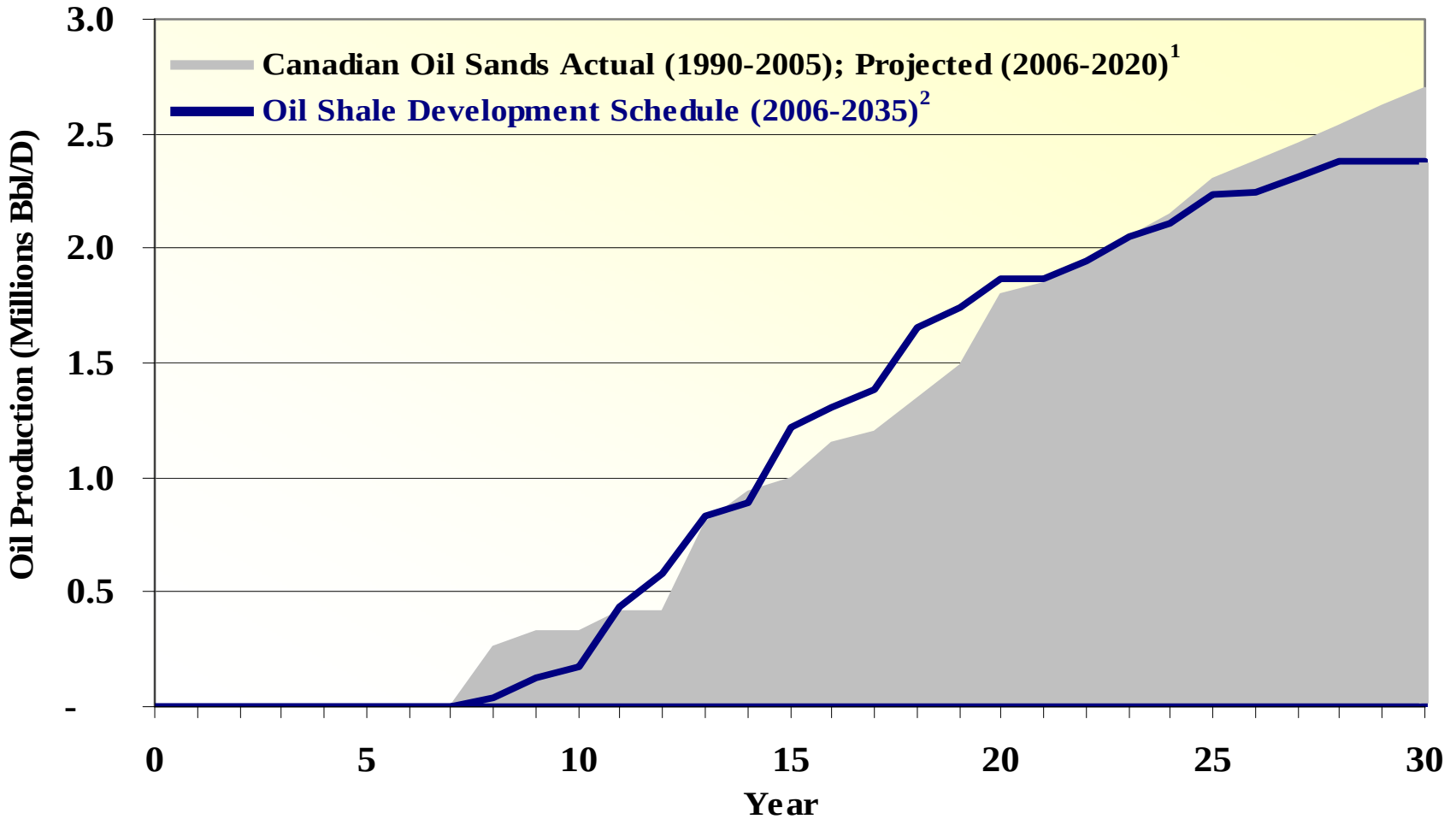




POTENTIAL OIL SHALE PRODUCTION
(Estimated by DOE Unconventional Fuels Task Force)



PRODUCTION SCHEDULE IS REALISTIC



1) Canadian Oil Sands Production Source: Energy Information Administration, IEO (2006)
2) U.S. Oil Shale Development Schedule: Oil Shale Working Group (2006)

ECONOMICS AND COSTS

DOE estimated following costs (100,000 bpd facility):

- -- In situ: $3.4 billion
- -- Retort surface: $4.4 billion
- -- Retort underground: $4.7 billion
- -- Annual O&M costs range $0.6 – $0.8 billion

But these have likely escalated significantly in recent years – perhaps by a factor of 2 or more

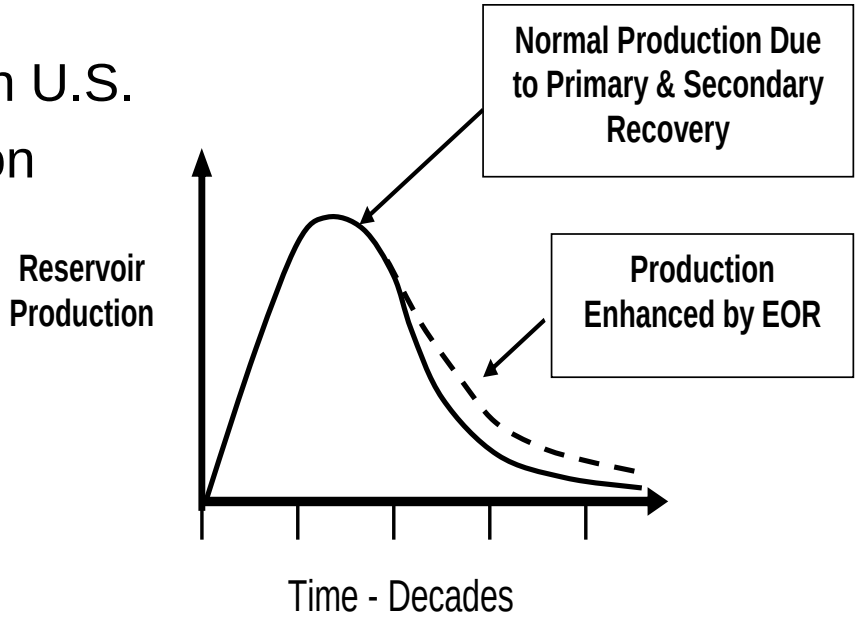
Further, RAND estimates costs to be much higher (double or more) and that oil shale requires oil prices of $70 - $95/bbl

Shell delaying its ICP commercialization

Bottom line: Economics highly uncertain, and first commercial plant unlikely for another decade

ENHANCED OIL RECOVERY

- 80+ billion barrels of “stranded” oil in U.S.
  – oil left after conventional extraction
- EOR is initiated after primary and secondary recovery
- Employed since 1950s
- Most produced via CO_2 injection
- Expensive; currently limited by available CO_2 and pipelines

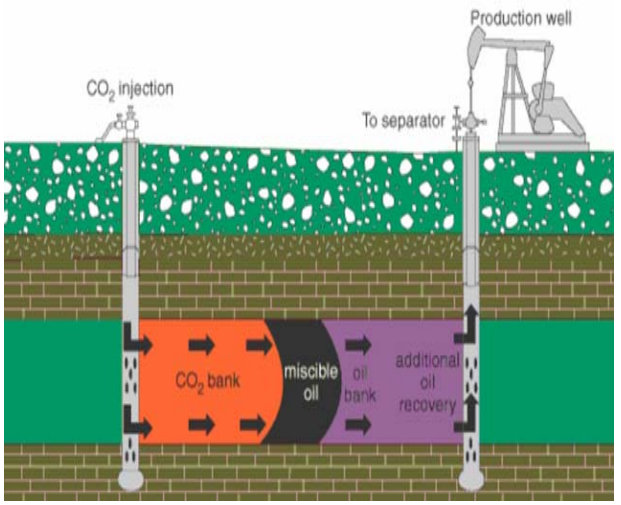


- **Major opportunity: A win-win** – produce more U.S. oil and sequester CO_2

EOR OPERATION AND GEOGRAPHY

Existing U.S. CO_2 Sources and Pipelines

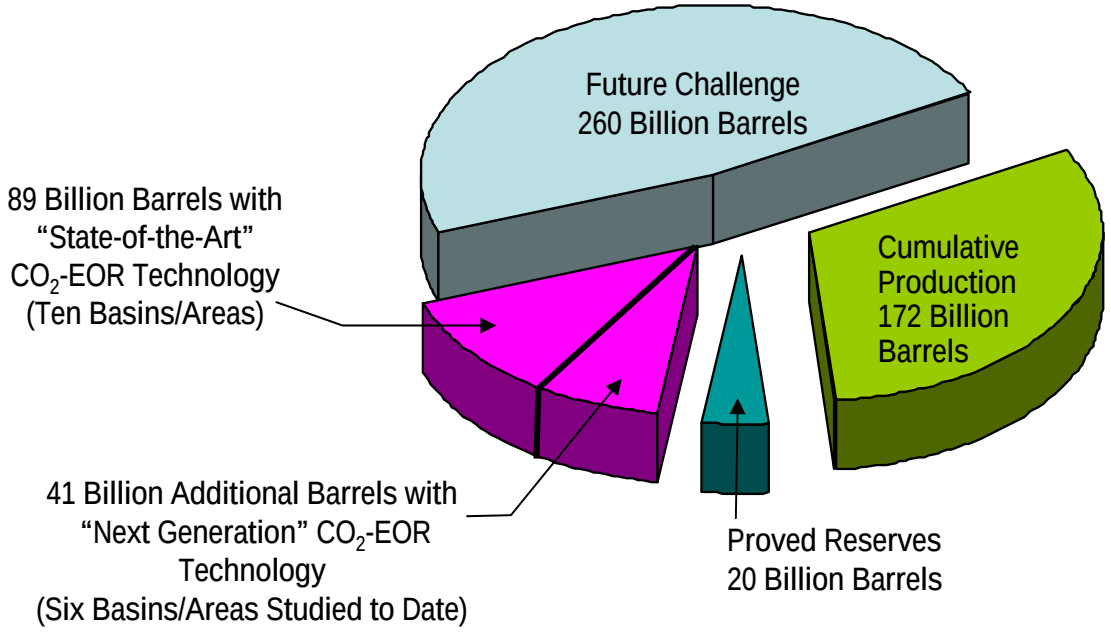
CO_2 EOR Operation



EOR POTENTIAL

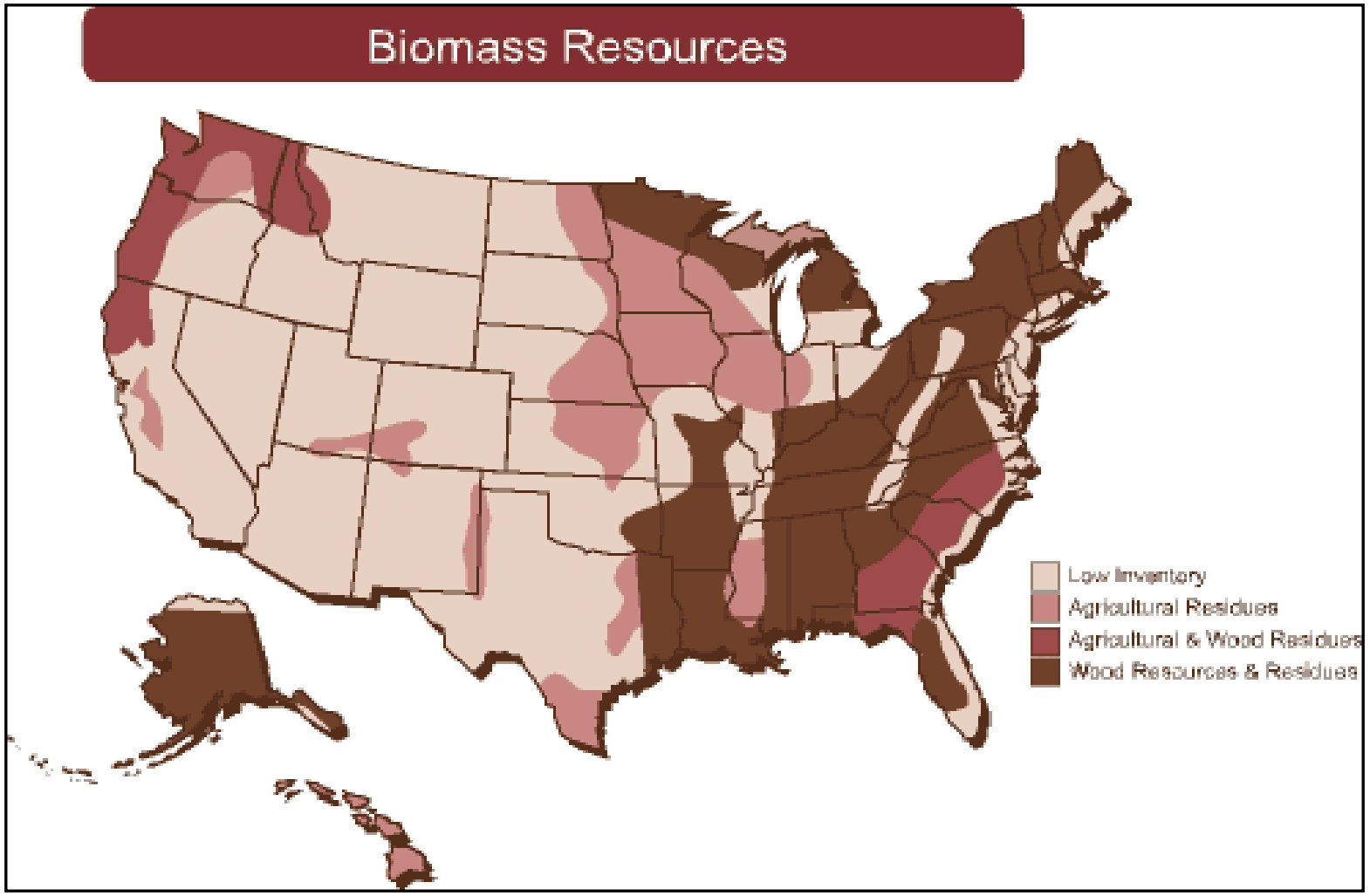
Original Oil In-Place: 582B Barrels

Oil left: 390B Barrels

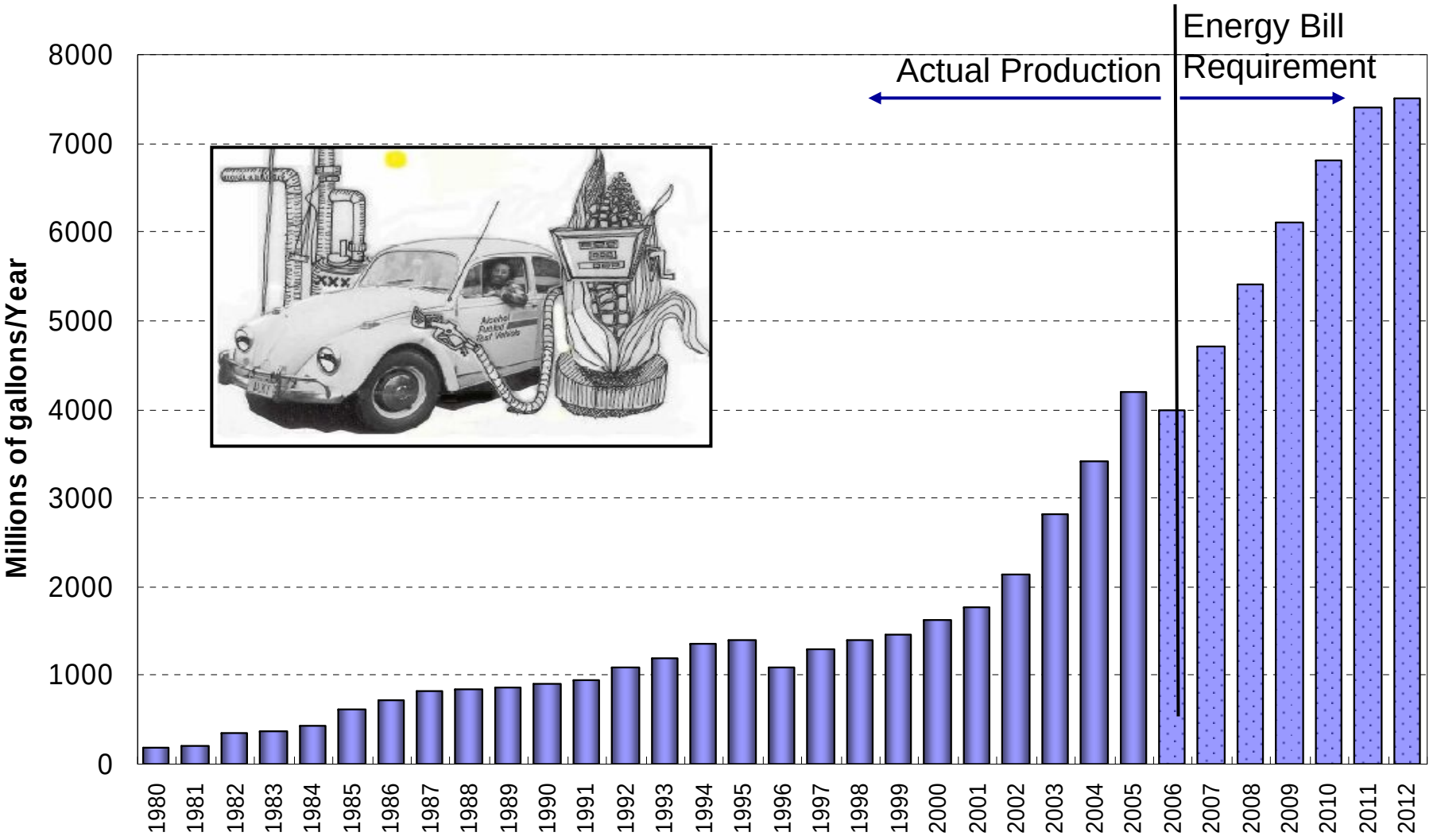


- 200K+ bpd currently produced in U.S.
- Most produced by small independent companies – not the "Exxons"
- New technology can significantly increase CO_2-EOR potential

BIOMASS RESOURCE POTENTIAL OF 500+ MILLION DRY TONS PER YEAR



U.S. ETHANOL PRODUCTION IS FORECAST (MANDATED) TO INCREASE SIGNIFICANTLY



OF U.S. RENEWABLES ONLY CELLULOSIC BIOFUELS MIGHT HELP

- Potential of corn-based ethanol is not energy efficient & created the food versus fuel problem
- Cellulosic ethanol is more complex, difficult, & expensive than corn-based ethanol
- Industrial cellulosic ethanol technology does not exist.
- **BEWARE PROMISES VS REALITY -- REMEMBER CORN ETHANOL**

CTL PLANT BENEFITS TO A STATE

- Volumes oil displacement
- Opportunity for guaranteed supplies in times of shortages
- Industry sales and profits
- Total (direct and indirect) employment created
- Specific jobs created by occupation & skill
- **Good jobs that cannot be re-located or off-shored**
- Tax revenues for state and local governments
- Technology development and spin-offs
- Revitalization of depressed regions

Most States View CTL Plants as Economic Development and Job Creation Projects: It is All About "JOBS, JOBS, JOBS"

STATE AND LOCAL IMPACT
(Example – 30,000 bpd Plant)

Development and Construction:

- **Direct jobs: 2,000 total**
- Payroll: $100 million/yr

Operations & Maintenance:

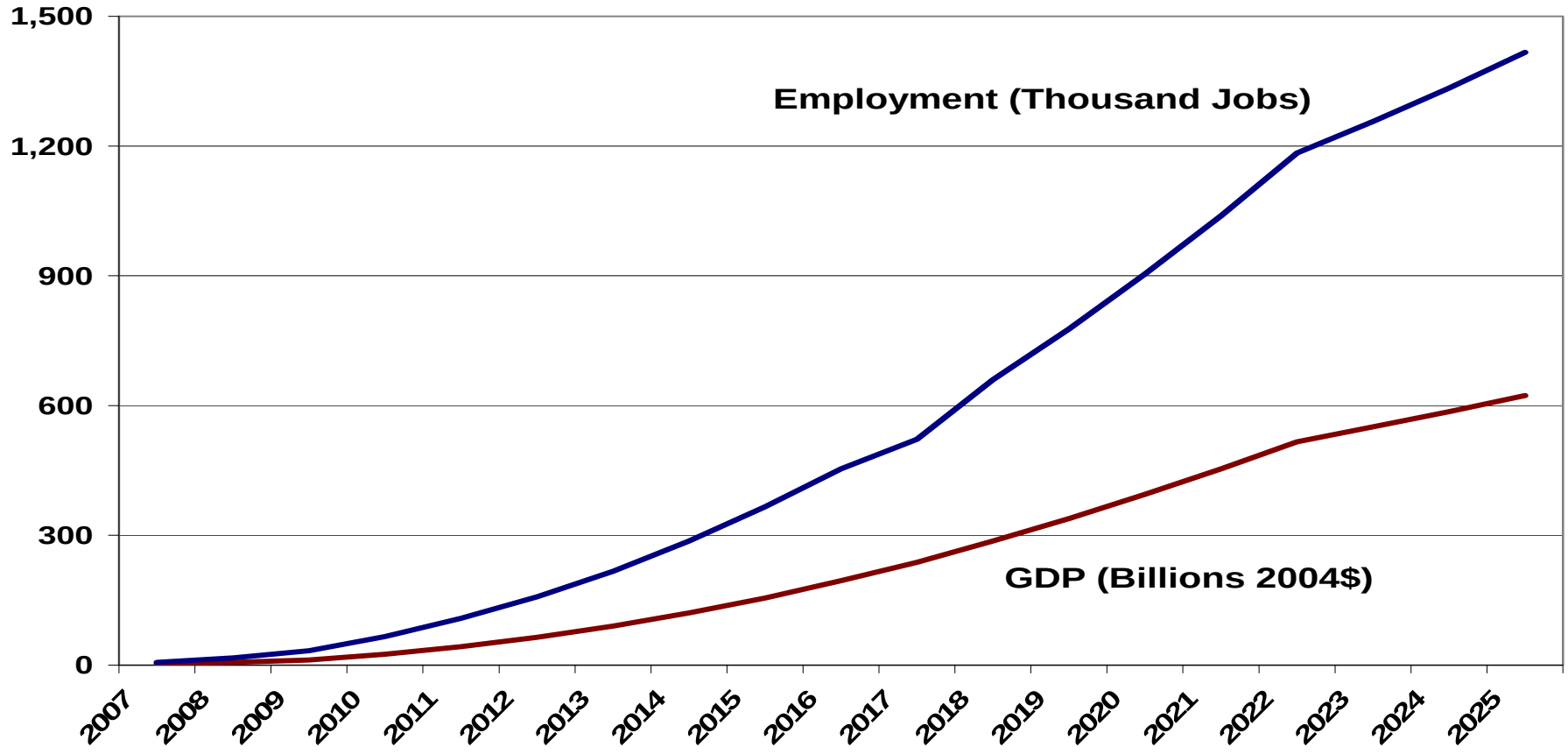
- Direct jobs: 350
- Payroll: $25 million/yr.
- Expenditure, job and payroll multiplier: 1.8 to 2.2
- **Total (direct plus indirect) annual jobs: ~ 700**

State and Local Government Tax Revenues: $10 million/yr.

NATIONAL IMPACT

(20 Year CTL Development Program)

By 2025, U.S. GDP increases >$600 billion and 1.4 million jobs are created

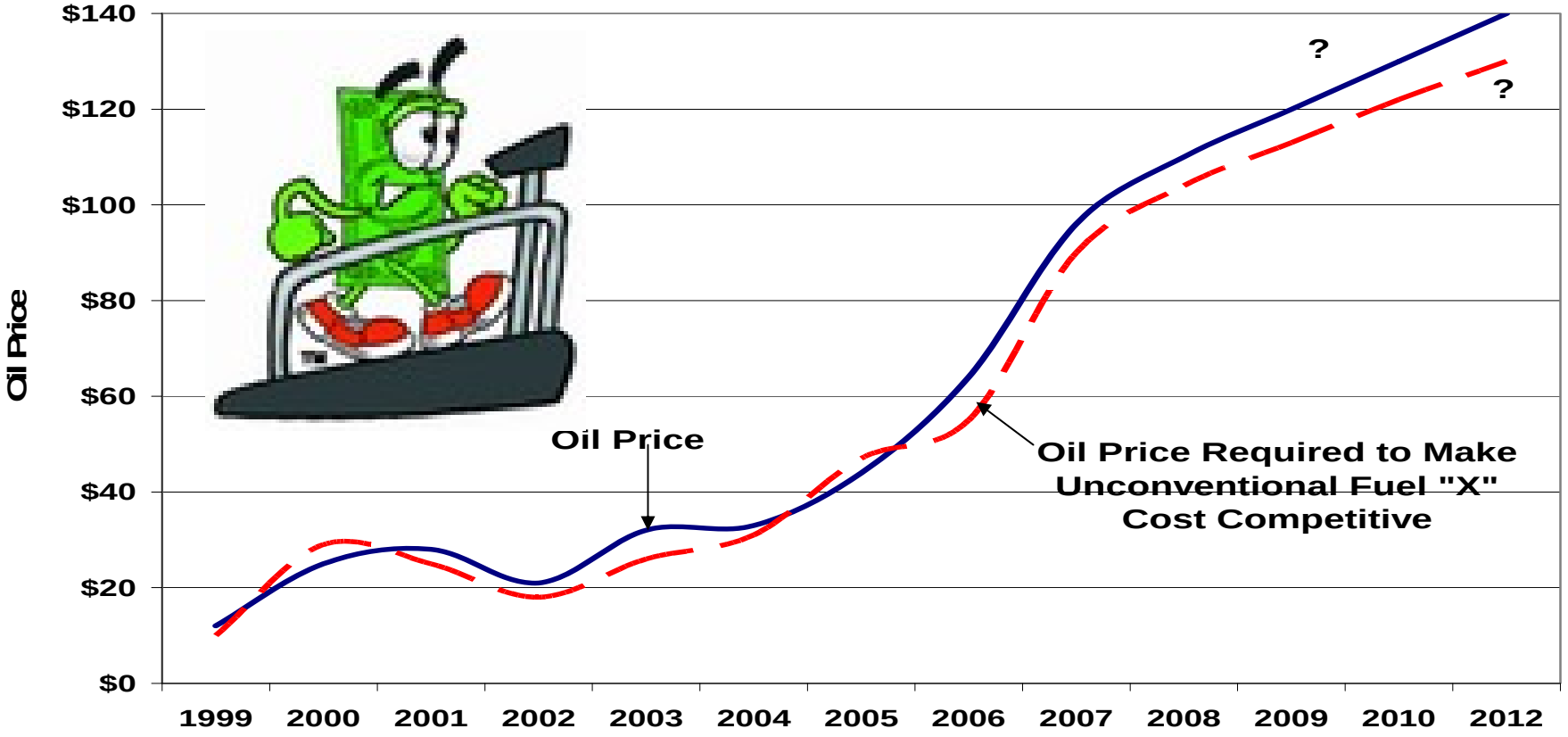


Source: Pennsylvania State University, “Economic Benefits of Coal Conversion Investments,” 2006.

ENERGY COST TREADMILL

"Unconventional fuels will become competitive as oil prices increase"

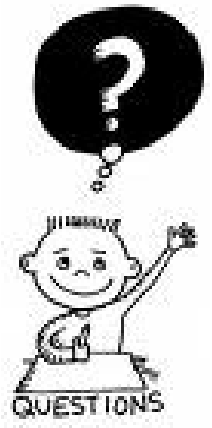
However, as oil prices have increased rapidly, so also have costs of unconventional fuels. Therefore, **price of oil required to make these fuels competitive keeps increasing**. Notationally:



ENERGY COST DILEMMA

- It is not only costs of unconventional fuels that are increasing.
- **Costs of all energy projects worldwide are increasing rapidly**: Oil & gas drilling, power plants, transmission lines, etc.
- Cost pressures result from increased demand from China, India, and other nations.
- Only a severe global recession will reduce these cost pressures.
- However, such a recession will also reduce oil prices – at least temporarily.
- Thus, **dilemma is that the same factors driving up oil prices are driving up the costs of all energy projects**, and these demand-related factors work in both directions.
- Thus, the costs of "unconventional fuel X" may always be too high to compete with the prevailing oil price.

THE FUNDAMENTAL QUESTION



- Question always asked is “can we afford to pursue unconventional fuel alternatives”
- This may be the **wrong question**
- Perhaps **we should be asking “can we afford *NOT* to pursue unconventional fuel alternatives”**
- Serious concerns over U.S. energy: Large imports, national security, foreign policy flexibility, balance of trade, vulnerability, etc.
- Aggressive government policies and incentives are required to develop any unconventional fuels
- Closing thought: **Two best examples of alternative fuels development are Canadian oil sands and South African CTL, and both required massive, long term government and industry support**