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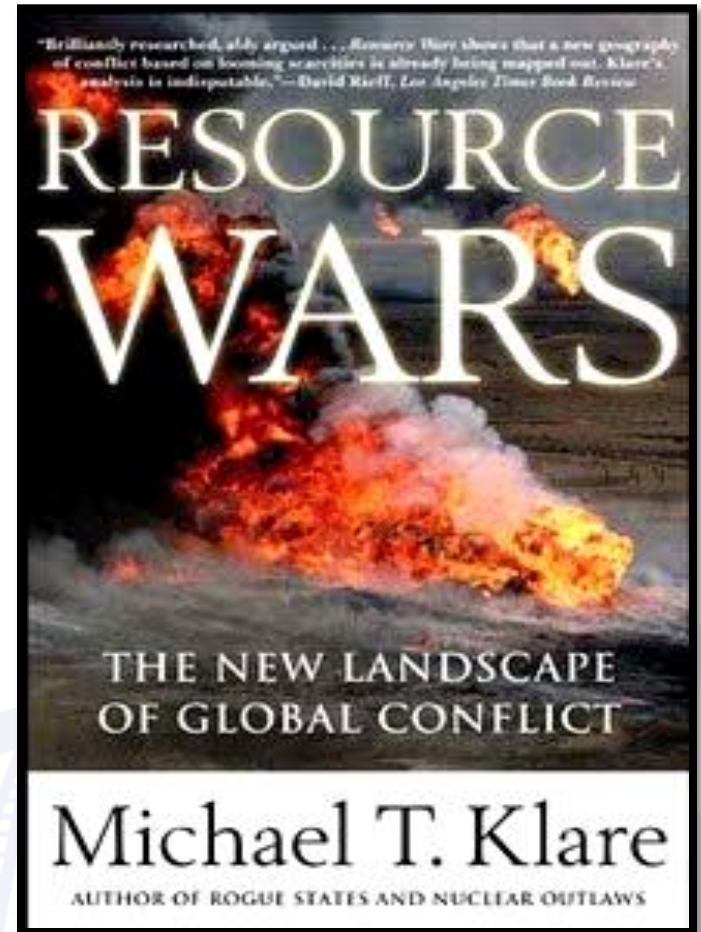
Twin Threats to Resource Scarcity: Oil & Water

Matthew R. Simmons, Chairman Emeritus
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World Has Many Scarce Resources

- As global population grew, highest quality resources declined.
- Decades of cheap resources added to over-consumption and discouraged new resource exploration.
- Most natural resources are non-renewable.
- List of scarce metals is striking:
 - Copper
 - Zinc
 - Tungsten
 - Silver
 - Gold
 - Uranium

To name but a few!



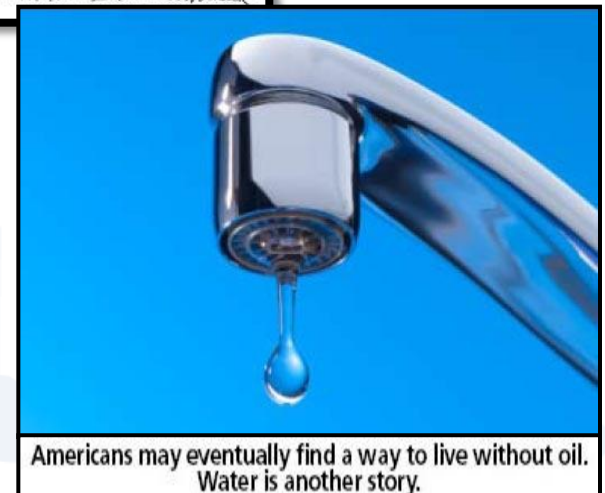
Many Scarce Resources Have Abundant Substitutes

- World could learn how to get along without copper.
- New technologies also obsolete some resource needs:
 - Telephone lines and wires are fast becoming obsolete
 - Lead is barely used today
- But, new technologies also create new resource demands.
- Lithium for batteries is classic example.



Few Resources Are “Invaluable” But, Two Top This List

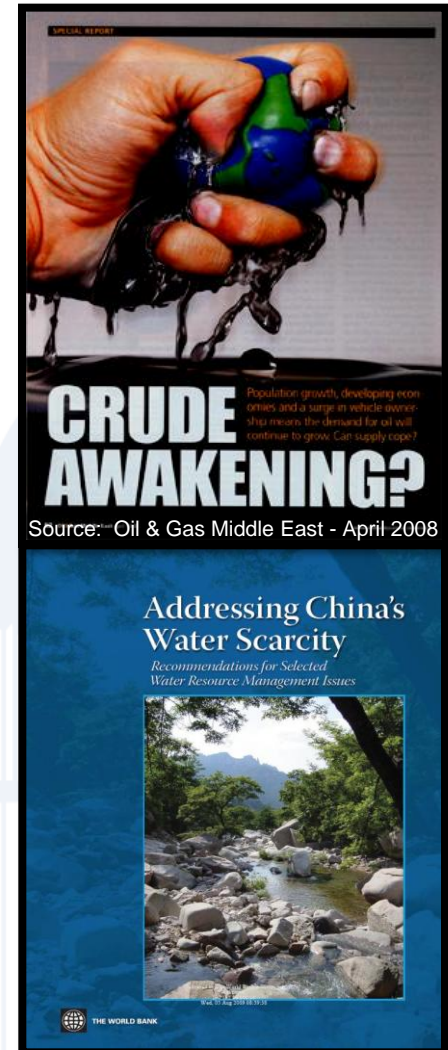
- Oil created miracle of 20th century:
 - Globalized travel
 - Long-distance
 - Suburban spread
 - Globalized food
- Water is even more priceless:
 - Without water, we cannot create modern energy
 - Without water, we have no food
- For a century, mankind ignored depletion of both precious resources.



Americans may eventually find a way to live without oil.
Water is another story.

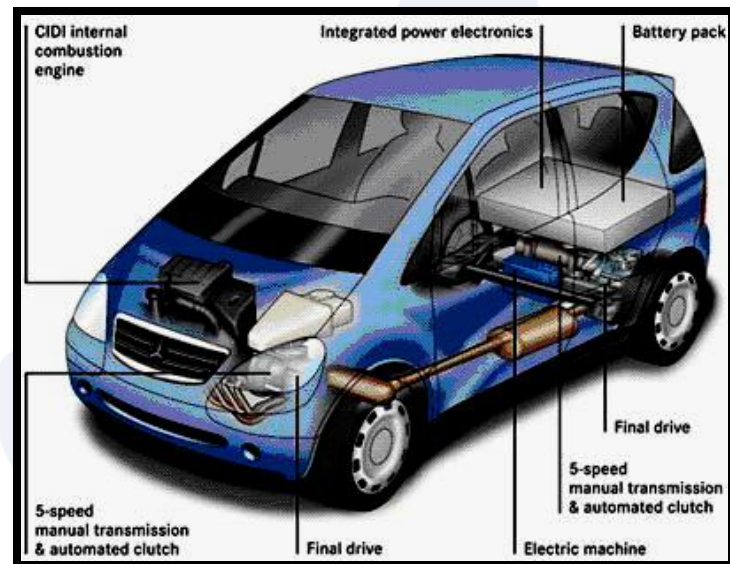
World Will Never Run Out Of Oil Or Water

- But, high quality (sweet and light) oil and potable fresh water are becoming scarce.
- Crude oil flows are steadily getting heavier and more sour.
- Many groups estimate remaining proven/unproven oil resources, but fail to differentiate high-quality flow.
- There are few estimates of remaining fresh water/potable ground water.
- Most of world's usable water is now brackish or saline.
- Running short of oil or water used to be a remote possibility.



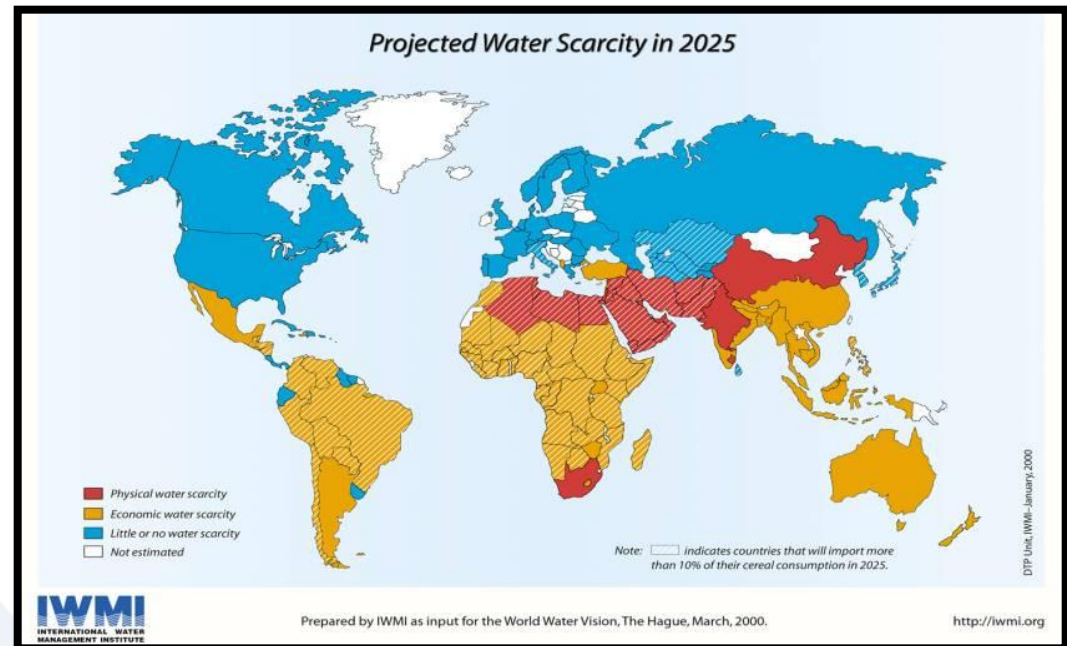
There Are Few Easy Substitutes For Oil

- Years ago, oil was used to create electricity, although there were always many other substitutes.
- Today, crude oil is essentially transportation energy, with few obvious alternatives:
 - Compressed natural gas works great for fleets
 - Electric cars/hybrids work, but barely dent 900 million internal combustion fuelled vehicles
 - Biofuels (except sugarcane ethanol) are very energy/water intensive to create



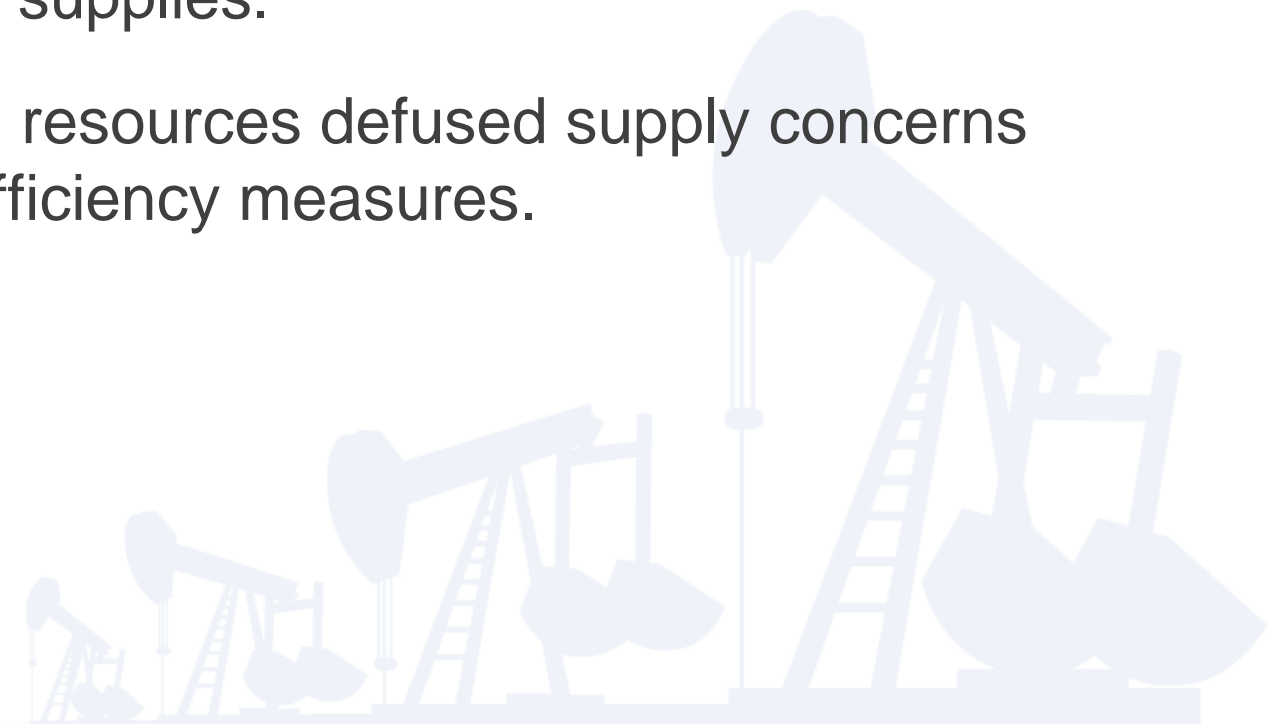
There Are No Substitutes For Potable Water

- Only known substitute for fresh water is desalinated brackish or seawater.
- Historically, this process has been very energy intensive.
- As global population grows, water usage has to rise for sanitation, food production and modern energy creation.
- It is unclear whether this can happen.
- It is less clear what happens if water supplies wane.



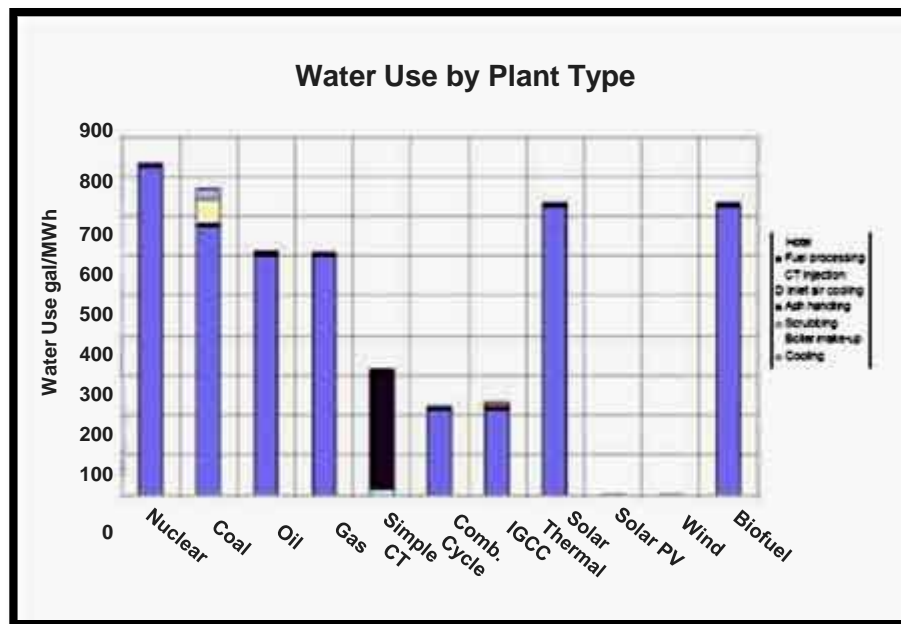
Historically, We “Gave” Both Resources Away

- From 1890 – 1970 (in current \$) oil prices averaged only \$15/Bbl (or \$.01 a cup).
- Water was essentially free to many key users and cheap for municipal water supplies.
- Low prices for both resources defused supply concerns and discouraged efficiency measures.



Modern Energy Production Requires Vast Amounts Of Water

- USA's power generation uses 40% of our fresh water.
- In theory, it is recycled as rain "somewhere".
- A gallon of motor gasoline uses 2 – 3 gallons/water in creation.



Some “Inconvenient Truths” About Oil

- Flimsy statistics indicate that global crude oil flow (excluding NGLs, etc.) peaked in 2005.
- Steep declines in North Sea, Mexico and other key sources are getting impossible to overcome.
- High quality light, sweet crude flows rapidly dwindling:
 - WTI is now “synthetic crude grade”
 - Brent turned into blended Brent
- Quality crude is being replaced by “junk crude”.

Table 11.1b World Crude Oil Production: Persian Gulf Nations, Non-OPEC, and World (Thousand Barrels per Day)

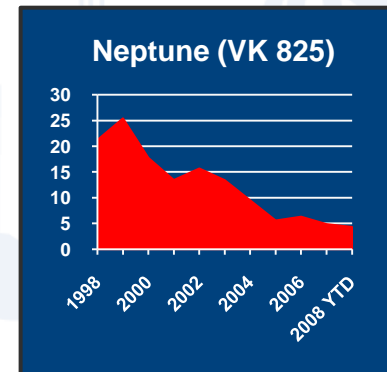
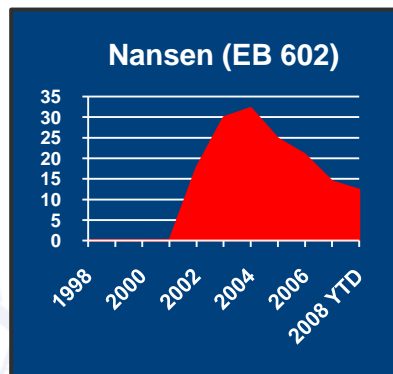
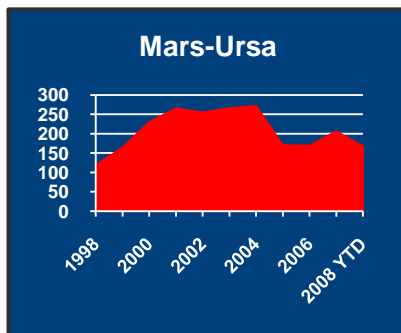
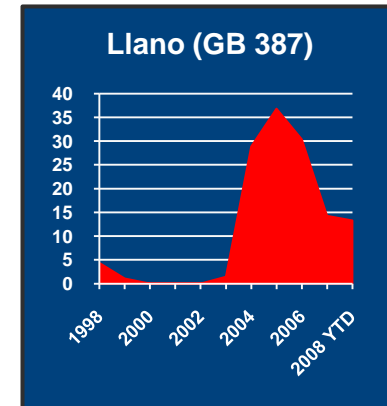
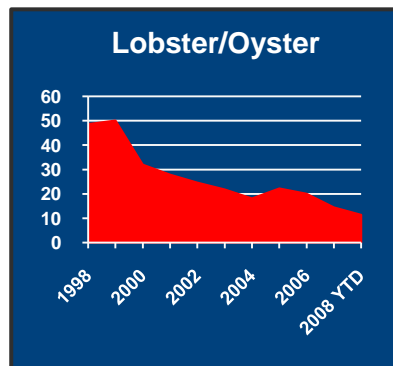
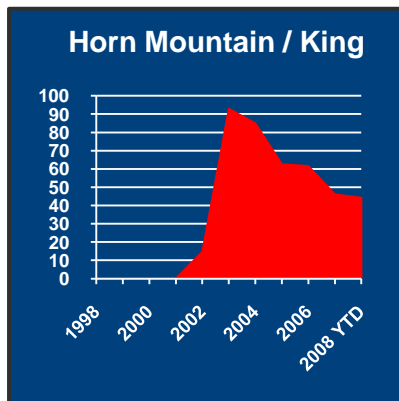
	Persian Gulf Nations ^b	Selected Non-OPEC ^a Producers								Total Non-OPEC ^a	World	
		Canada	China	Egypt	Mexico	Norway	Former U.S.S.R.	Russia	United Kingdom			United States
1973 Average	20,808	1,798	1,000	166	466	32	8,324	NA	2	9,208	24,888	66,679
1975 Average	18,654	1,456	1,460	226	706	189	9,828	NA	12	9,276	26,992	62,828
1980 Average	17,091	1,456	2,114	696	1,936	480	11,706	NA	1,822	16,077	32,802	60,568
1985 Average	9,830	1,471	2,606	887	2,746	773	11,886	NA	2,630	8,971	37,554	63,090
1990 Average	15,278	1,663	2,774	873	2,668	1,030	10,976	NA	1,820	7,566	36,822	60,492
1995 Average	17,208	1,856	2,960	620	2,918	2,700	—	8,896	2,489	6,659	36,736	62,386
2000 Average	17,367	1,837	3,131	922	2,856	3,091	—	8,889	2,608	6,495	36,882	63,762
1997 Average	18,096	1,922	3,200	860	3,028	3,142	—	8,929	2,618	6,462	37,220	66,744
1998 Average	19,337	1,981	3,108	634	3,070	3,011	—	8,864	2,816	6,252	37,459	66,906
1999 Average	19,447	1,907	3,196	862	2,900	3,019	—	8,079	2,684	5,887	37,599	66,922
2000 Average	19,892	1,977	3,249	798	3,012	3,222	—	8,479	2,276	6,822	38,482	68,496
2001 Average	19,698	2,029	3,000	720	3,127	3,226	—	8,917	2,282	6,891	39,014	68,101
2002 Average	17,794	2,171	3,369	715	3,177	3,131	—	7,408	2,292	6,746	39,919	67,108
2003 Average	19,083	2,300	3,409	713	3,271	3,042	—	8,132	2,093	6,681	40,724	69,448
2004 Average	20,787	2,368	3,486	673	3,368	3,044	—	8,806	1,846	6,419	41,637	72,512
2006 January	21,285	2,330	3,561	658	3,351	2,720	—	8,470	1,775	5,441	41,358	73,231
February	21,355	2,298	3,570	658	3,349	2,809	—	8,520	1,741	5,494	41,516	73,514
March	21,426	2,171	3,584	652	3,323	2,827	—	8,525	1,804	5,501	41,541	73,842
April	21,565	2,300	3,584	659	3,409	2,864	—	8,888	1,771	5,559	41,717	74,140
May	21,375	2,360	3,611	656	3,441	2,796	—	8,500	1,743	5,591	42,121	74,296
June	21,685	2,330	3,646	656	3,426	2,796	—	8,026	1,643	5,450	41,558	73,976
July	21,695	2,339	3,654	658	3,082	2,715	—	8,950	1,626	5,340	41,143	73,757
August	21,655	2,372	3,668	655	3,414	2,643	—	9,140	1,342	5,218	41,169	73,818
September	21,915	2,268	3,623	659	3,367	2,623	—	9,170	1,218	5,254	42,413	73,399
October	21,425	2,452	3,649	664	3,221	2,577	—	9,230	1,612	4,534	40,885	73,857
November	21,425	2,548	3,621	667	3,311	2,645	—	9,210	1,453	4,837	41,425	73,980
December	21,325	2,645	3,520	647	3,388	2,883	—	9,240	1,645	4,994	41,903	74,288
Average	21,691	2,389	3,609	668	3,354	2,969	—	9,048	1,649	5,178	41,491	73,897
2006 January	21,175	2,595	3,670	664	3,372	2,657	—	9,030	1,707	5,106	41,579	73,759
February	21,375	2,524	3,662	657	3,311	2,520	—	9,040	1,639	5,045	41,412	73,647
March	21,250	2,411	3,710	651	3,350	2,610	—	9,150	1,597	5,045	41,396	73,489
April	21,250	2,531	3,680	663	3,370	2,407	—	9,170	1,590	5,128	41,496	73,891
May	21,050	2,341	3,712	655	3,328	2,535	—	9,150	1,500	5,161	41,386	73,154
June	21,305	2,336	3,700	627	3,287	2,368	—	9,260	1,392	5,160	40,979	73,061
July	21,680	2,512	3,716	620	3,232	2,271	—	9,240	1,453	5,102	41,627	74,076
August	21,710	2,543	3,660	630	3,252	2,430	—	9,330	1,202	5,059	41,179	73,754
September	21,350	2,501	3,648	640	3,258	2,338	—	9,350	1,364	5,037	41,242	73,465
October	21,135	2,602	3,650	660	3,173	2,380	—	9,450	1,482	5,105	41,793	73,809
November	20,825	2,658	3,672	615	3,163	2,466	—	9,320	1,504	5,105	41,805	73,437
December	20,695	2,658	3,592	619	2,978	2,508	—	9,420	1,472	5,166	41,864	73,218
Average	21,282	2,626	3,673	639	3,260	2,461	—	9,247	1,490	5,102	41,464	73,690
2007 January	20,476	2,578	3,811	616	3,143	2,471	—	9,420	1,510	5,196	41,857	73,133
February	20,356	2,618	3,739	614	3,148	2,454	—	9,460	1,654	5,147	42,124	73,315
March	20,445	2,694	3,685	612	3,182	2,391	—	9,473	1,654	5,178	41,993	73,240
April	20,494	2,634	3,749	609	3,182	2,427	—	9,369	1,666	5,218	42,067	73,520
May	20,494	2,584	3,781	645	3,110	2,181	—	9,440	1,564	5,240	41,640	72,866
June	20,403	2,580	3,826	679	3,206	1,921	—	9,440	1,495	5,139	41,521	72,510
July	20,528	2,572	3,643	679	3,166	2,327	—	9,460	1,436	5,120	41,666	73,154
August	20,662	2,708	3,746	679	3,043	2,278	—	9,370	1,376	5,228	41,876	73,459
September	21,012	2,670	3,716	679	3,161	2,190	—	9,520	1,381	4,899	41,229	73,318
October	21,158	2,582	3,722	609	2,995	2,273	—	9,500	1,507	5,038	41,614	73,938
November	20,373	2,584	3,737	609	2,925	2,387	—	9,425	1,409	5,026	41,562	73,751
December	21,474	2,515	3,607	609	2,954	2,235	—	9,400	1,436	5,072	41,436	74,202
Average	20,882	2,611	3,729	637	3,082	2,270	—	9,487	1,477	5,103	41,637	73,810

^a Organization of the Petroleum Exporting Countries.
^b The Persian Gulf Nations are Bahrain, Iran, Iraq, Kuwait, Qatar, Saudi Arabia, and the United Arab Emirates. Production from the Neutral Zone between Kuwait and Saudi Arabia is included in "Persian Gulf Nations."
^c Revised. NA=Not available. --=Not applicable. E=Estimate.
 Notes: * Crude oil includes lease condensate but excludes natural gas plant liquids. * Monthly data are often preliminary figures and may not average to the annual totals because of rounding or because updates to the preliminary monthly data are not available. * Data for geographic coverage is the 50 States and the District of Columbia.
 Web Page: See <http://www.eia.doe.gov/energy/energy.html> for all available data beginning in 1973.
 Sources: See end of section.

Source: EIA Monthly Energy Report – March 2008

High Percentage Of Oil Flows Come From Very Old Fields

- ≈300 giant/supergiant oilfields make up 2/3 of world supply.
- Almost all these fields are past their peak flows.
- Most are over 50-years old.
- Most of remaining oil supply comes from small fields.



Junk Crude Is Harder To Refine Into Finished Oil

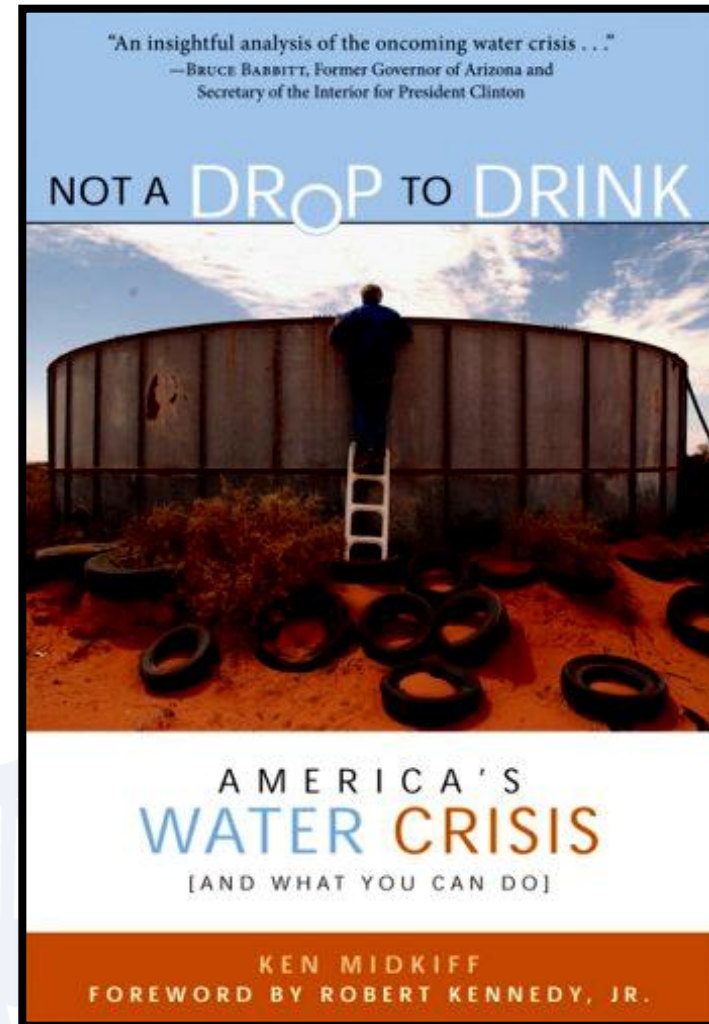
- Junk crude is great source for asphalt or bunker fuel.
- But, most refineries were built to process light/intermediate sweet crude, not junk.
- World's population of complex refineries are few and far between.
- Creating motor gasoline, jet fuel and diesel will get increasingly costly and hard to grow.



Some “Far More Inconvenient” Water Truths

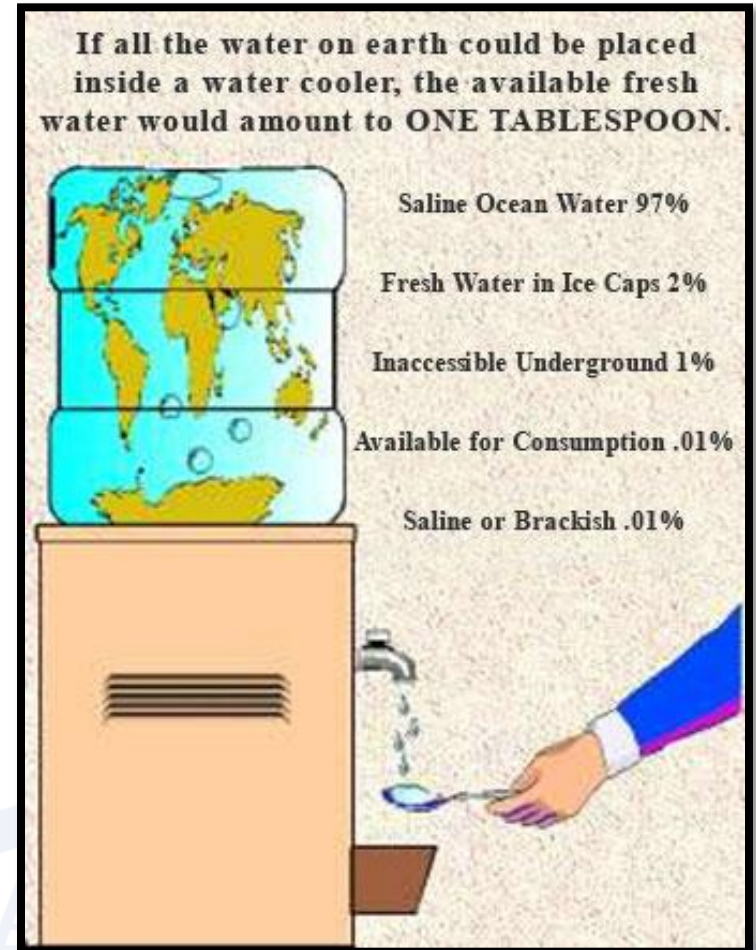
- “We are running out of fresh water. This scarcity may be most under-appreciated global challenge of our time.”*
- Many of world’s megacities (those exceeding 10 million people) are now experiencing “water shortages”:
 - Mexico City
 - Calcutta
 - Cairo
 - Jakarta
 - Beijing
 - Lagos
 - Manila

*World Water Institute



More Inconvenient Water Truths

- Tiny amount of world's fresh water comes from rivers, lakes and streams.
- “Aquifer supplied ground water” is now primary fresh water supply.
- Knowledge of aquifer water tables is sketchy:
 - Drilling wells into water tables is still only accurate measurement
- One giant oil well can drain an entire aquifer.



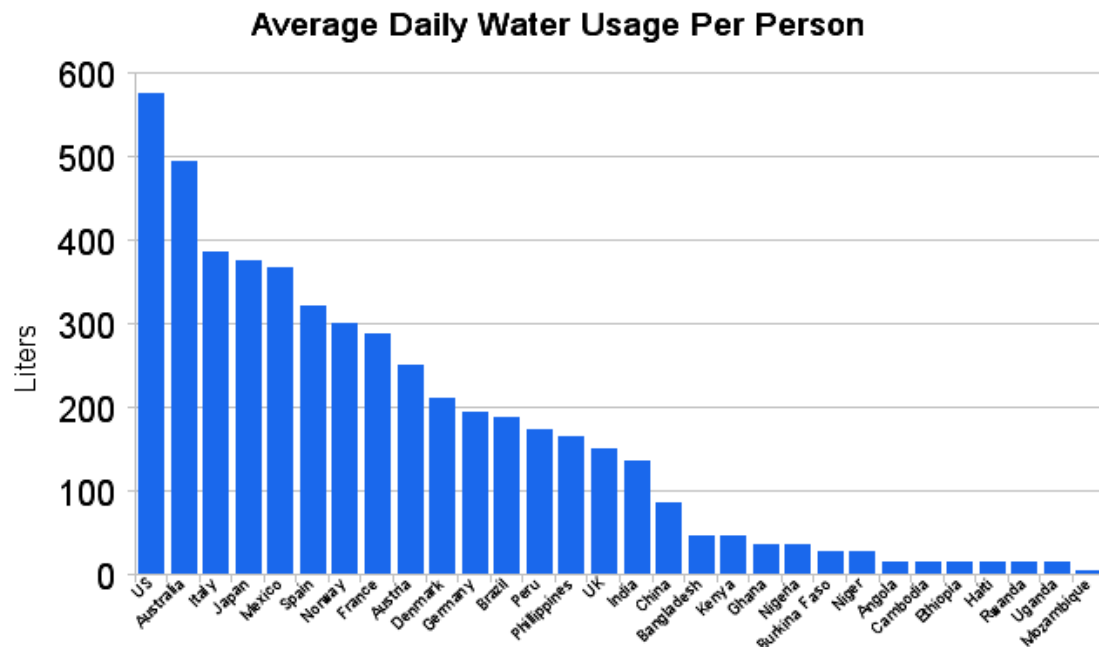
Water Scarcity Is Already A Major Health Hazard

- Two billion people now live with un-sanitized water.
- Over last decade, children killed by diarrhoea caused by polluted water exceeded number of people killed in all armed conflicts since WWII.
- Every eight seconds, a child dies from drinking dirty water.



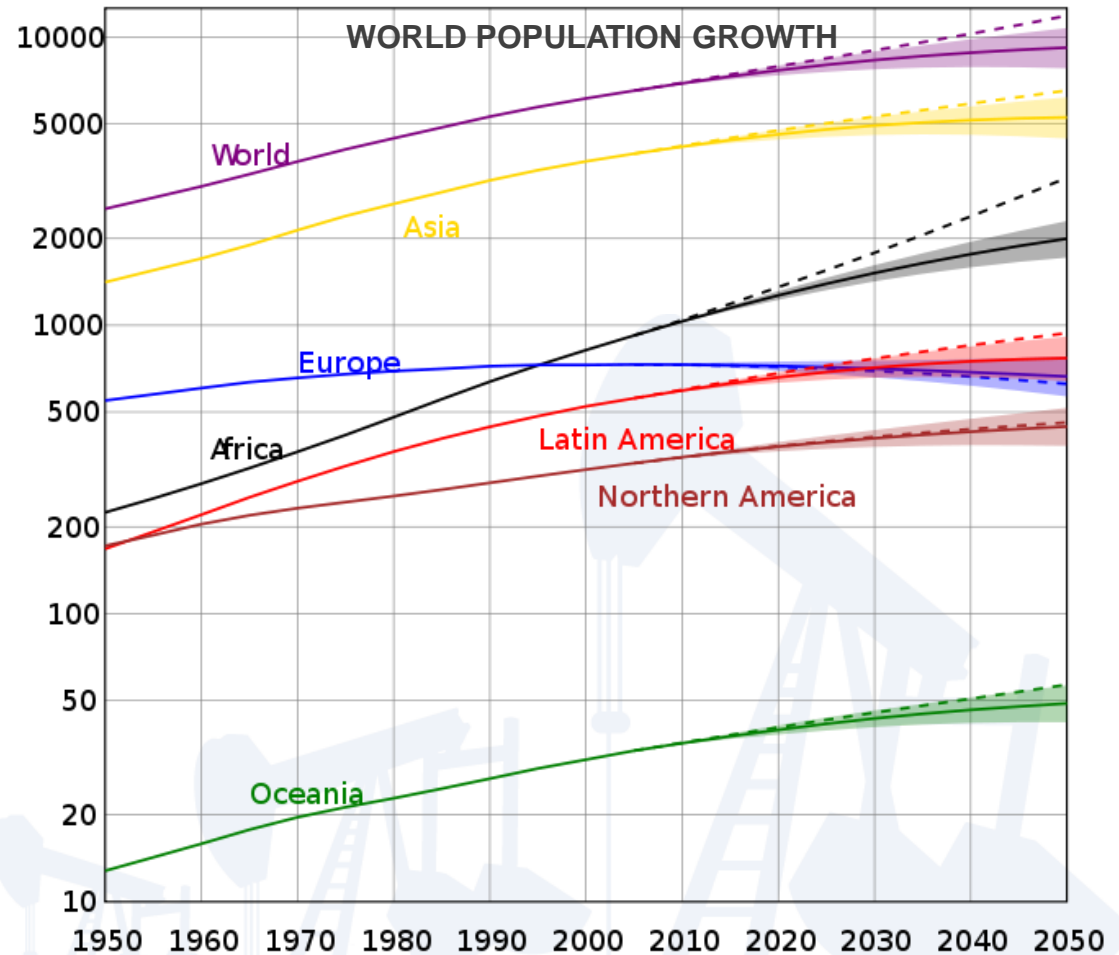
World's Most Prosperous People Use Most Of Our Water And Oil

- USA uses ≈ 25 Bbls/oil per person/year.
- Non-OECD countries use 2.7 Bbls/oil per person/year.
- Average water use per person in North America is 600 litres per day.
- Outside North America, average person only uses 50 litres/day for drinking, cooking and sanitation.



How Did “We” Get In Such A Mess?

- Two easy answers:
 - The world’s rich got richer and richer
 - Global population grew too fast



Source: Wikipedia

Middle East Is Epicenter Of This Scarcity Crisis

- Too many people still think Middle East is sparsely populated.
- Combined population grew almost three-fold from 1970-2010.
- There are now more people in the Middle East than in USA and Canada.

	Population				
	1970	1980	1990	2000	2010* Est
	Population in Thousands				
Bahrain	220	348	501	635	738
Egypt	33,574	42,634	54,907	65,159	80,472
Iran	26,854	39,422	56,669	63,273	67,038
Iraq	9,414	13,233	18,140	22,679	29,672
Israel	2,903	3,737	4,478	6,115	7,354
Jordan	1,503	2,163	3,267	4,688	6,407
Kuwait	748	1,370	2,142	1,974	2,789
Lebanon	2,383	2,899	3,440	3,791	4,125
Oman	783	1,185	1,794	2,432	2,968
Qatar	115	237	446	627	841
Saudi Arabia	6,109	9,999	16,061	23,147	29,207
Syria	6,258	8,752	12,500	16,471	22,198
Turkey	35,758	45,048	56,561	67,329	77,804
United Arab Emirates	249	1,000	1,826	3,219	4,976
Yemen	7,098	9,133	12,416	17,407	23,495
Total	133,969	181,160	245,148	298,946	360,084

Source: U.S. Census Bureau

Population Growth Caused Explosion In Oil Use

- Total Middle East oil consumption was 2.6 million barrels per day in 1970.
- By 2008, it had grown from 3.1X to 8.1 million barrels per day.
- But, per capita consumption only grew from 7.1 barrels per person per year to 8.2 barrels .
- As prosperity and jobs finally spread, the per capita oil use could soon soar.

Oil Consumption

	1980	1990	2000	2008
	Thousand Barrels/day			
Bahrain	16	20	23	44
Egypt	260	465	553	702
Iran	590	1,003	1,248	1,741
Iraq	217	400	462	616
Israel	160	165	255	251
Jordan	37	66	101	111
Kuwait	106	85	264	351
Lebanon	45	33	106	93
Oman	17	39	53	96
Qatar	17	28	48	123
Saudi Arabia	610	1,107	1,537	2,376
Syria	110	205	256	273
Turkey	314	477	667	676
United Arab Emirates	75	243	330	525
Yemen	45	76	97	152
Total	2,618	4,411	6,000	8,130

Source: IEA

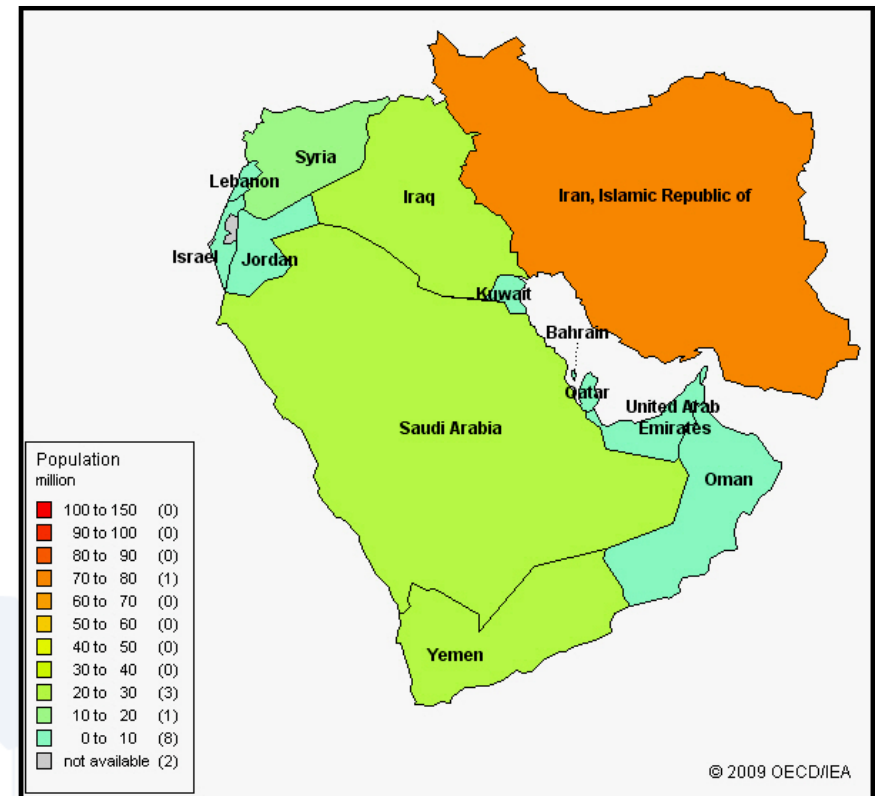
Fresh Water Always Scarce In The Middle East

- Only handful of key rivers deliver fresh water to limited areas in Middle East:
 - Nile River
 - Tigris River
 - Euphrates River
- Now, all suffer from “hot stains” and increasing salinity.
- Desalination became Middle East’s water solution:
 - Saudi Arabia, alone, accounts for 25% of world’s desalinated water



Oil Exports Will Wane If Middle East Oil Supply Does Not Grow

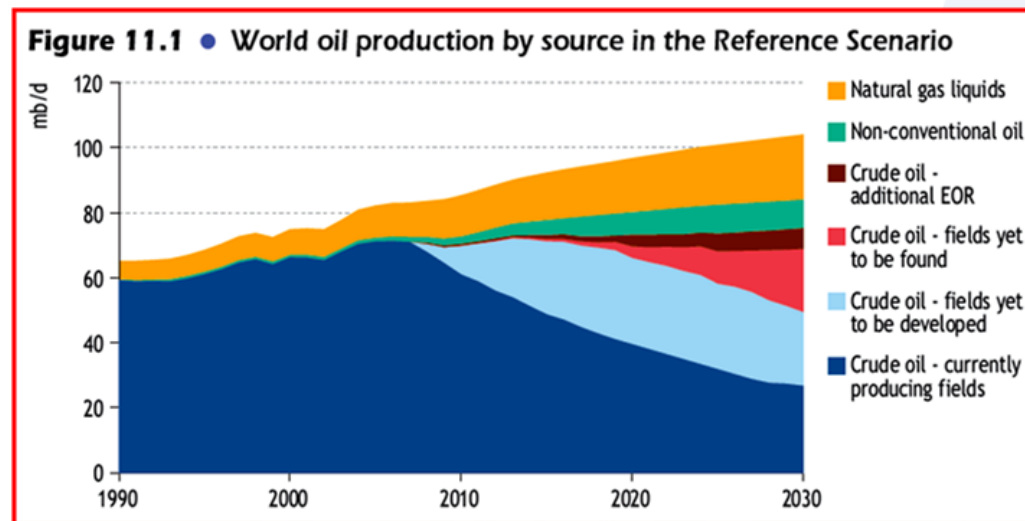
- Given current population trends, Middle East could have 500 million people within a decade.
- If per capita oil consumption grows from 8 to 12 barrels/person/year, this would double current internal oil consumption.
- If production stays flat, exports would fall by $\approx 25\%$.



Could The World Get Along With Shrinking Middle East Oil Exports?

- Future energy projections assume increase in Middle East oil exports will fuel future growth.
- IEA's latest forecasts summarize this dilemma:

“To keep current oil supply flat through 2030, world needs four new Saudi Arabias.”



Source: IEA World Energy Outlook 2008

It Is Time To Properly Price Oil And Water

- The replacement cost of incremental oil is far higher than \$147/barrel.
- If energy producers had to pay a fair price for the water they use, this would raise energy prices much higher.
- Why do we know so little about what constitutes a fair price for oil and water?



How Did We Get Into Such A Deep Hole?

- Rule #1: When you are in a deep hole: STOP DIGGING!
- Is there anyway to stop digging ourselves into an ever-deeper oil and water hole?
- The intertwining of oil and water is historical irony.
- The two do not mix and we can not get along without both.
- Lack of transparent data was the shovel responsible for this deep hole.



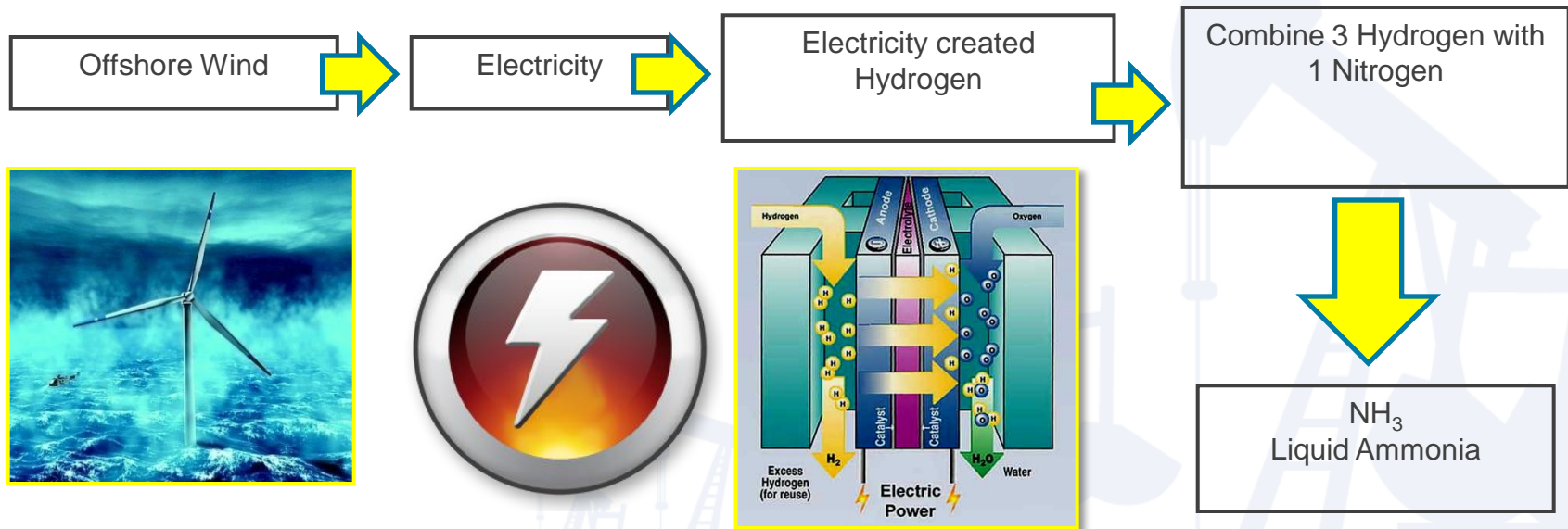
Is It Always Darkest Before Dawn?

- There is a dawn ahead in solving this dilemma.
- It is Ocean Energy: A New Era.



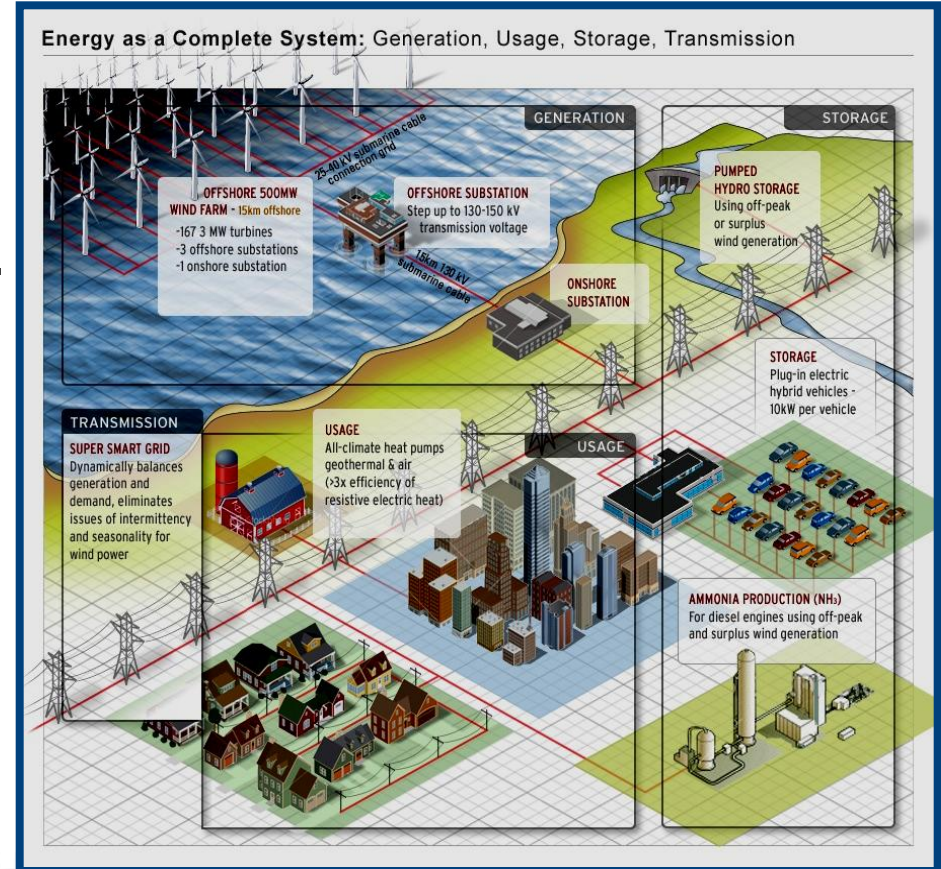
The Gulf Of Maine Will Become Test Ground For Creation Of Ocean Energy

- Ocean Energy Institute (OEI) is helping create world-class deepwater wind in Gulf of Maine.
- Maine's offshore wind will create kilowatts to combine with seawater.
- Output creates NH_3 (liquid ammonia) and desalinated seawater.
- Through advanced composites, deepwater wind can be profitable without subsidies.



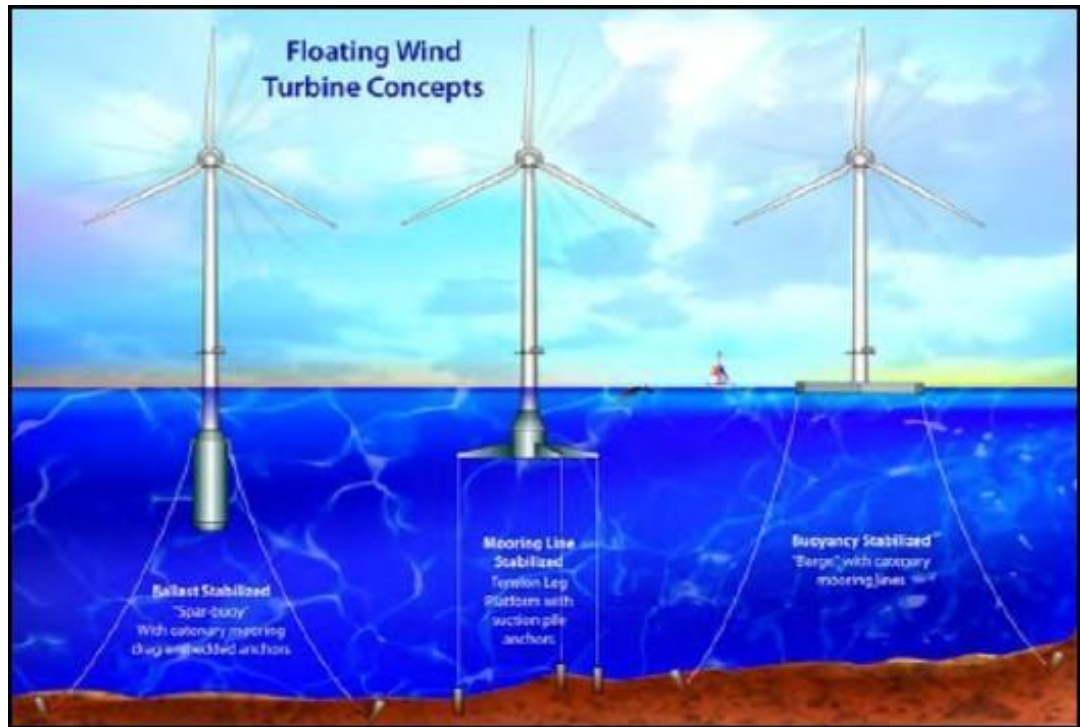
If It Works In Maine, It Can Scale Globally

- Recent Rice University Conference “From Gulf of Maine to Gulf of Mexico” highlighted opportunity for development of offshore wind in Gulf of Mexico and around the globe.
- Particularly valuable for China, India and the Middle East.
- Unclear which by-product will be most valuable:
 - Liquid ammonia; or
 - Desalinated water



Several New Technological Advances Improve Offshore Wind Turbines

- The University of Maine's advanced composites (light, yet strong material).
- Forward osmosis.
- Process to alter electrolysis.
- All could result in costs lower than most alternate energy sources.



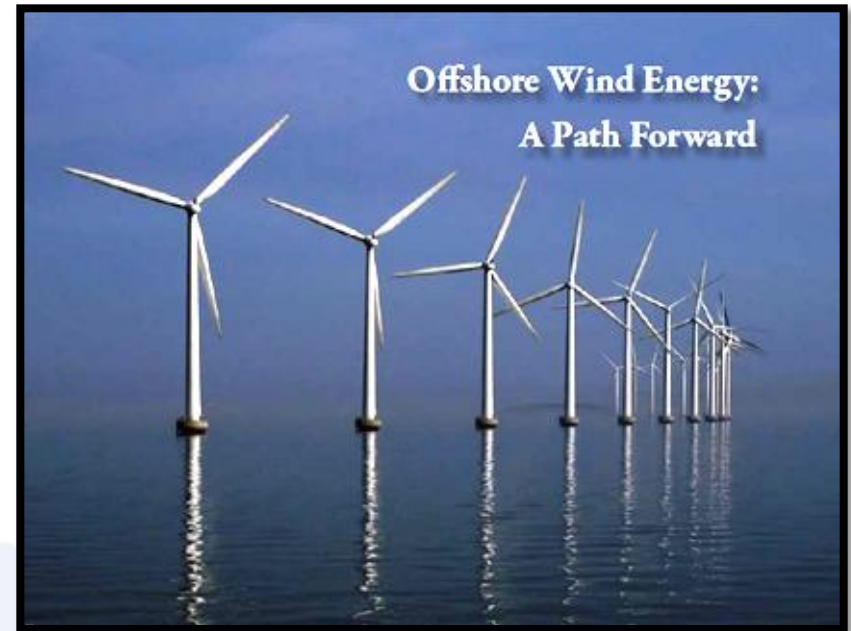
Other Pending Ocean Energy Initiatives

- Once Wind Project is underway, OEI plans to embark on evaluating every form of energy from the oceans:
 - Tides
 - Waves
 - Currents
 - Aquatic biofuels
 - Seeps
 - Gas hydrates
 - OTEC

All hold great promise and are little understood

Ocean Energy Is Our Last Frontier

- We know oceans contain vast energy sources.
- We know oceans make up 70% of our globe.
- Location is ideal: 60% of global population work and live within 50 miles of coastlines.
- Offshore wind is highest quality wind (and free).
- Other ocean sources can also be tapped.
- 2.5 million new jobs could be created in U.S. alone with clean-energy investments.
- This exciting opportunity is where offshore oil and gas was 80-years ago.





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