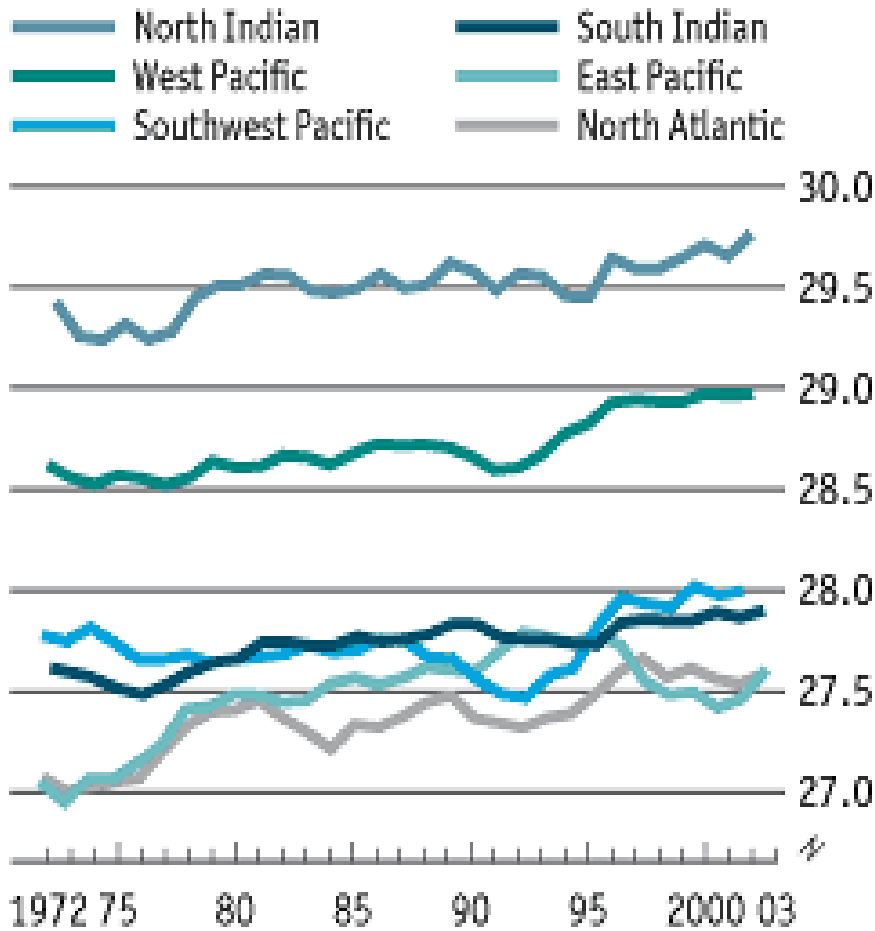


# Balmy seas

1

Summer sea-surface temperature, °C, by ocean basin

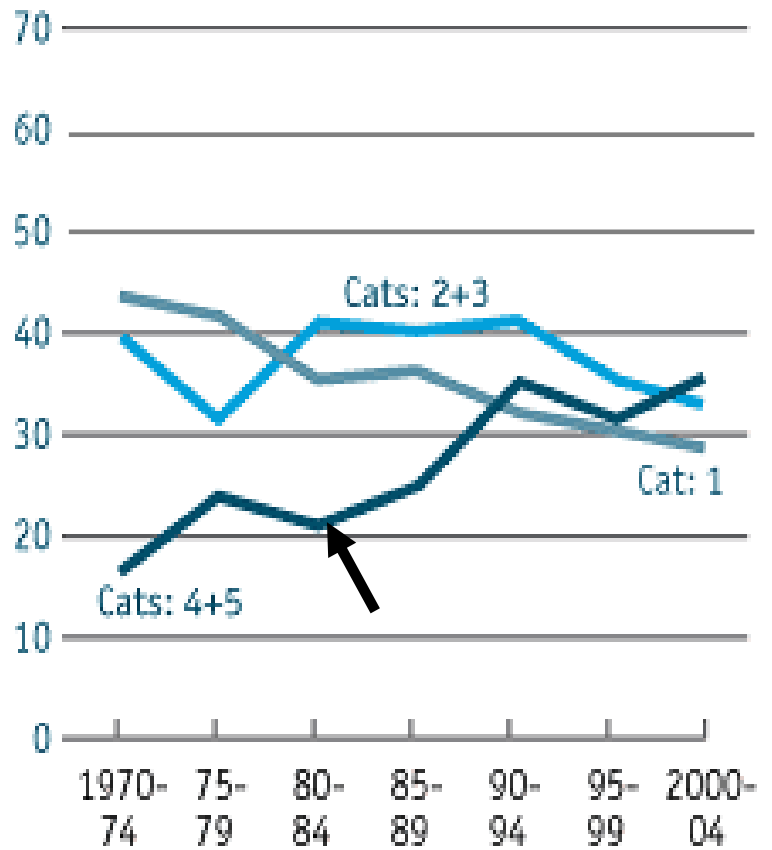


Source: Science

# Stormy weather

2

% of hurricanes in different categories of intensity



Source: Science

# CO<sub>2</sub> - EMITTING SOURCES

<u><b>Fossil fuel</b></u> -- <b>Biomass</b>	<u>Dependence on Mideast?</u>
<u><b>Coal</b></u> (huge supplies worldwide)	none
<u><b>Oil</b></u> (refined to <u><b>Diesel</b></u> or to <u><b>gasoline</b></u> , refiners outside Mideast)	very strong
<u><b>Natural gas</b></u> (Russia, Canada & US also major suppliers)	significant
<b>Ethanol</b> (Brazil and US Midwest, <b>use-proven for cars</b> )	none
<b>Synthetic Diesel</b> ( <b>some use, Europe</b> )	none
<b>Methane</b> ( biodegraded garbage, coal mines, <b>some use in heating &amp; electricity generation</b> )	none

# NO GREENHOUSE GAS (CO<sub>2</sub>)

## MARKET PROVEN

- **Nuclear Fission**

- (safety risk but best hope)

**Hydroelectric** (suitable geographic formation, e.g. Niagara, Hoover, Three Gorges)

- **Geothermal** (Iceland)

## POTENTIAL WIDE USE

- **Hydrogen** (now generated involving CO<sub>2</sub> evolution - -storage, distribution & end-use expensive)

## INTERMITTANT ELECTRICITY GENERATION

require means to store power during down-time

- **Wind** turbines
- **Sun** photovoltaic cells, also non-electric heat adsorption

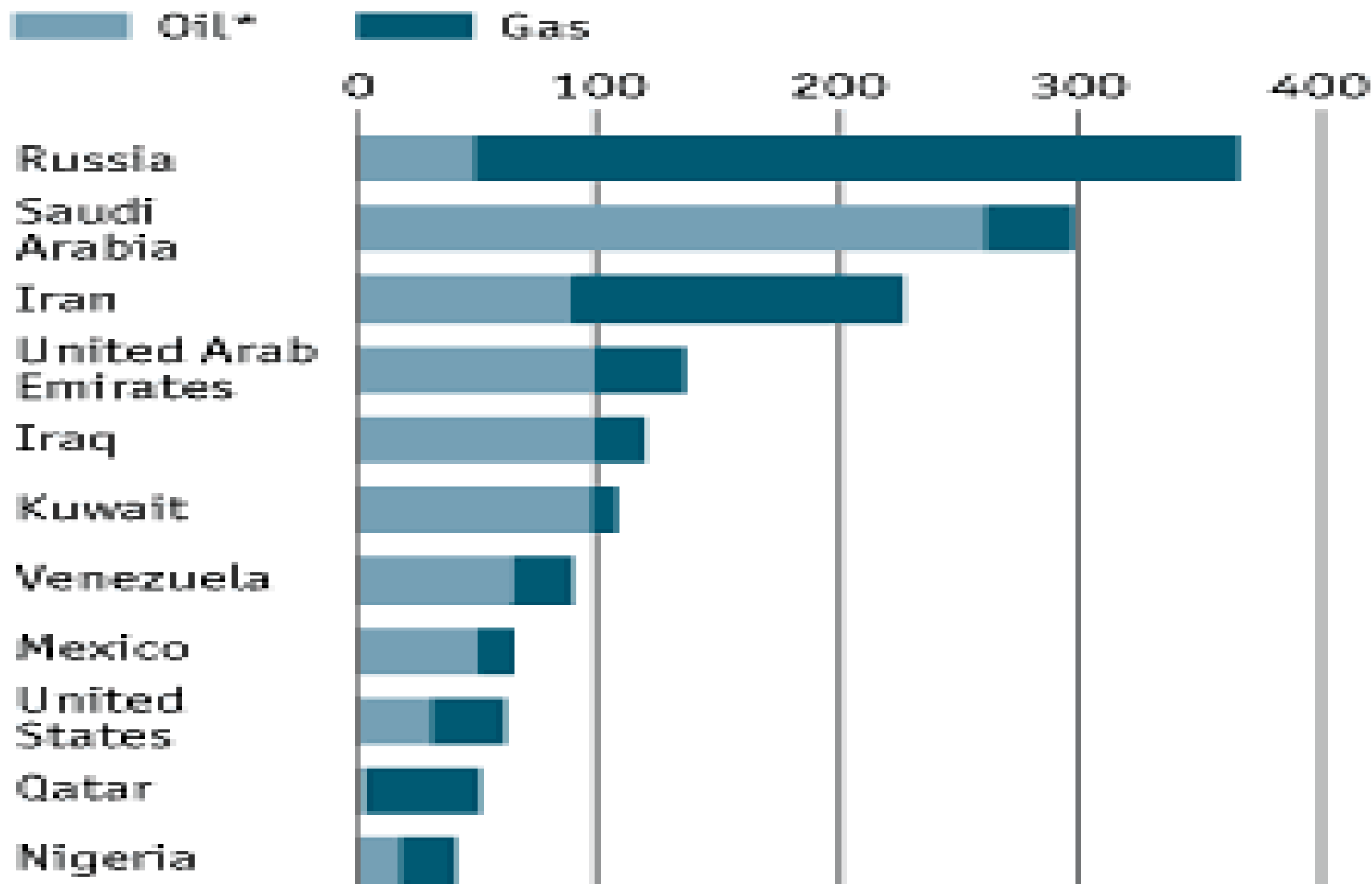
## DECADES FROM NOW

- **Fusion** (engineering as yet not available)

# Resourceful

Largest proved oil and gas reserves

Barrels of oil equivalent, bn



Source: PFC Energy

\*Includes condensates

# Plant Costs, Lead Times, Capacities

## Comparison for a 1000 MW plant:

**Nuclear:** \$2 billion capital, 5 yrs. to build

Coal: 1.2 3

Gas: 0.5 2

## Nuclear capacity

- 31 countries have nuclear power plants
- **439 plants in the world**, of these **107 in US**
- 30 new plants will soon be built in China

## Nuclear's Share of electricity generation :

World	16%	Japan	28%
<b>France</b>	<b>78 % !!!</b>	Germany	29%
US	20 %	UK	23%

**CAPITAL INVESTMENT** per single home, **2.5KW**  
per home assumed for **Nuclear, Coal, Gas & Wind**

<b>Nuclear</b> , \$2.0 billion/1000MW ( <b>French</b> 20% less) ,	\$ 5,000 \$ 4,000
<b>Coal</b> , \$1.2 billion/1000MW	\$ 3,000
<b>Gas</b> , \$0.5 billion/1000MW	\$ 1,250
<b>Solar panel, Japanese</b> \$1.3 billion subsidy for 160,000 houses (may not cover all costs)	\$ <b>8,125</b>
<b>Premium on cost of a Zero Energy House (ZEH), solar panel</b> <u>plus</u> best energy saving features, 1500 sq.ft., <b>California</b>	\$ <b>25,000</b>
<b>Wind</b> turbine, typical value	\$ <b>8,700</b>

# HYDROGEN PRODUCTION

## Global Source

Natural gas	48%
Oil	30%
Coal	18%
Electrolysis	<u>4%</u>
Total	100%

Amount (billion  
kg/yr.)

World 45 -- US 8

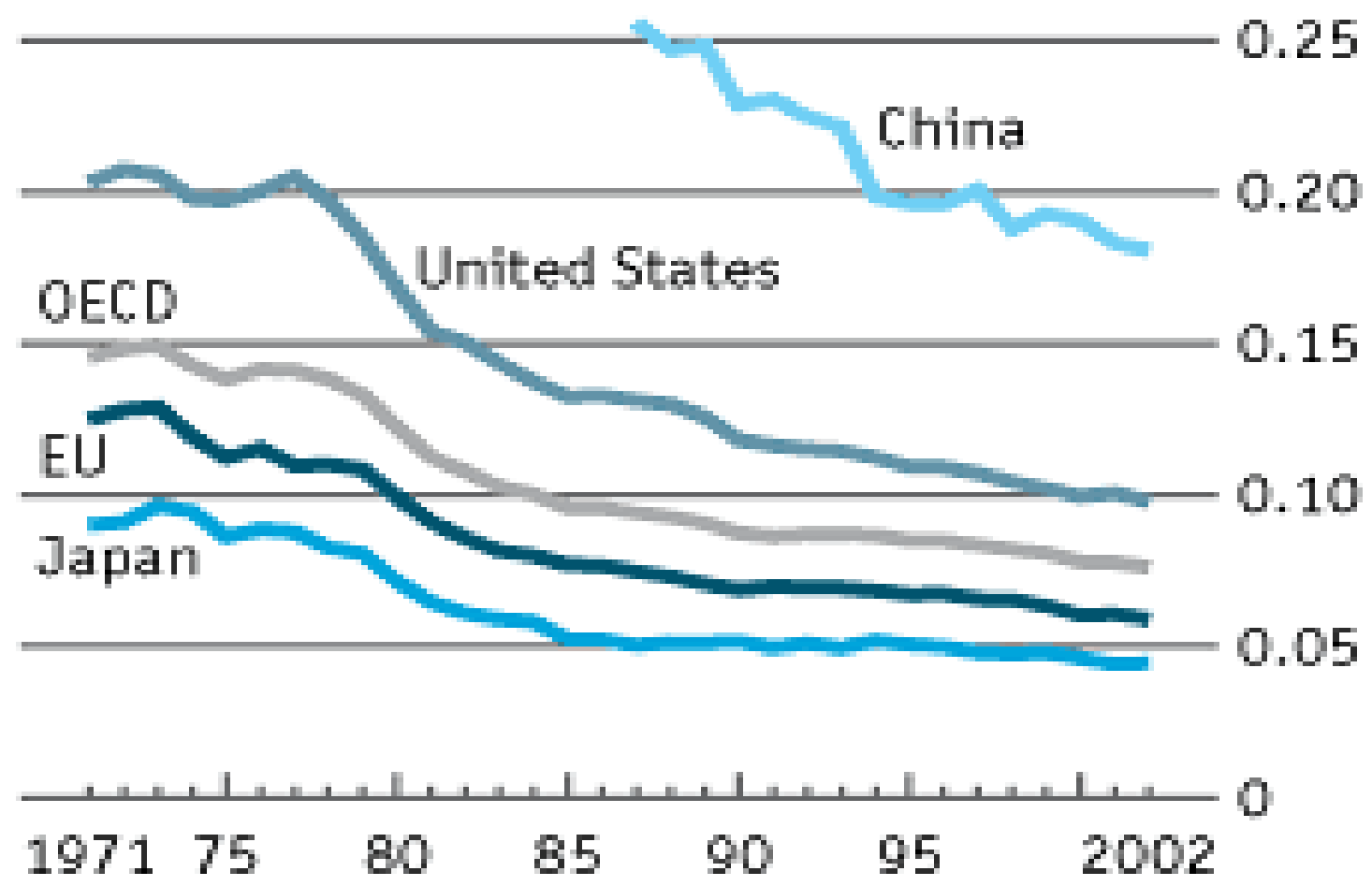
Electrolysis makes environmental sense only if electricity is not fossil fuel based.

Energy content of hydrogen can be, depending on the production method, much less or somewhat more than that of the fuel used for generating it.

Current major uses of hydrogen are **oil refining** and ammonia production.

# Getting less thirsty

Ratio of oil use to GDP\*



\*Tonnes of oil equivalent, per \$'000, 1995 prices

Source: IEA

# INTERNATIONAL ACTIONS

KYOTO : agreement (1997), 160 nations attended

- Global Goal: **Reduce CO<sub>2</sub> emissions below those of 1990 by 5.2%; accomplish this by 2012**
- National Goals: EU 8%, US 7%, Japan 5%, other 21 industrially advanced nations 5-6%. Less developed countries (incl. China and India, now major polluters) have no obligations until 2012.
- Commitments: Russia ratified in February, 2005; 84 other nations already ratified making Kyoto now internationally binding. US has not ratified though it contributes 20-25% of global emissions.
- Outlook: Without Chinese, Indian and US participation the global goal is not achievable.

WHAT NEXT?. Kyoto needs revision and updating,