THE FUTURE OF ENERGY

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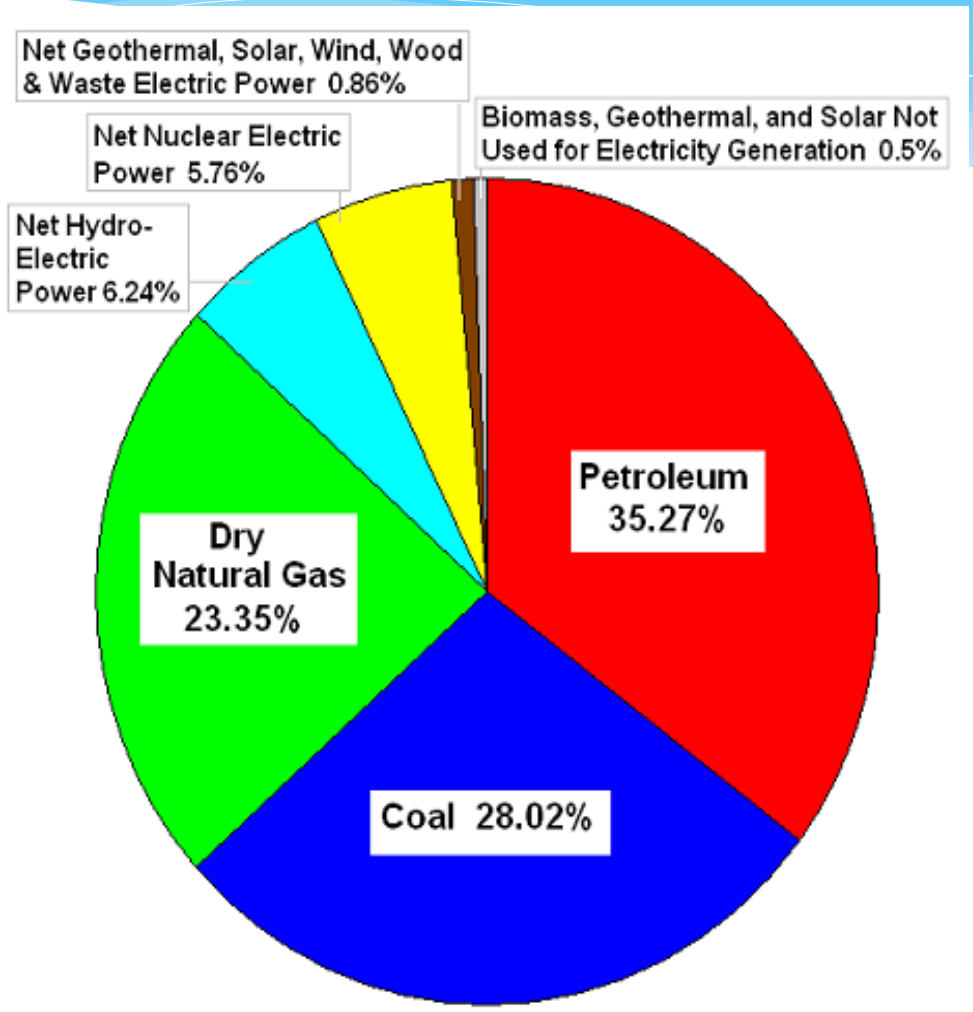
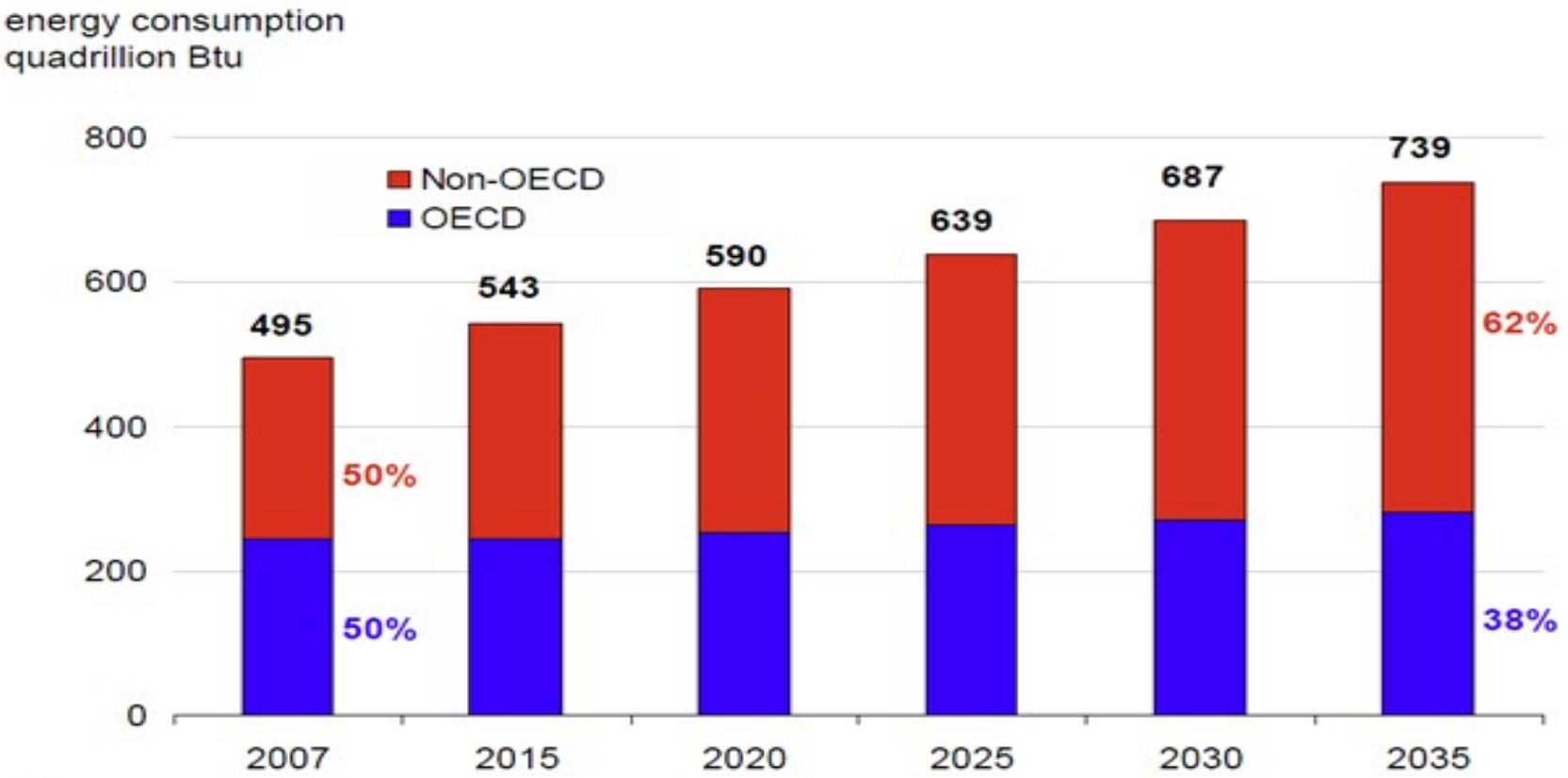
CURRENT GLOBAL ENERGY CONSUMPTION BY SOURCE



World Consumption 2006

MOST GROWTH WILL COME FROM DEVELOPING COUNTRIES

Non-OECD countries account for 86% of the increase in global energy use



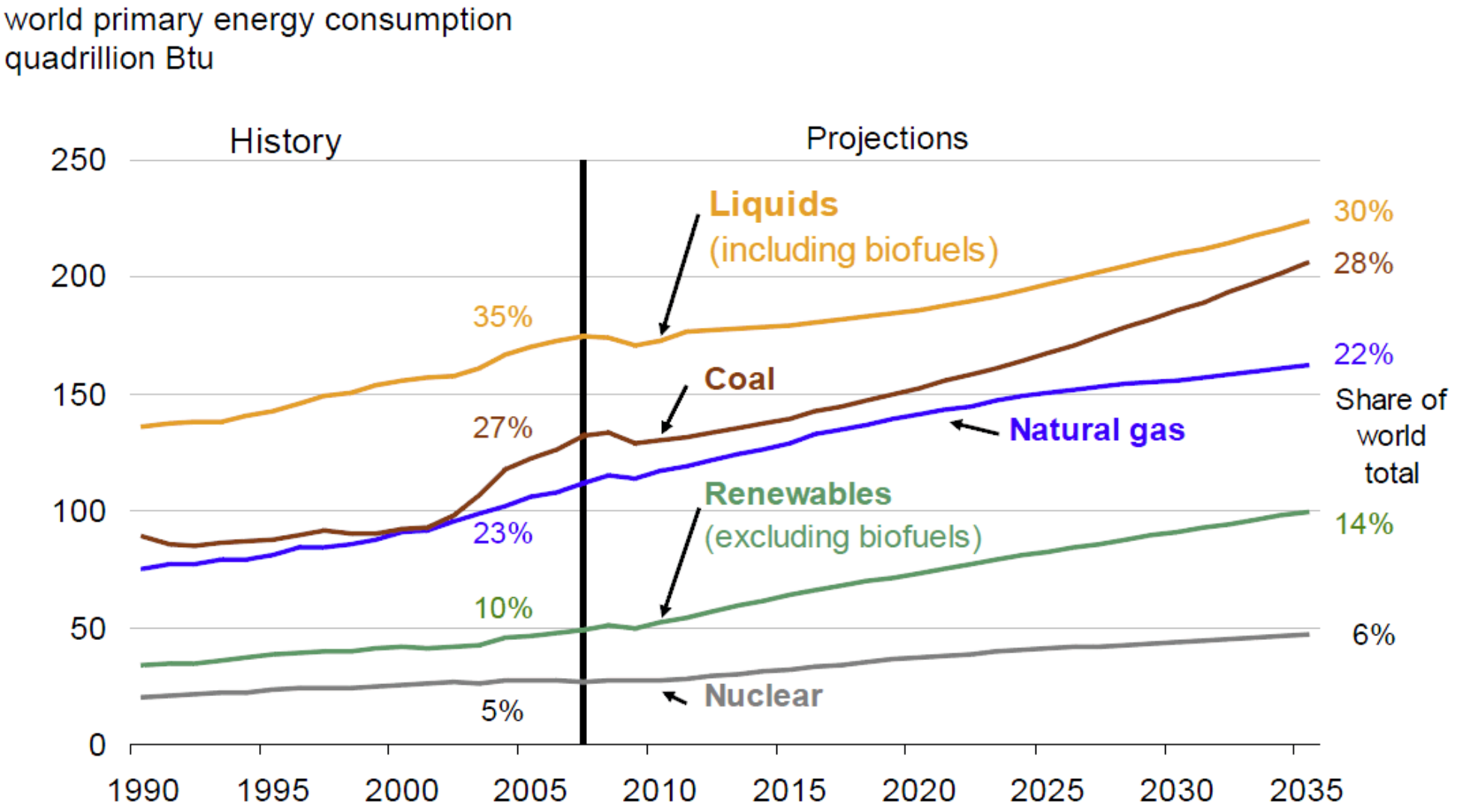
Howard Gruenspecht, CSIS, May 25, 2010

Source: EIA, *International Energy Outlook 2010*

SOME FUNDAMENTAL DRIVERS OF ENERGY MARKETS

- RENEWABLES
- PEAK OIL AND BIOFUELS
- SHALE GAS
- THE FUTURE OF NUCLEAR POWER AFTER JAPAN
- CLIMATE REGULATION: WHERE IS IT HEADED?

Renewables are the fastest growing energy source (but from a relatively small base)



Source: EIA, *International Energy Outlook 2010*

RENEWABLES HAVE SHOWN DRAMATIC GROWTH

- WIND, SOLAR AND BIOMASS HAVE SHOWN 20-40% ANNUAL GROWTH, ALBEIT FROM A SMALL BASE
- SOLAR IS AN ANNUAL $70 BILLION MARKET AND WIND 60 BILLION
- THE BIOFUELS MARKET IS WORTH ABOUT $55 BILLION

PEAK OIL

- GLOBAL OIL DEMAND IS INCREASING MAINLY BECAUSE OF CHINA, INDIA AND MIDDLE EAST CONSUMPTION
- PRODUCTION HAS NOT INCREASED SIGNIFICANTLY
- EXISTING FIELDS ARE DECLINING AND BIG NEW ONES HAVE NOT BEEN FOUND FOR SOME TIME

- BUT THERE IS A LOT OF OIL TO BE EXPLOITED IN THE FORM OF SHALE OIL
- HUGE RESERVES IN CANADA AND VENEZUELA
- HOWEVER THEY EMIT ABOUT 30% MORE CARBON THAN CONVENTIONAL CRUDE AND ALSO USE HUGE AMOUNTS OF WATER

THIS IS HOW IT LOOKS

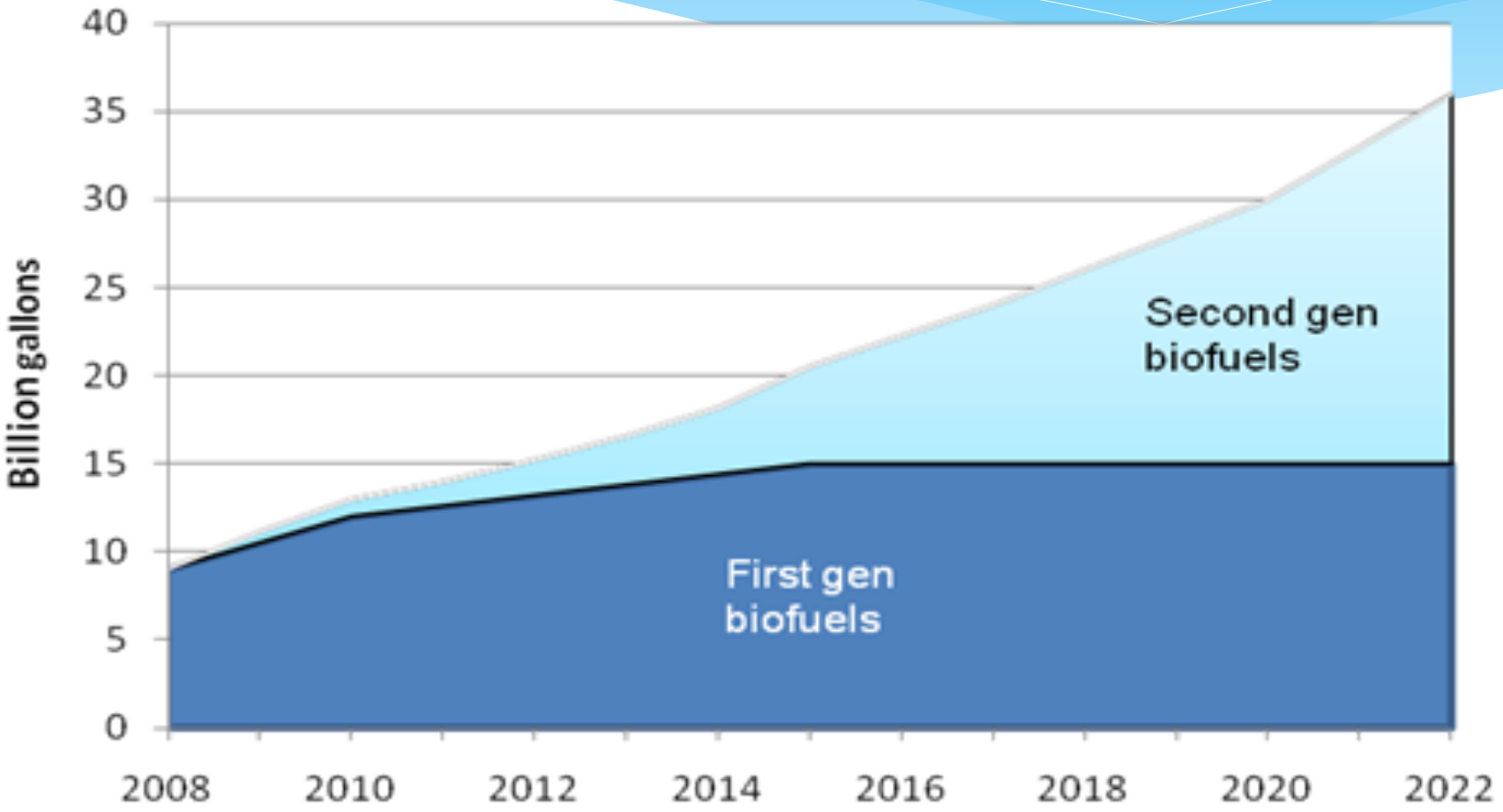
OILSANDS LEAVE A SERIOUS ENVIRONMENTAL FOOTPRINT

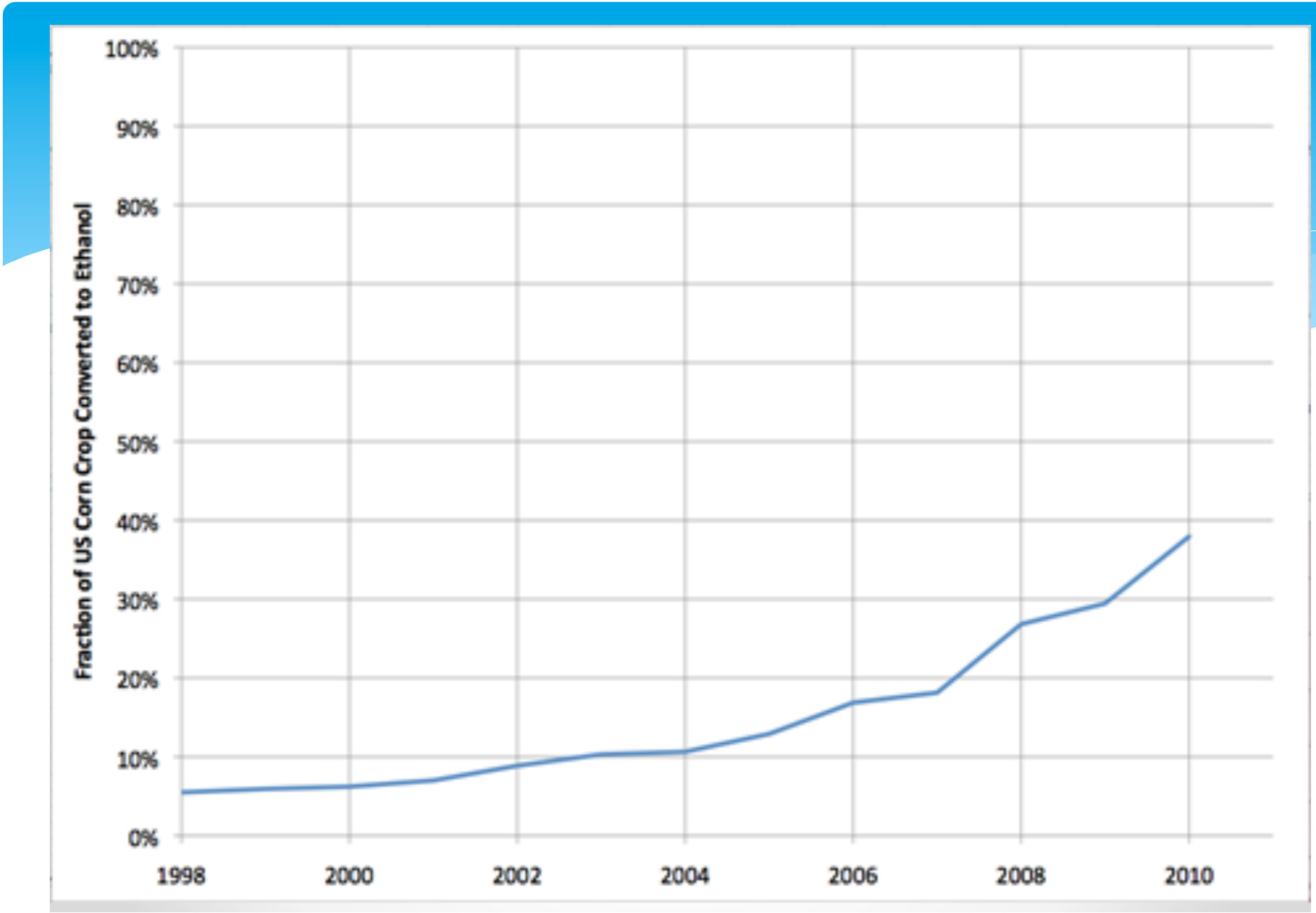
TRUCKS CARRYING OILSANDS

IN SUMMARY..

- THERE IS PLENTY OF OIL, BUT IT IS COSTLY TO EXTRACT AND DIRTY
- A NEW KID IN THE BLOCK – BIOFUELS
- SUPPLIES 10% OF ALL US GASOLINE DEMAND
- ABOUT 3% IN EUROPE
- RECENT MODELING WORK WITH MARIE-HELENE HUBERT, MICHEL MOREAUX AND LINDA NOSTBAKKEN

US BIOFUEL MANDATE



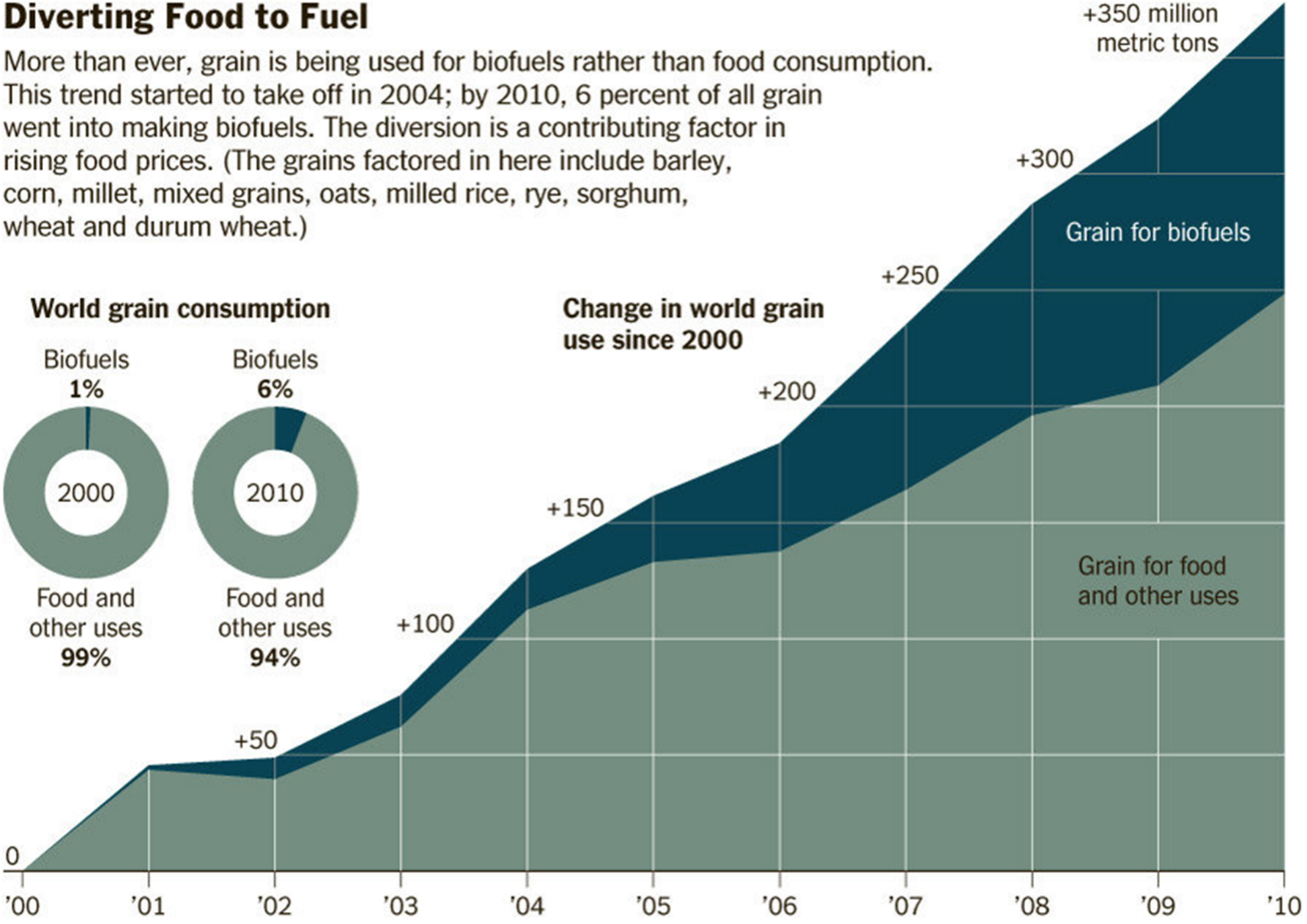

Fraction of US Corn Crop Converted to Ethanol
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1998
2000
2002
2004
2006
2008
2010

The New York Times

April 7, 2011

Diverting Food to Fuel

More than ever, grain is being used for biofuels rather than food consumption. This trend started to take off in 2004; by 2010, 6 percent of all grain went into making biofuels. The diversion is a contributing factor in rising food prices. (The grains factored in here include barley, corn, millet, mixed grains, oats, milled rice, rye, sorghum, wheat and durum wheat.)

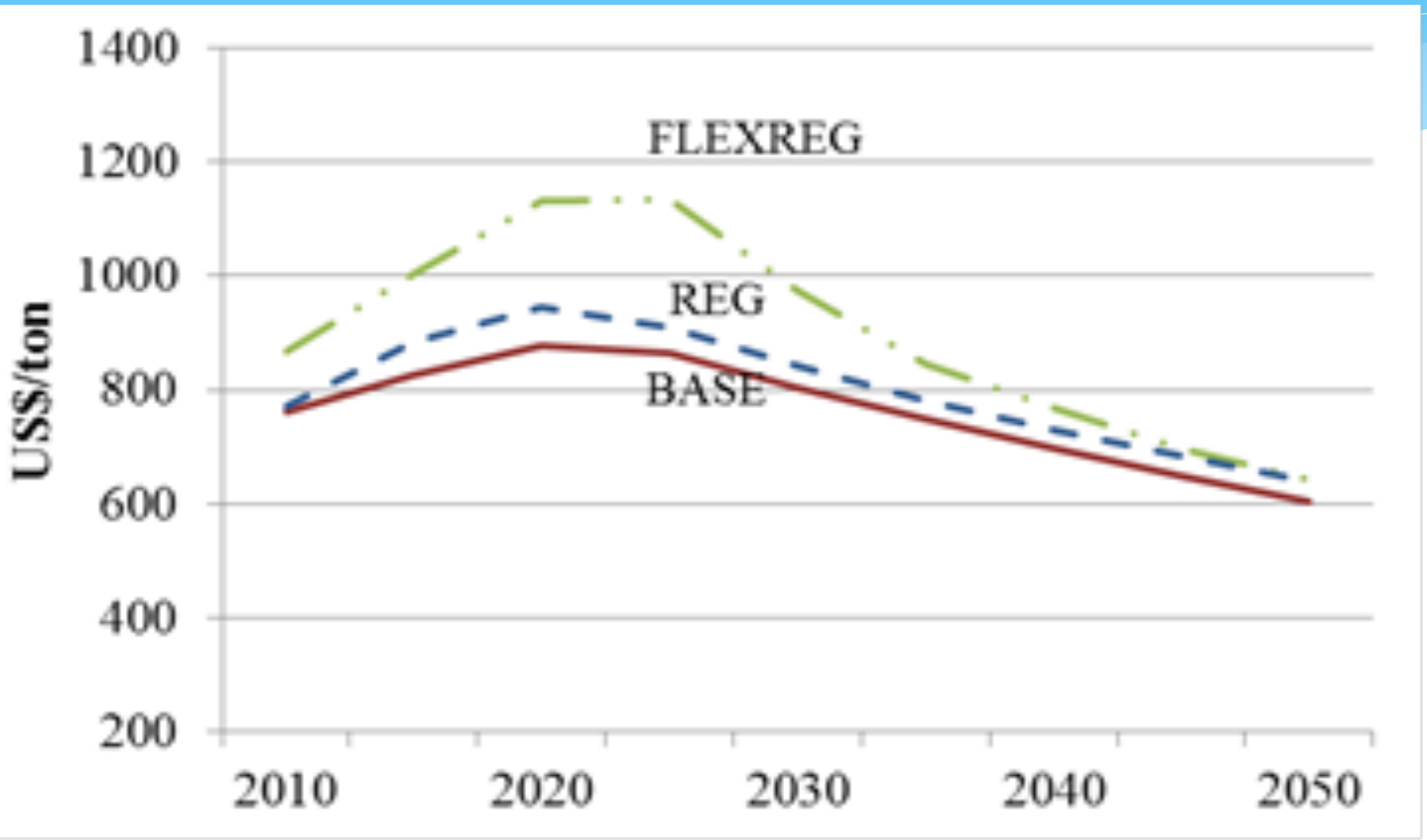


Sources: United States Department of Agriculture; Food and Agricultural Policy Research Institute

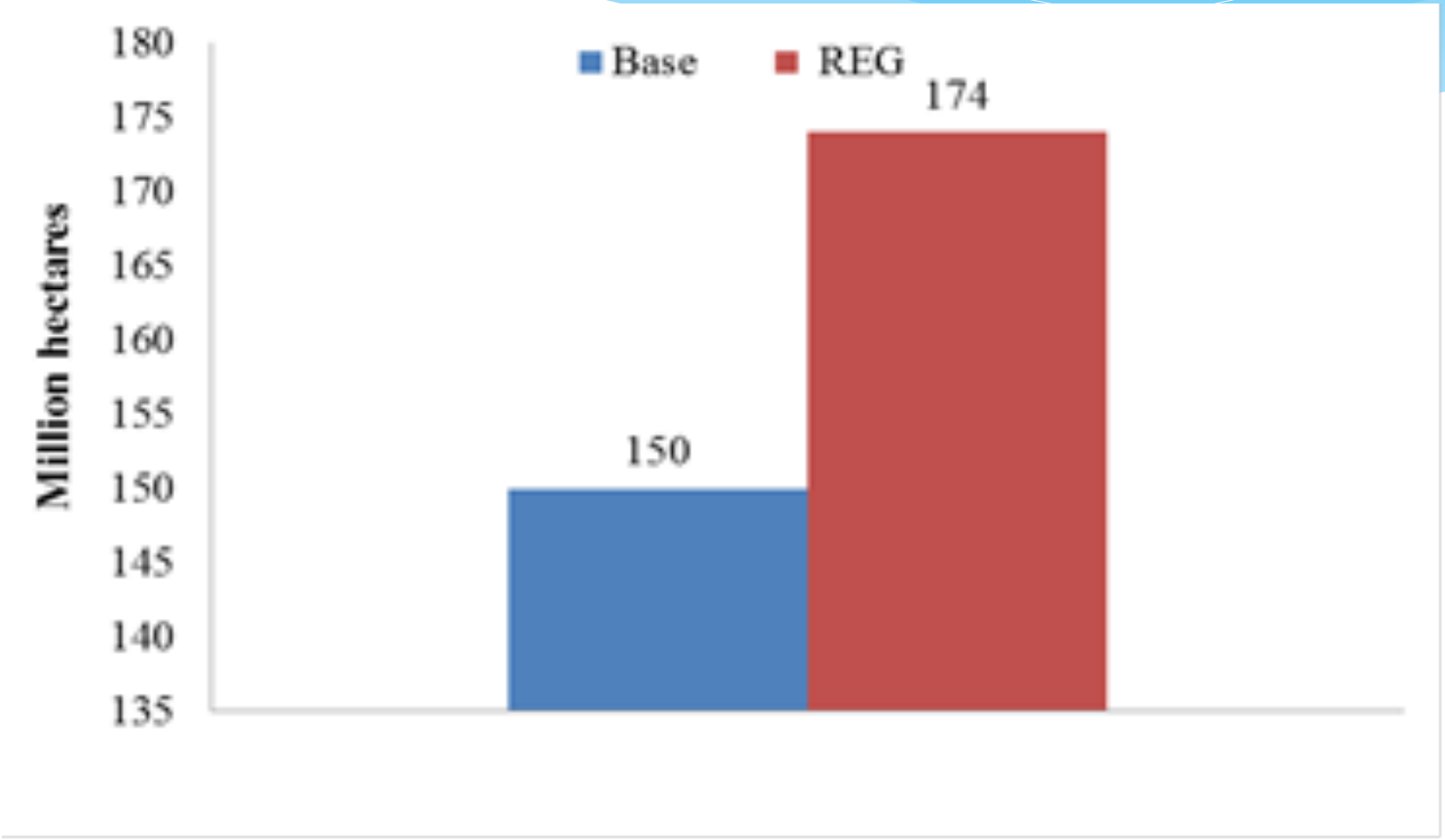
BIOFUELS HAVE COME UNDER ATTACK..

- FOR DIVERTING LARGE AMOUNT OF CALORIES FROM FOOD TO ENERGY
- THEREBY CAUSING FOOD PRICE INCREASES
- FOR CAUSING LAND-USE CHANGES AND INDIRECT EMISSIONS OF CARBON

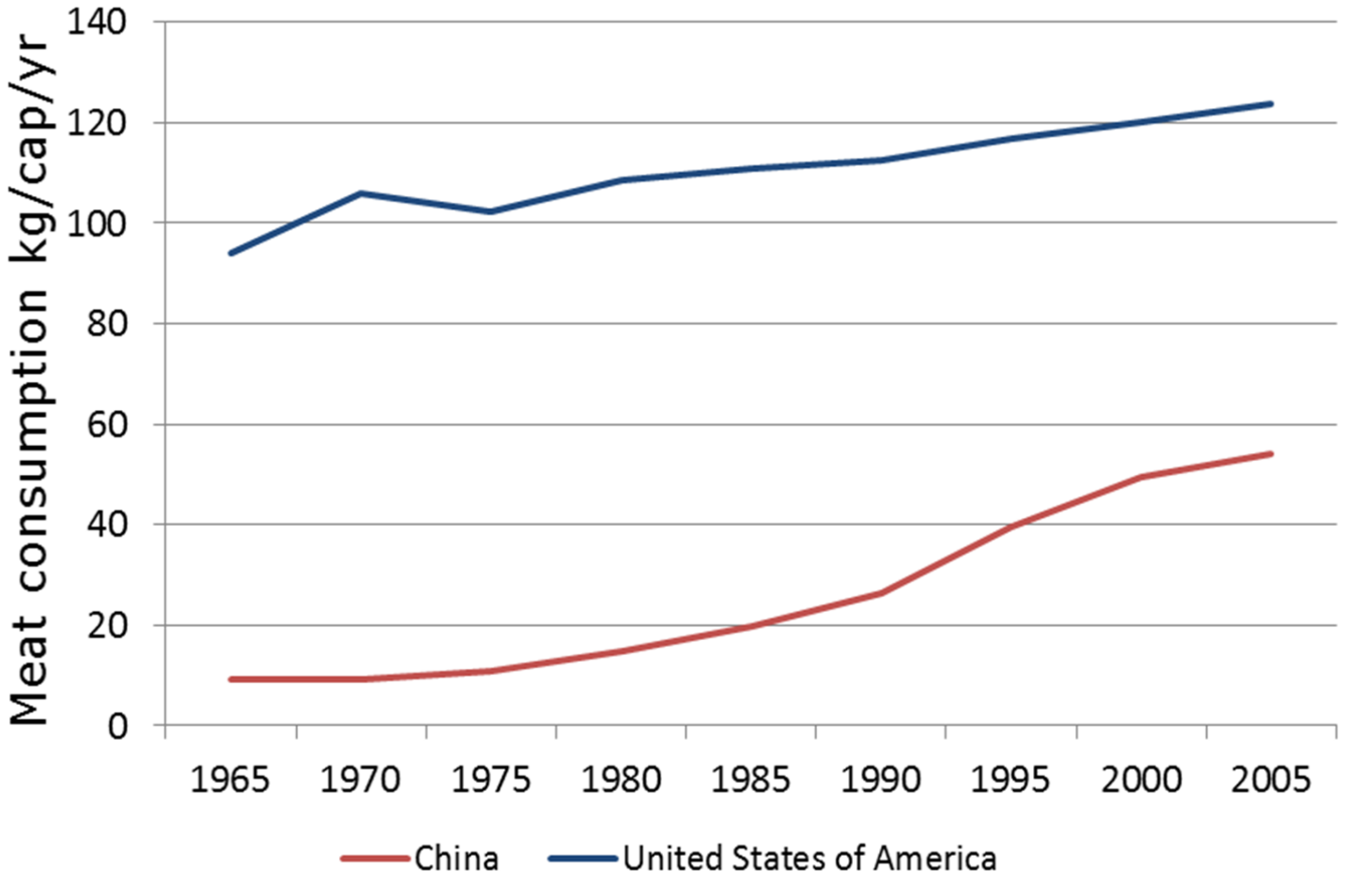
OUR RESEARCH SUGGESTS THAT FOOD PRICE INCREASES MAY BE MUTED..



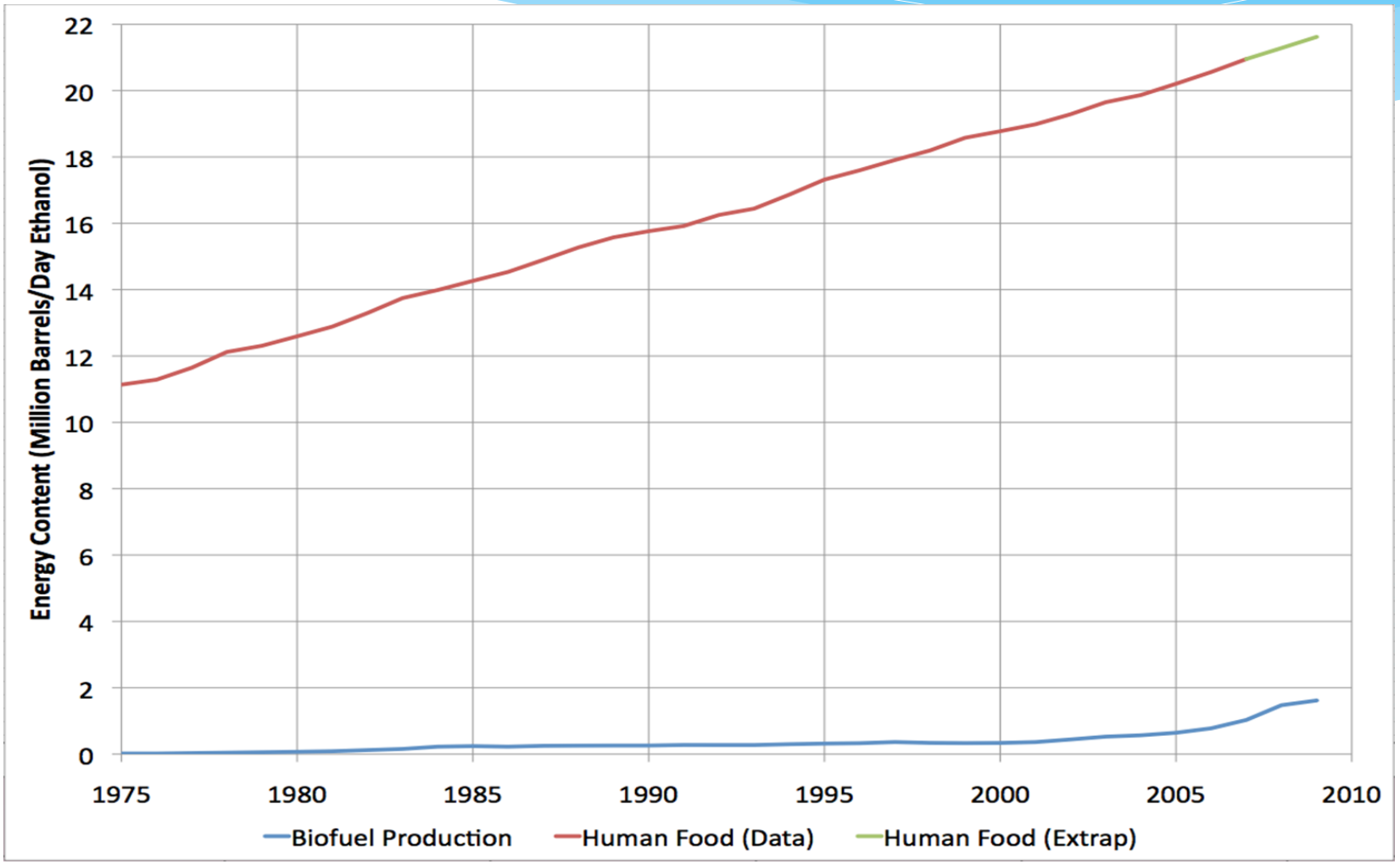
BUT IN THE LONG RUN, LARGE SCALE LAND CONVERSION OCCURS IN DEVELOPING COUNTRIES



AN ISSUE OFTEN IGNORED IN ASSESSMENT OF BIOFUEL IMPACTS IS..



STUART STANIFORD'S SMALL POOL, BIG POOL PROBLEM



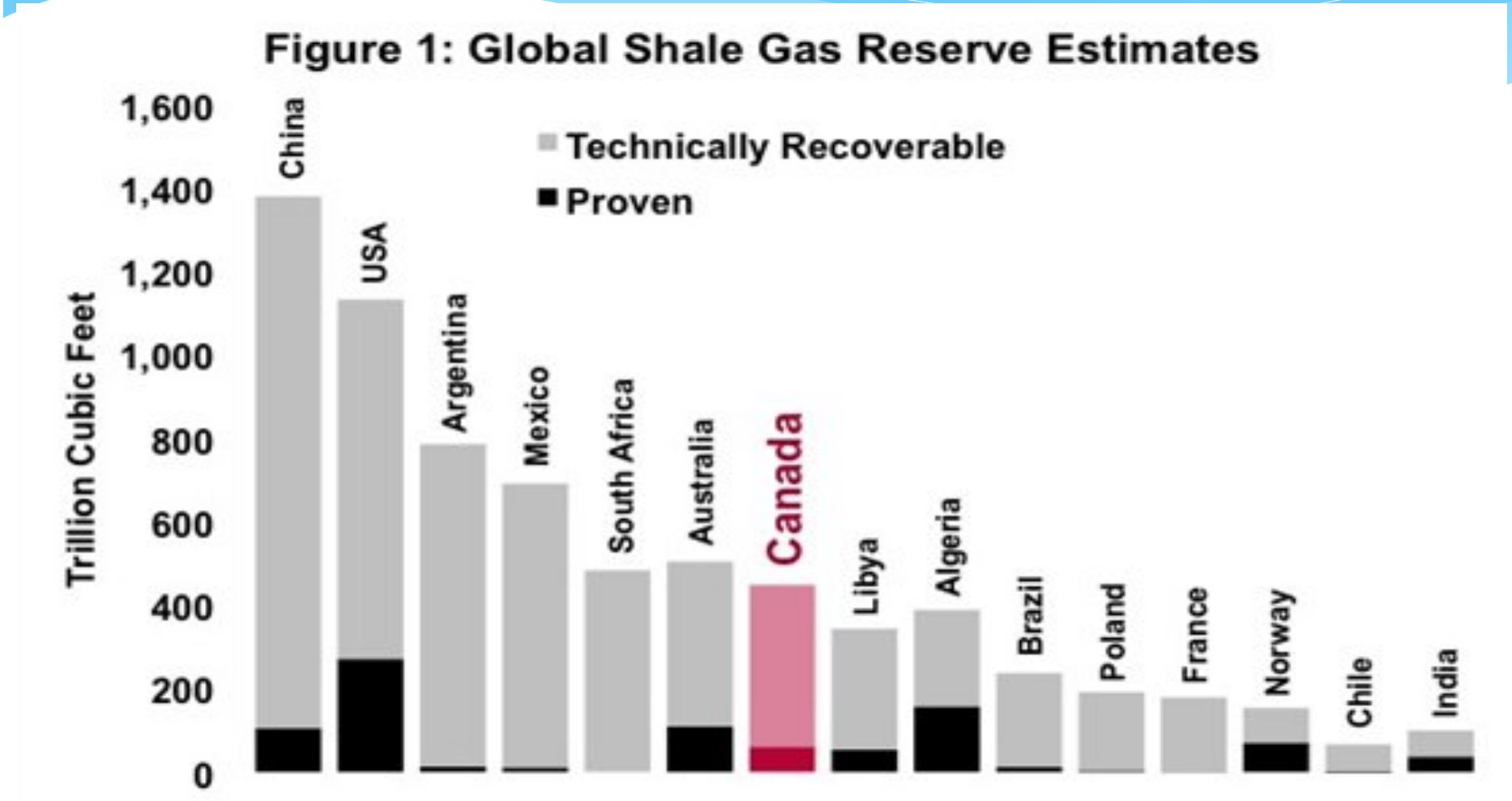
IN SUMMARY..

- BIOFUELS ARE HERE TO STAY
- SECOND GENERATION BIOFUELS SUCH AS CELLULOSIC WILL BECOME ECONOMICAL
- AND ARE LESS LAND-USING
- AND HAVE A MUCH LOWER IMPACT ON FOOD PRICES

NEW SHALE GAS DISCOVERIES

- THE US HAS FOUND GAS IN ROCK FORMATIONS EQUAL TO 150 YEARS OF CONSUMPTION
- GAS PRICES HAVE FALLEN BY A FACTOR OF 3-4
- NEW POWER GENERATION IS EXPECTED TO SWITCH FROM COAL TO GAS
- AND RELIEVE THE DIFFICULT ISSUES WITH NUCLEAR

1,000 TCF = 170 BILLION BARRELS OF OIL



- GAS MAY BE USED FOR TRANSPORTATION (CNG AND GAS TO LIQUIDS)

- SERIOUS QUESTIONS ABOUT ENVIRONMENTAL IMPACTS OF GAS EXTRACTION ESPECIALLY IN POPULATED AREAS

NUCLEAR POWER AFTER FUKUSHIMA

- LARGE SHORT RUN IMPACTS
- BUT THE BIG GROWTH IN NUCLEAR POWER IS COMING FROM ASIA
- 440 REACTORS PLUS 60 UNDER CONSTRUCTION
- PROVIDES 20% OF ELECTRICITY

- EXISTING PLANTS HAVE RECEIVED 30-40 YEAR RENEWALS AND BECAUSE OF EFFICIENCY CAPACITY HAS INCREASED
- SO IN THE LONG RUN, THE QUESTION WILL BE WHETHER THERE ARE CHEAPER AND CLEANER ALTERNATIVES TO NUCLEAR
- BUT NUCLEAR IS EXPECTED TO STAY
- THERE IS PLENTY OF URANIUM FROM DISMANTLED WEAPONS PROGRAMS

HOW WILL ENVIRONMENTAL REGULATION IMPACT ENEGRY USE?

- KYOTO MAY BE DEAD BUT THE FLOODGATES HAVE BEEN OPENED
- ETS, WCI, LCFS AND RGGI
- LOCAL AND REGIONAL INITIATIVES MAY IMPACT ENERGY USE
- BIG CHANGES IN FUEL EFFICIENCIES, HYBRID AND FLEX FUEL VEHICLES ETC.

- IT IS NOT CLEAR THAT FOSSIL FUELS WILL CEASE TO BE IMPORTANT

- DOMESTIC ENERGY PRICES IN MANY COUNTRIES WILL MATCH WORLD PRICES, SO CONSUMPTION WILL GO DOWN

- THIS MAY AFFECT VEHICLE FLEET, HOME CONSTRUCTION AND URBAN DENSITIES

WHAT WILL THE ENERGY FUTURE LOOK LIKE?

- IN THE LONG RUN,
- MUCH CLEANER
- RENEWABLES, GAS AND BIOFUELS WILL PLAY MAJOR ROLES
- ENERGY WILL BE EXPENSIVE, AT LEAST IN THE SHORT RUN
- DEMAND WILL INCREASE UNTIL POPULATION STABILIZES

WHAT WILL IT MEAN FOR OCEANS?

- MORE DRILLING FOR HYDROCARBONS
- MORE TANKER TRAFFIC WITH LNG DELIVERIES
- UPGRADING OF PORTS
- CHINA AND INDIA WILL EMERGE AS PREMIER SHIPPING DESTINATIONS

- CARBON REGULATION MAY REDUCE EMISSIONS PER SHIP BUT MAY INCREASE SHIPPING VOLUMES (BECAUSE IT IS THE CHEAPEST)

- THE OCEAN AND LAND MAY COMPETE TO SUPPLY ANIMAL PROTEIN: WHERE IS THE BALANCE?