What is Sustainability About, Really?

Dr. Susan Krumdieck
Advanced Energy and Materials Systems Lab
Department of Mechanical Engineering
University of Canterbury
Christchurch

Outline

- What do we really want - Sustainability or more oil?
- What are the real problems?
- What are the real solutions?
- AEMS Lab Research

What do we really want?

More Oil

Survival

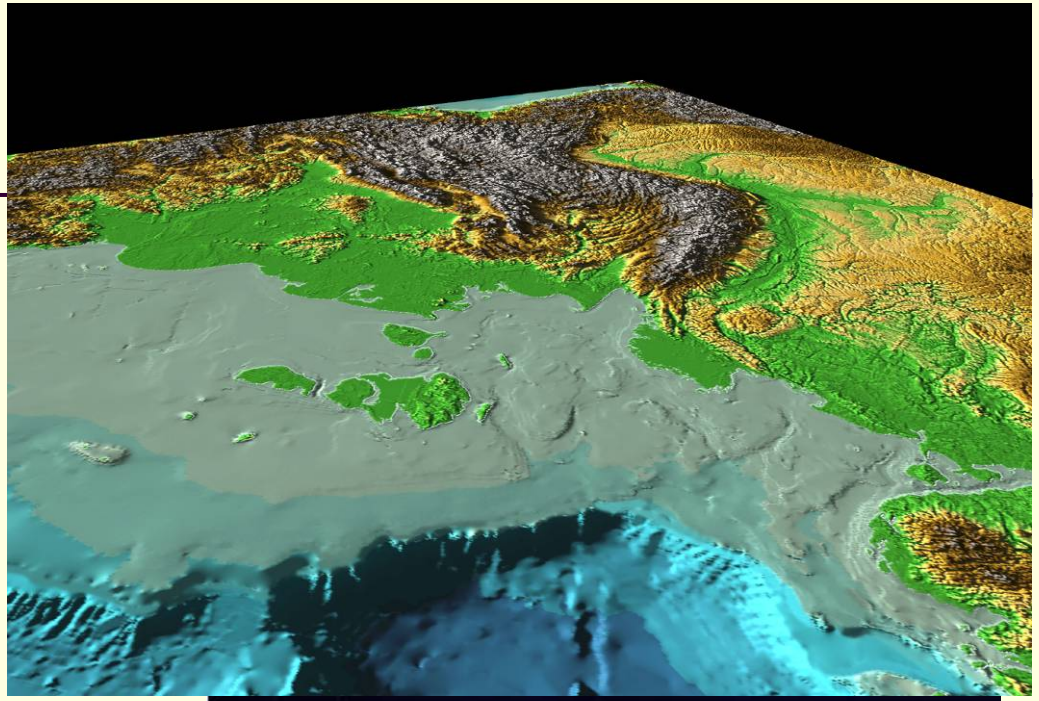
Safety
Individual
Immediate

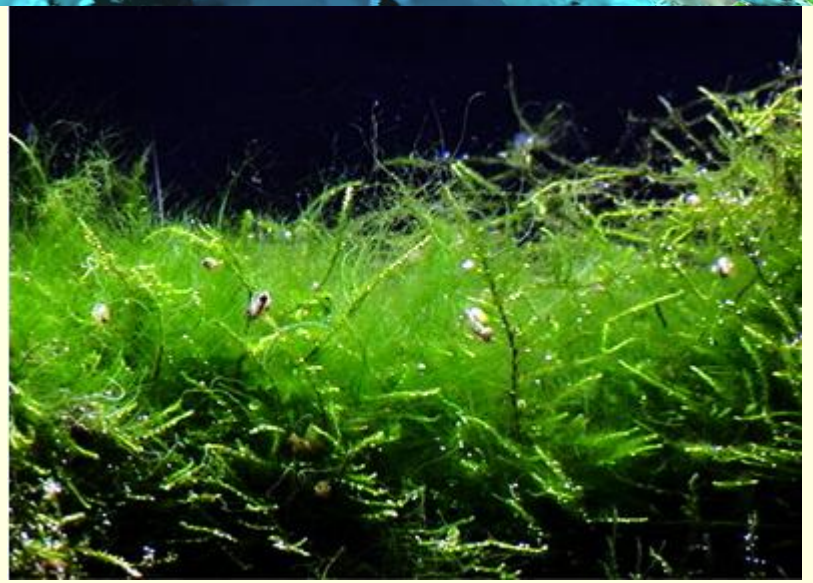
Security
Organization
Long Term

Sustainability
System
Continuous

More Oil?

Once upon a time,
200 million years ago…

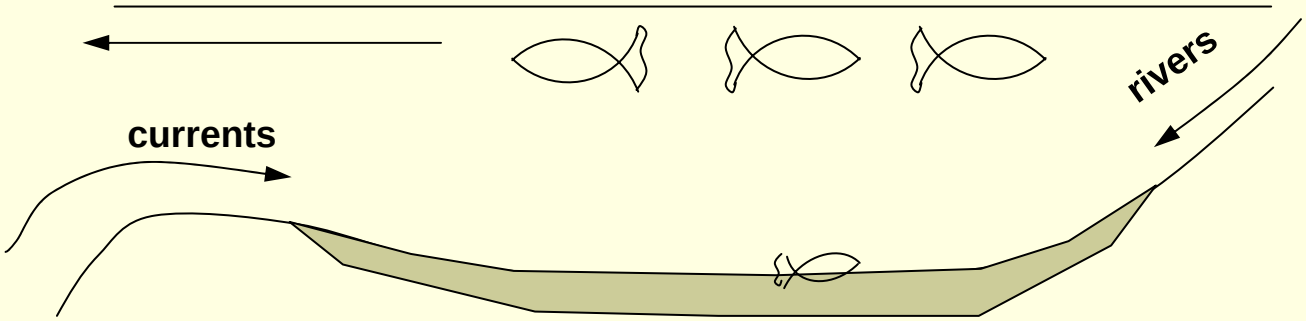




The shallow seas around continents were teaming with life

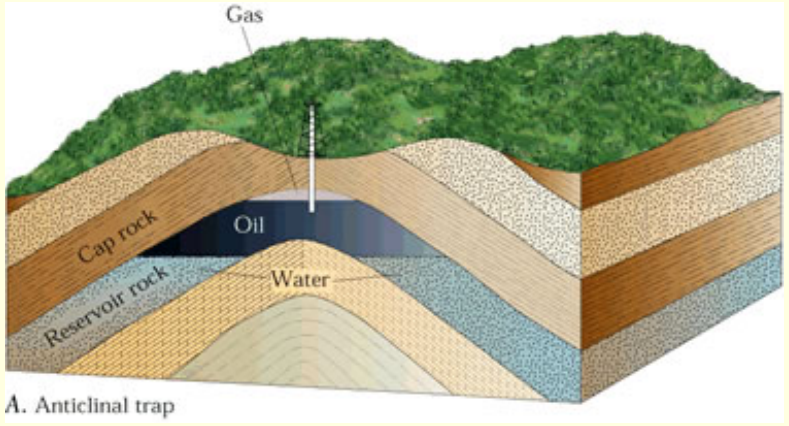
Recipe for Oil

- Prodigious plant and animal growth
- Marine nutrient trap
- 2300 – 4600 meters of sedimentation
- 82^{o} – 145^{o} C
- A few 10's of millions of years



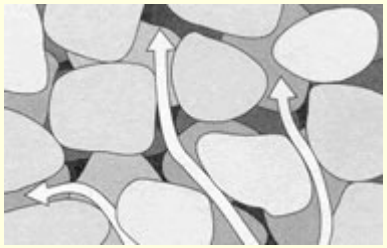
Oil Reservoirs

- The hydrocarbons are lighter than water and will migrate up to the surface unless they get trapped



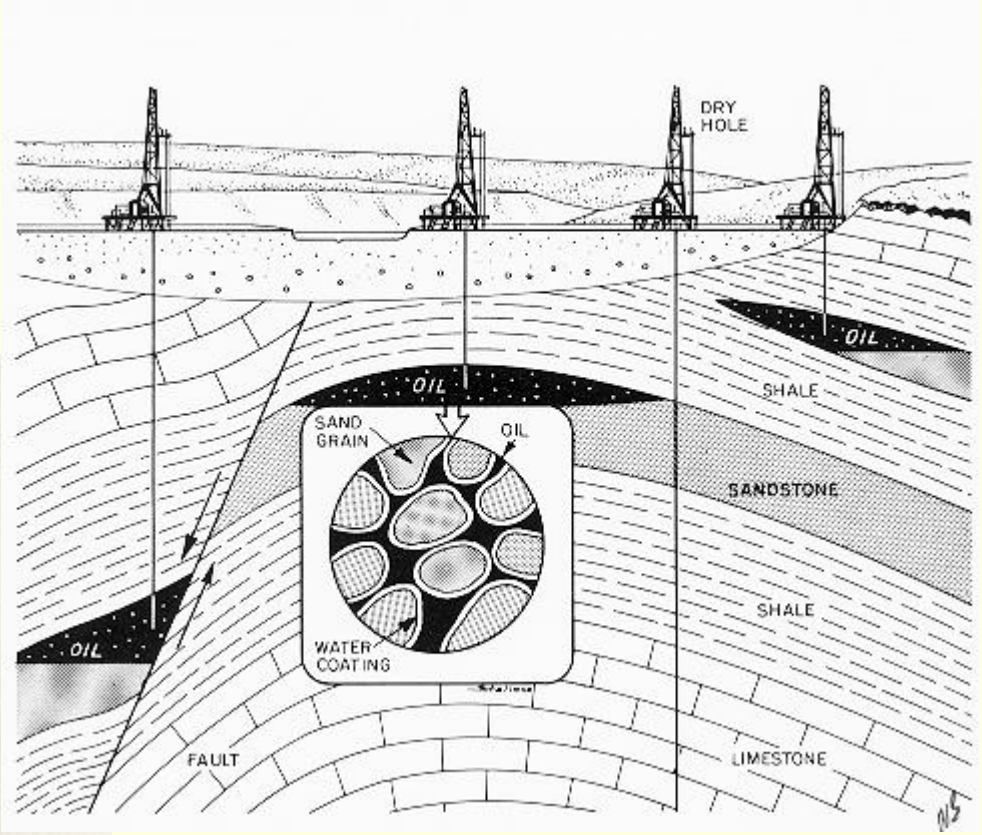
A. Anticlinal trap

- The oil can't be extracted unless the source rock is porous and permeable.



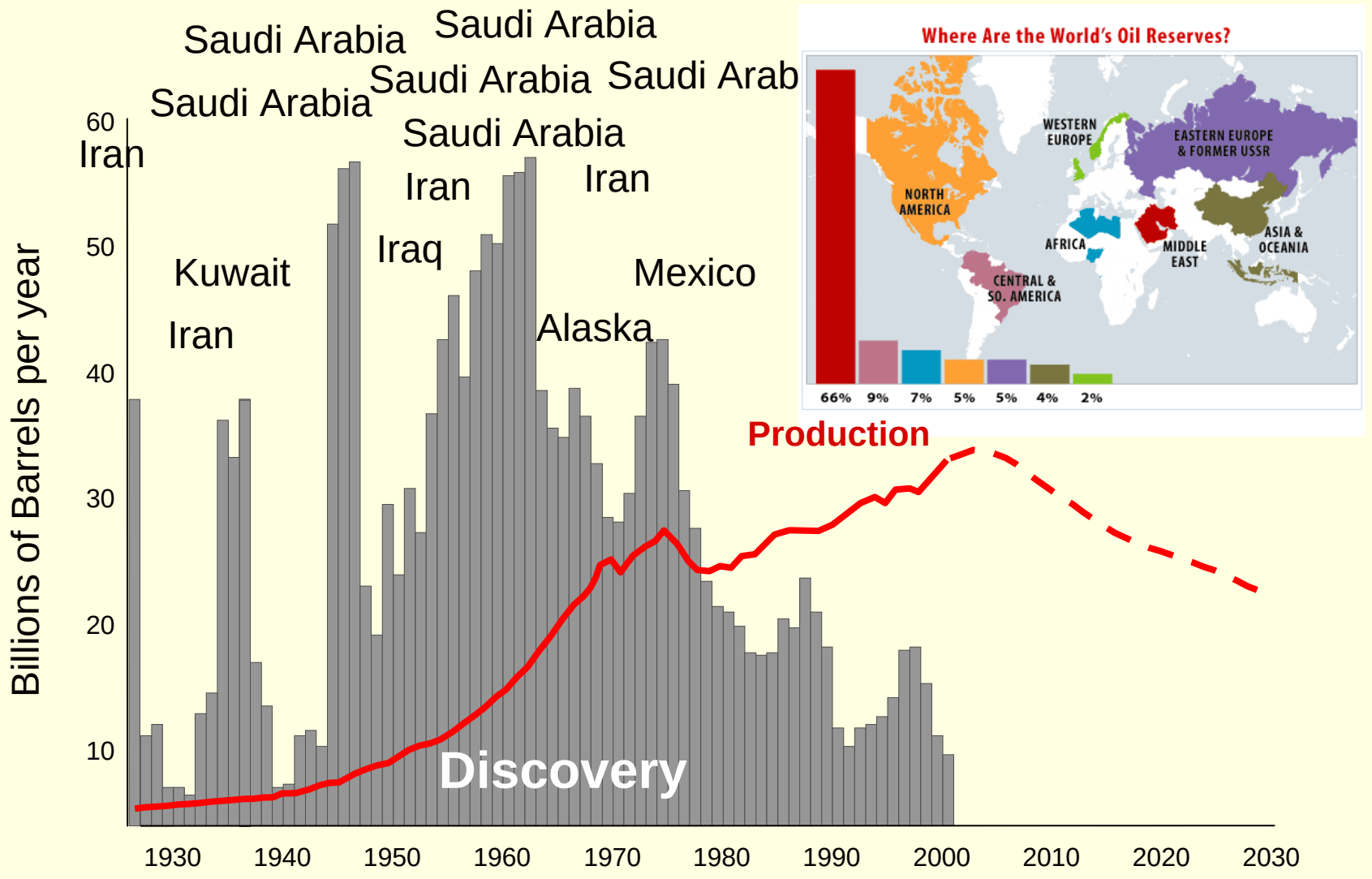
The Oil Field

Trapped oil under pressure



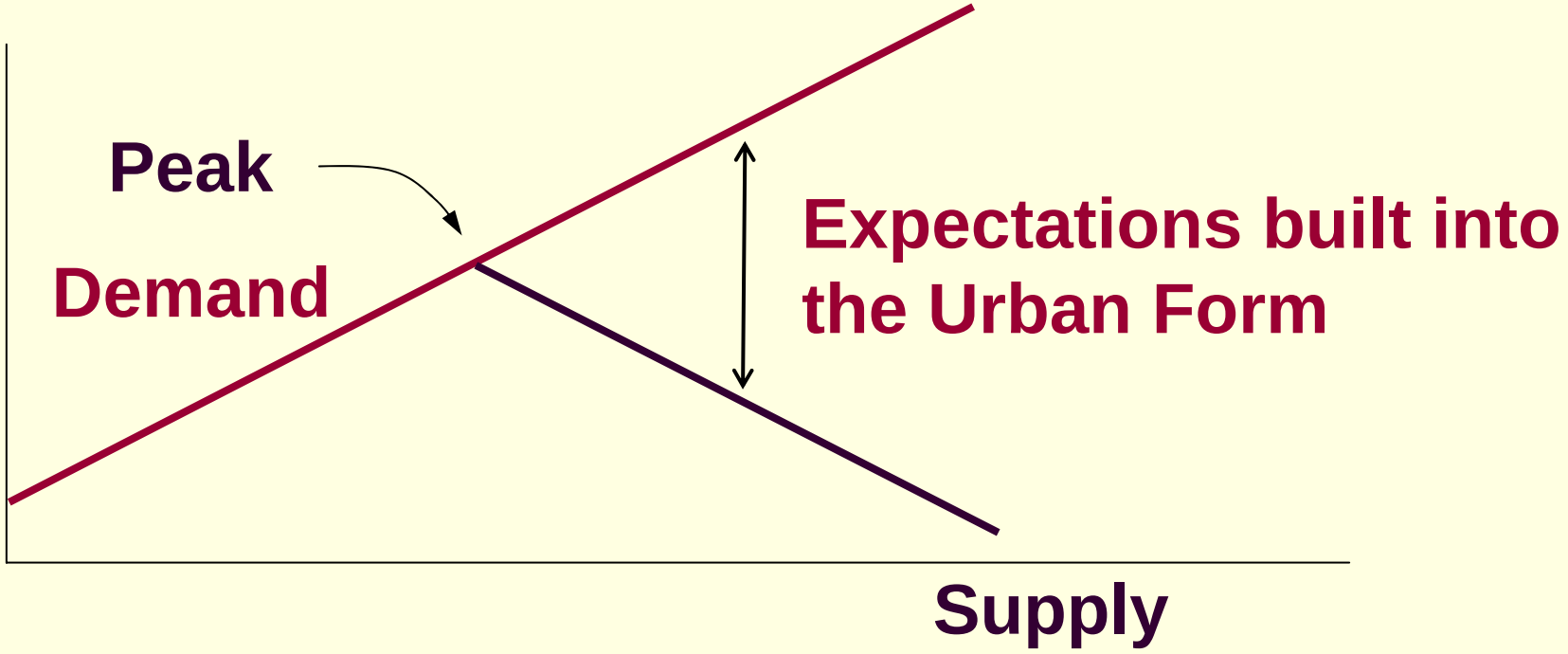
Source Rock

Giant Consumption is a Real Problem

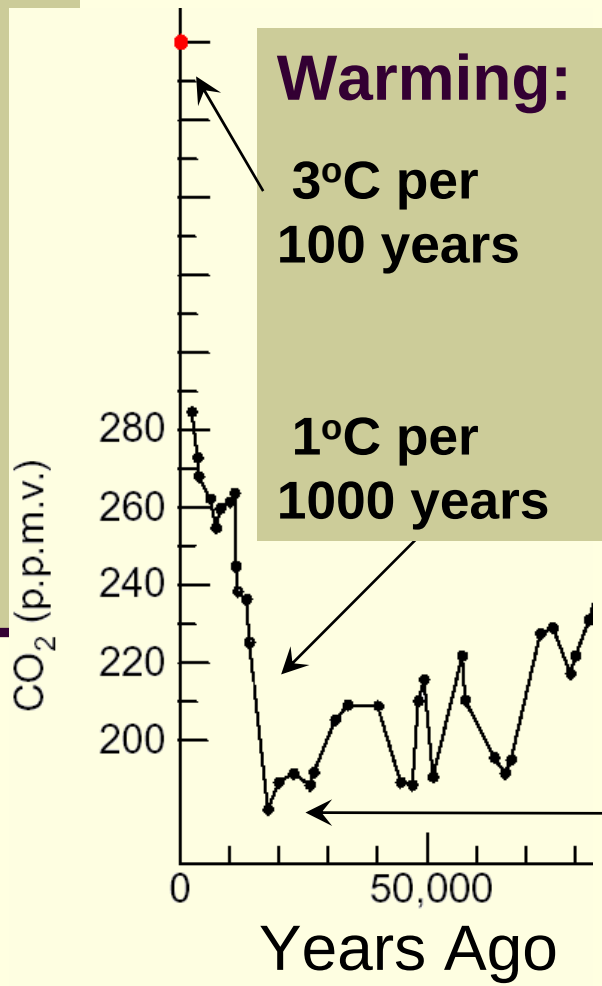


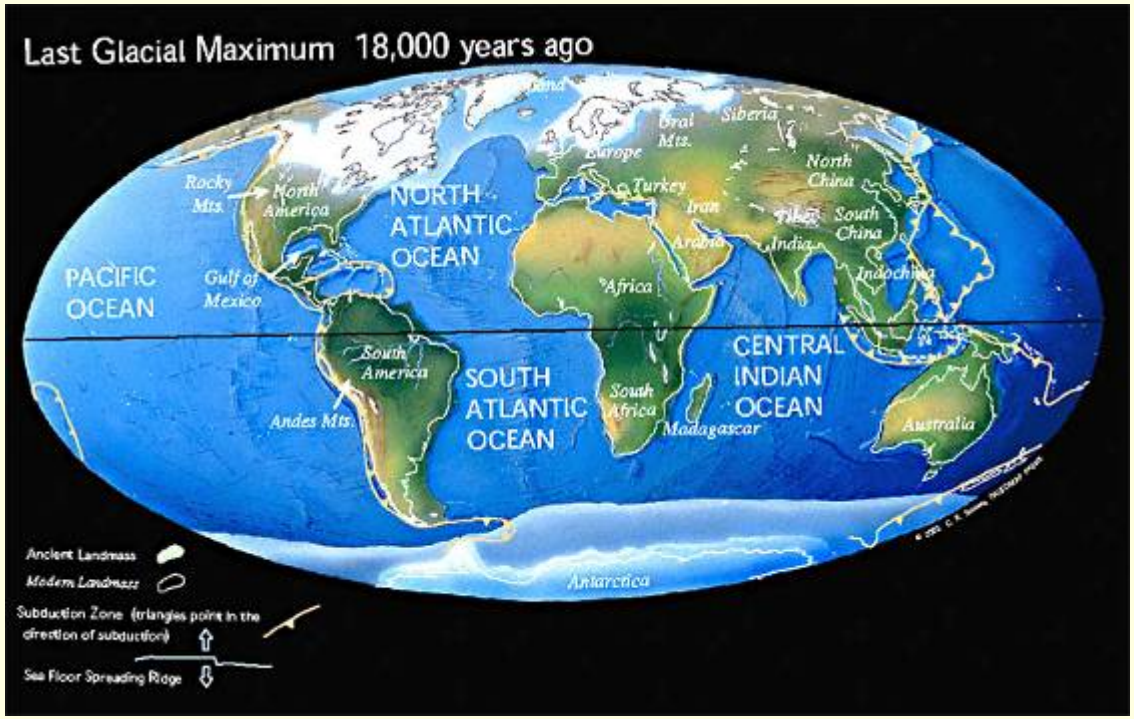
Security is a Real Problem

- Currently 1-4% Annual Fuel Demand Growth
- Peak in World Oil Supply (2005)
- 2-4% Petroleum Consumption Decline



Climate Change is a Real Problem

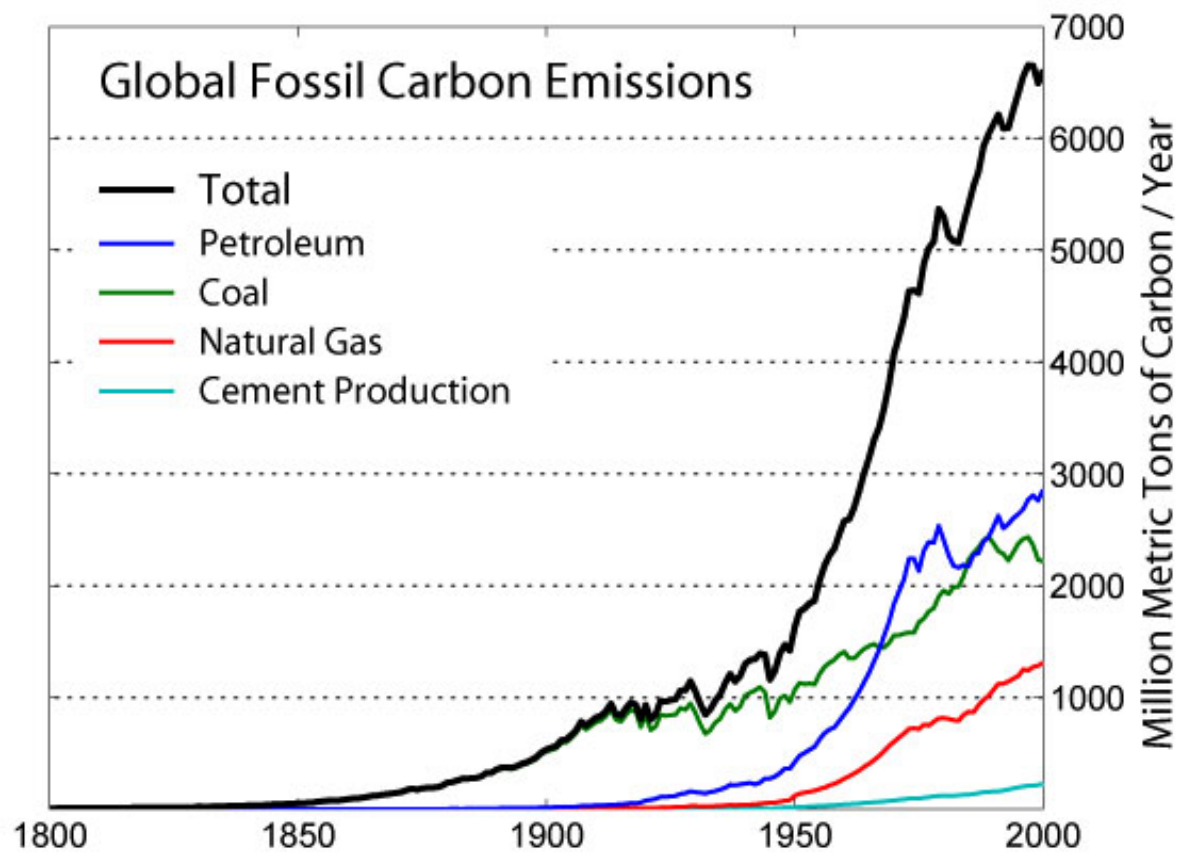




Glacial Maxima

M. Bush, M. Silman, D. Urrego, Science 303 (2004) 827-829

Burning Fossil Fuel is the CO_2 Problem



This is your Engineering Problem Definition

Possible Solutions?

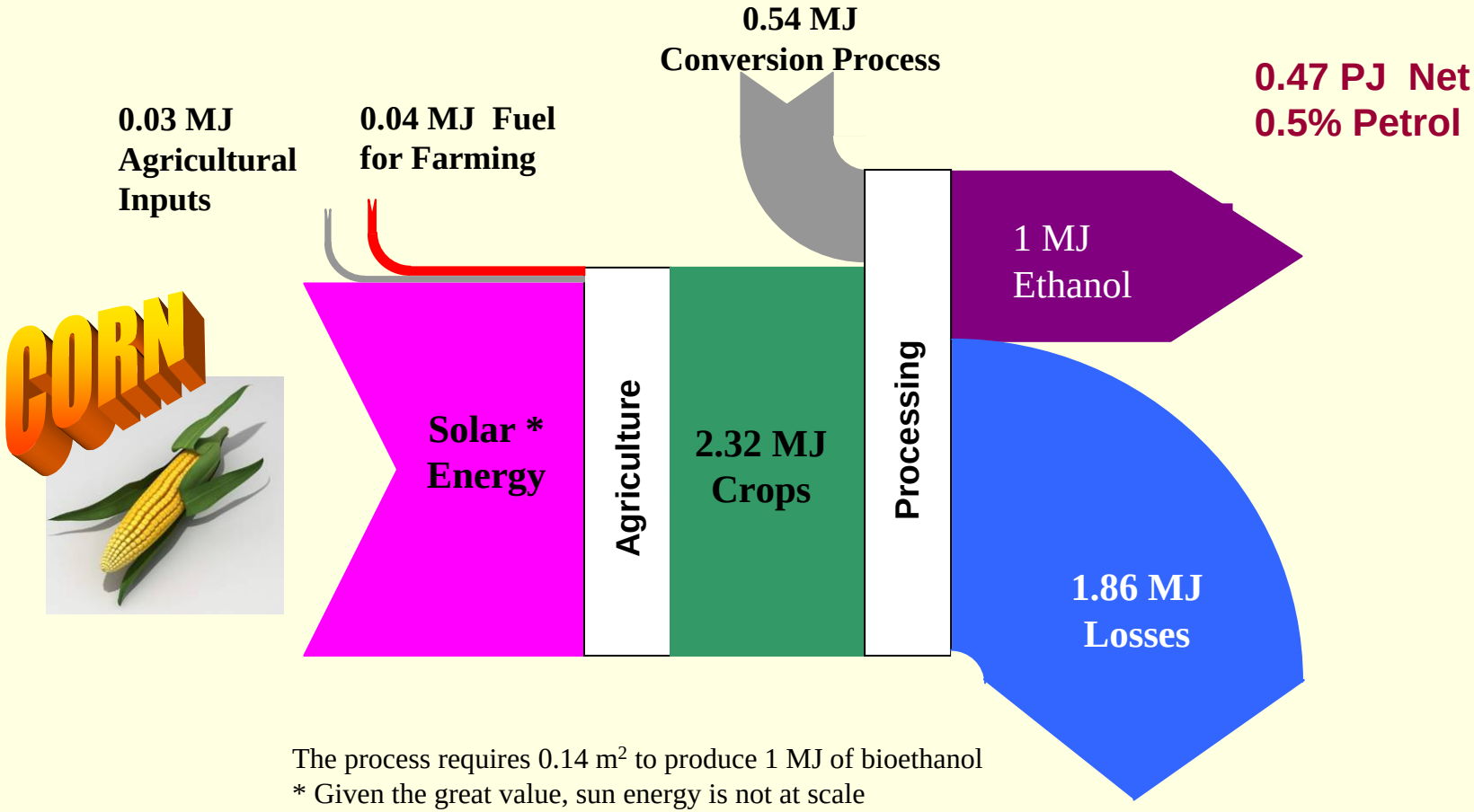
Biofuel

What about Biofuels?

- Do they “fill the gap”?
- What resources can be used?
- What inputs are required?
- What is the processing?
- What’s the return on investment?

Our Biofuel Study

Current NZ Crops and Agricultural Wastes



The process requires 0.14 m^2 to produce 1 MJ of bioethanol

* Given the great value, sun energy is not at scale

Waste to Transport Fuel

Doesn't improve sustainability

Whey

1.5 PJ Net
1.5% Petrol

Chip Oil

Wood

Wastes already being used instead of fossil fuel in processing, domestic and industrial heating and boilers!

Total Crop and Waste Ethanol

- Food Crops Converted to Fuel:
  - Corn, Wheat, Barley, Potatoes

Ethanol Energy - Fossil Energy Input = 1359 PJ

1.2% of NZ Petrol Use 2004

- Waste Streams:
  - Kiwi, Whey

Ethanol Energy - Fossil Energy Input = 0.17 PJ

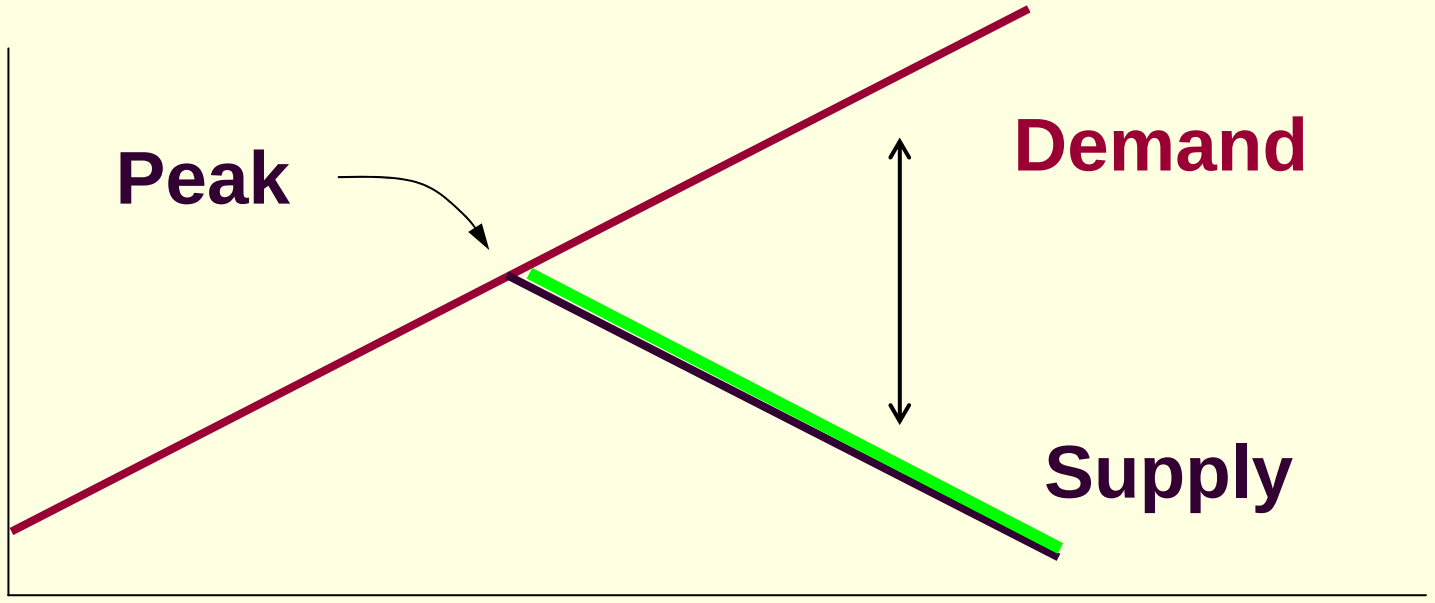
0.1% of NZ Petrol Use 2004

Still have that security problem!

- Tallow & Rapeseed

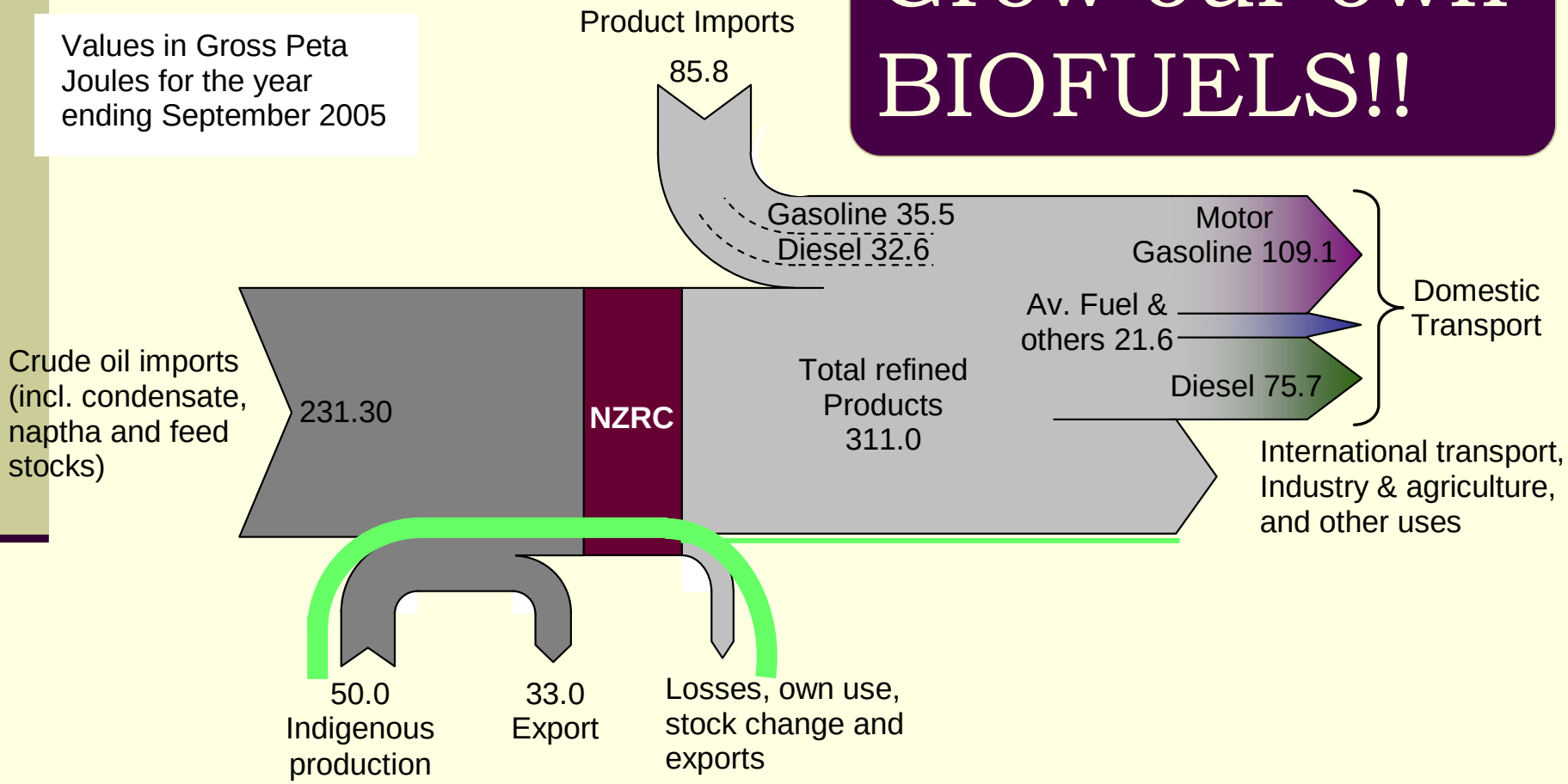
Biodiesel Energy - Fossil Energy Input = 8.461 PJ

8.25% of NZ Diesel Supply 2004



Still burning giant amount of oil!

Grow our own BIOFUELS!!



New Zealand is Dependent on World Oil Market

Biofuels not the Panacea for us

But we've got to do something…. We've got to start somewhere….

If Biofuels aren't the answer…?

- What are we going to do to be able to use less fossil fuel and produce less CO_2?

Demand Side Management

Demand Side Management Projects

Experience in Electricity Supply

- Alternatives
- Analysis and Modelling
- Decisions
- Implementation
  - Demonstration Projects, Pilot Studies
  - Incentives, Marketing
- Monitoring of Programmes

My Family's Week

Work, School, Church, Shop, Volleyball, Choir = 169km

DSM Results:

	Oil Reduction
Drive the Caldina instead of the Van (6 L/100km instead of 10 L/100km)	40%
Share Rides	21%
Give up Volleyball	15%
Eat the corn, ride the bike	33%
Ferment the corn, drive the car (2% Ethanol)	1%

Vehicle Fuel Efficiency

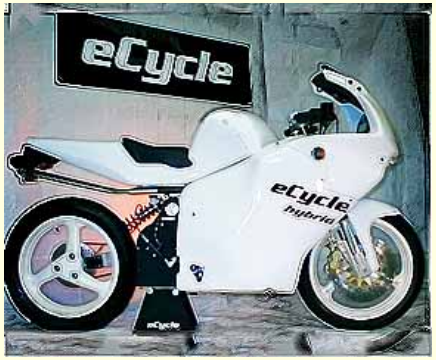
Energy Efficiency Improvement

Diesel Car (same size) 20-50%

Petrol Hybrid (same size) 5-30%

Down-Size Petrol Vehicles 30-60%

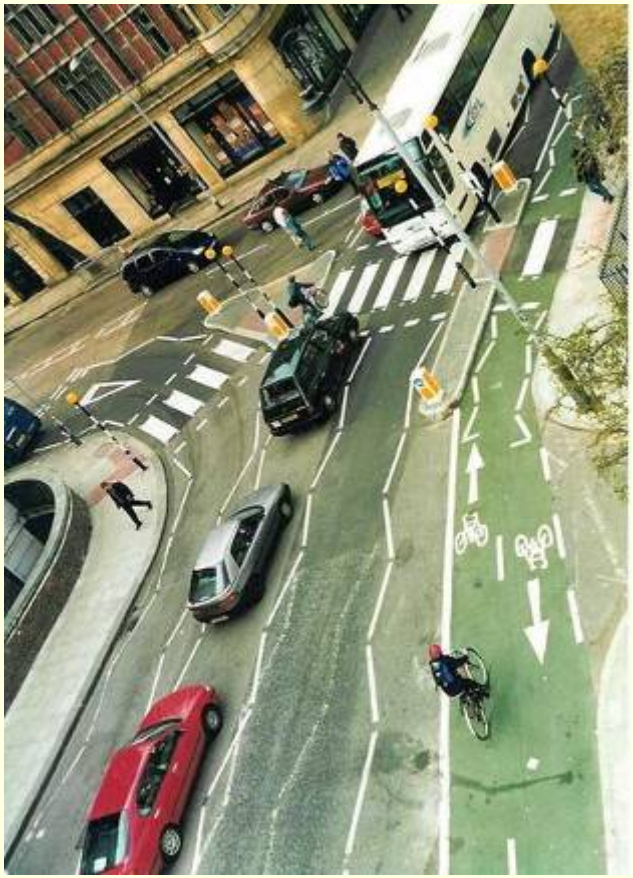
Motor Cycles and Scooters



Just have to buy a new car!

Travel Efficiency

Mode Shift and Destination Shift



May even SAVE money!

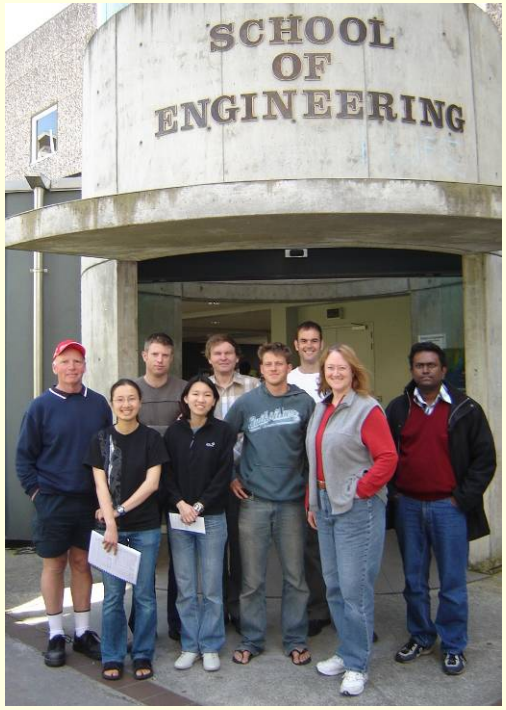
Transformation

Engineering Forward

- EROI Must be Positive
- Productive, Sustainable Land Use
- Oil Production/Consumption Decline
- 50% reduction of CO_2 emissions by 2020

Engineering Research

Sustainability

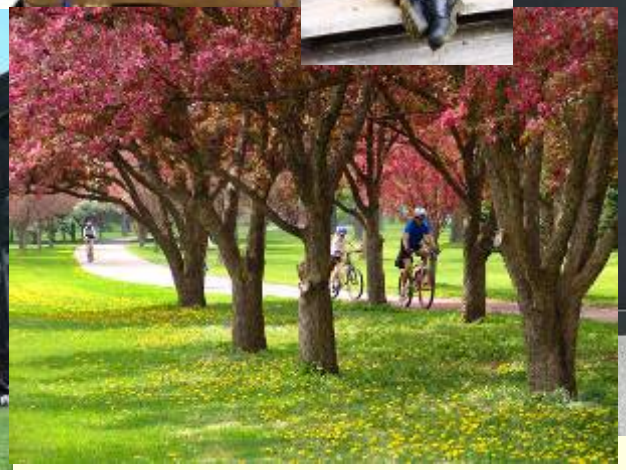


AE&M SYSTEMS LAB

Advanced Energy and Material Systems Lab

Renewable Energy City

Silke Project



Local Food Production

- Reclaimed paved space
  - 55% of fresh produce, dairy & poultry grown within the urban form

Zero Food Miles

Silke Project

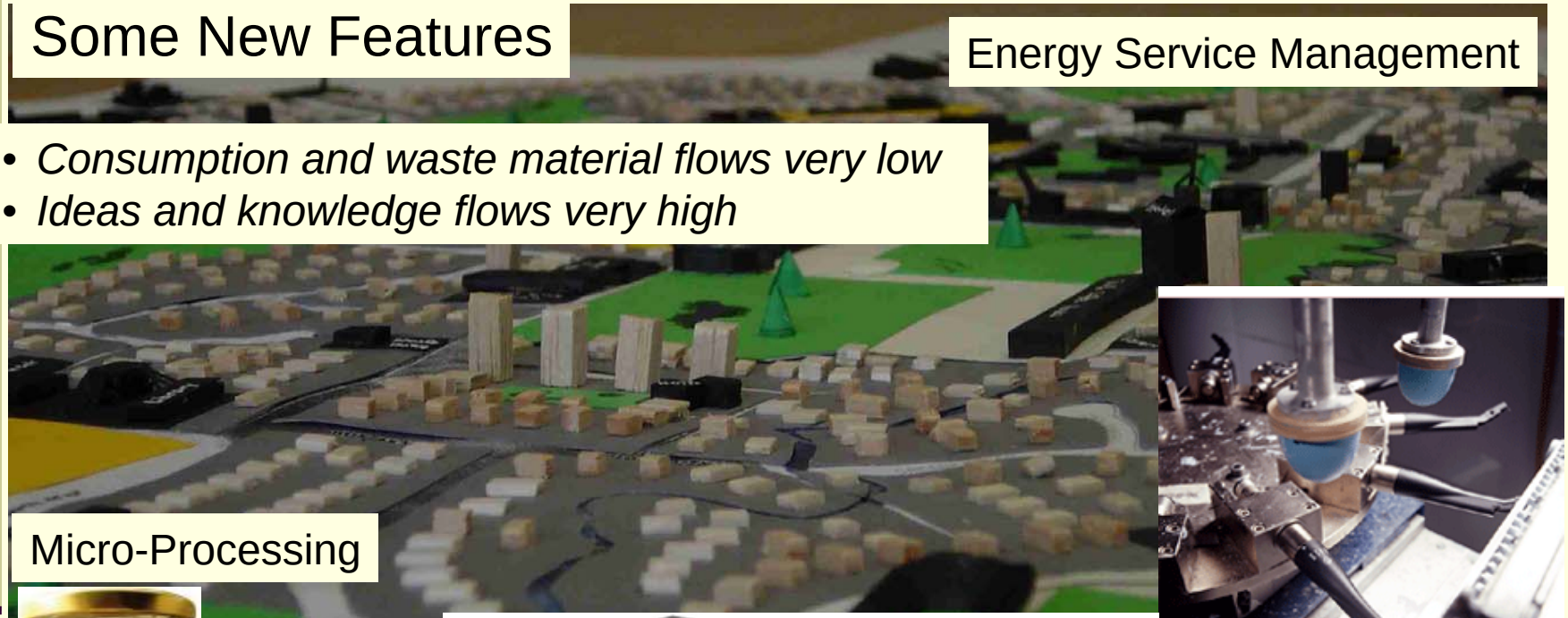
Production and Manufacturing

Silke Project

Some New Features

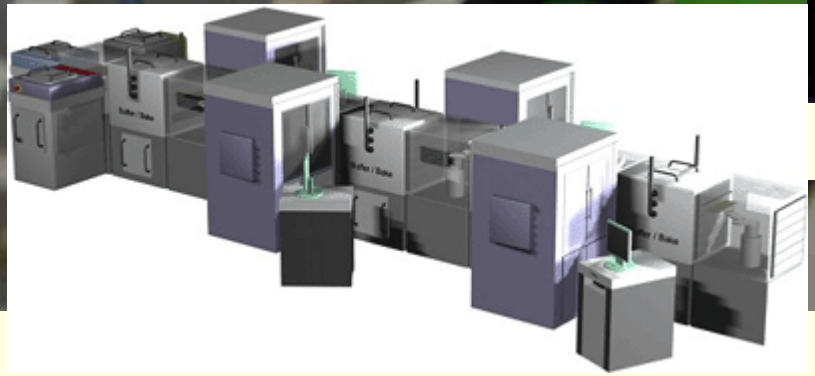
- *Consumption and waste material flows very low*
- *Ideas and knowledge flows very high*

Energy Service Management



Micro-Manufacturing

Micro-Processing



Renewable Energy Transport

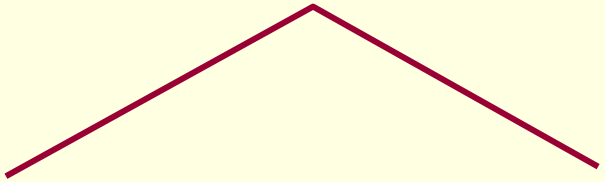
Silke Project

Research for Security

Risk Assessment

Demand Side Management

- Objectives:
  - Maintain security of transport activities
  - Affordability of transport and infrastructure
- Strategic Goals:
  - Reduce GHG emissions
  - Reduce Oil Imports
- Mutual Benefit – Supplier and Consumers



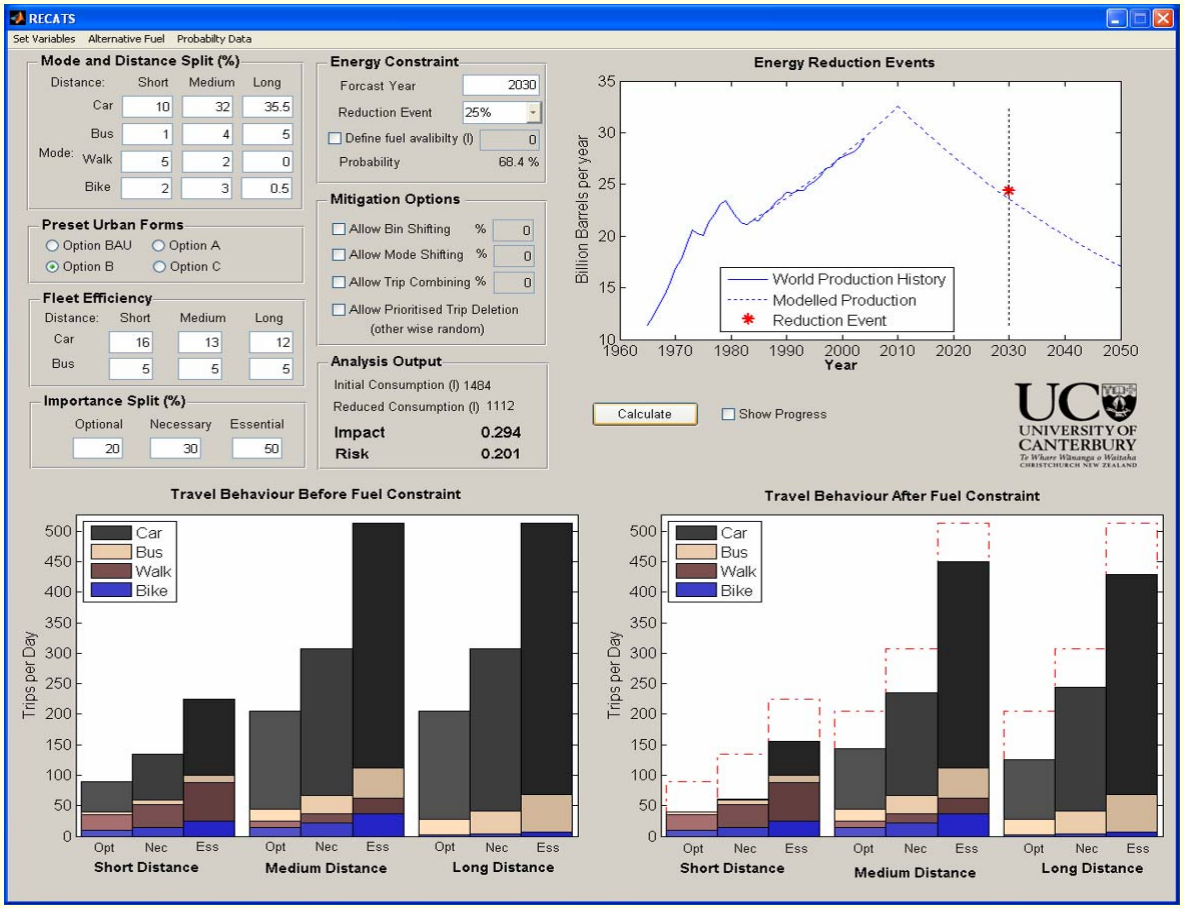
Supply & Demand

Risk Assessment

Research for Security

Energy Risk to Essential Activities as a Function of Urban Form

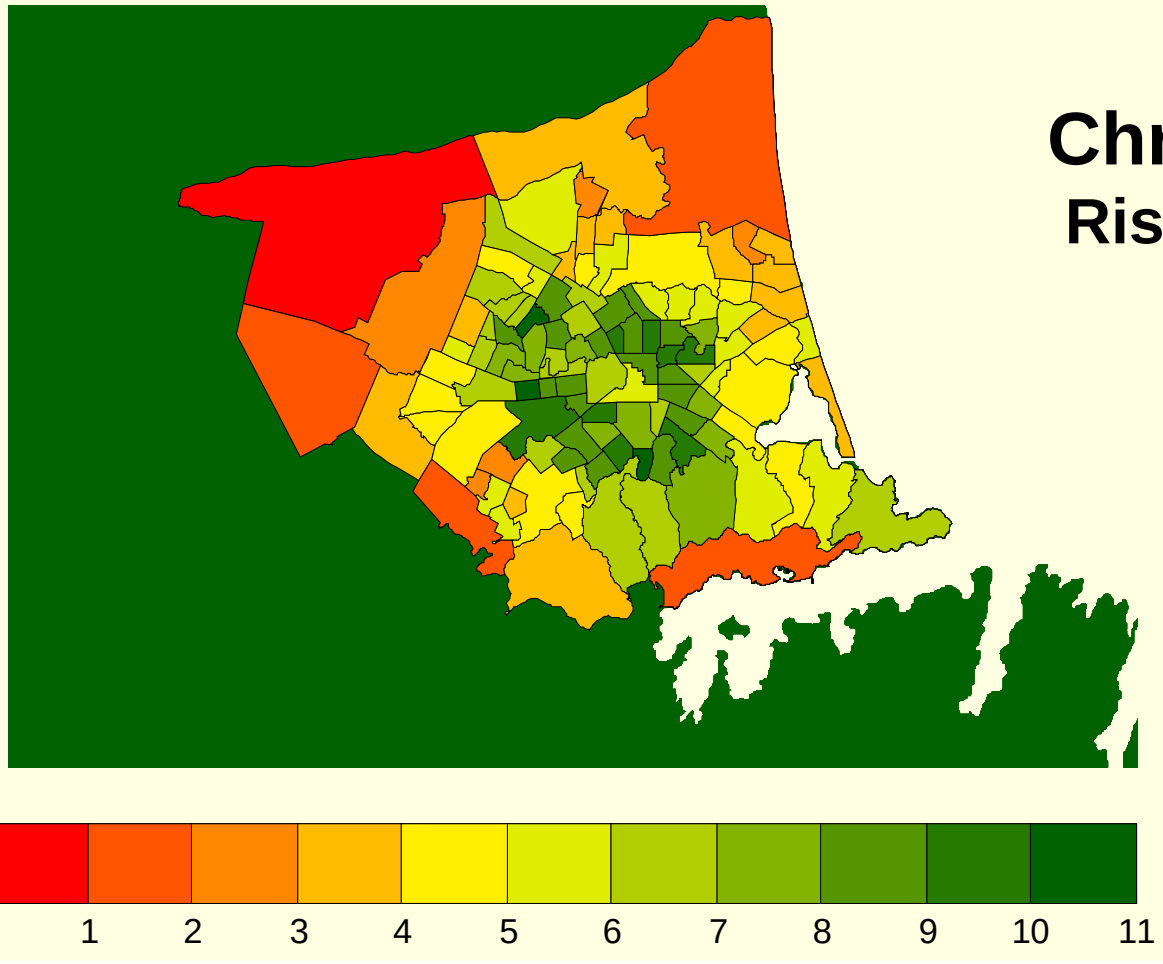
RECATS



Research for Security

Risk Assessment

Energy Risk to Essential Activities as a Function of Urban Form



Christchurch
Risk Factors

RECATS

MWH

DSM & Adaptability

Transport DSM Research

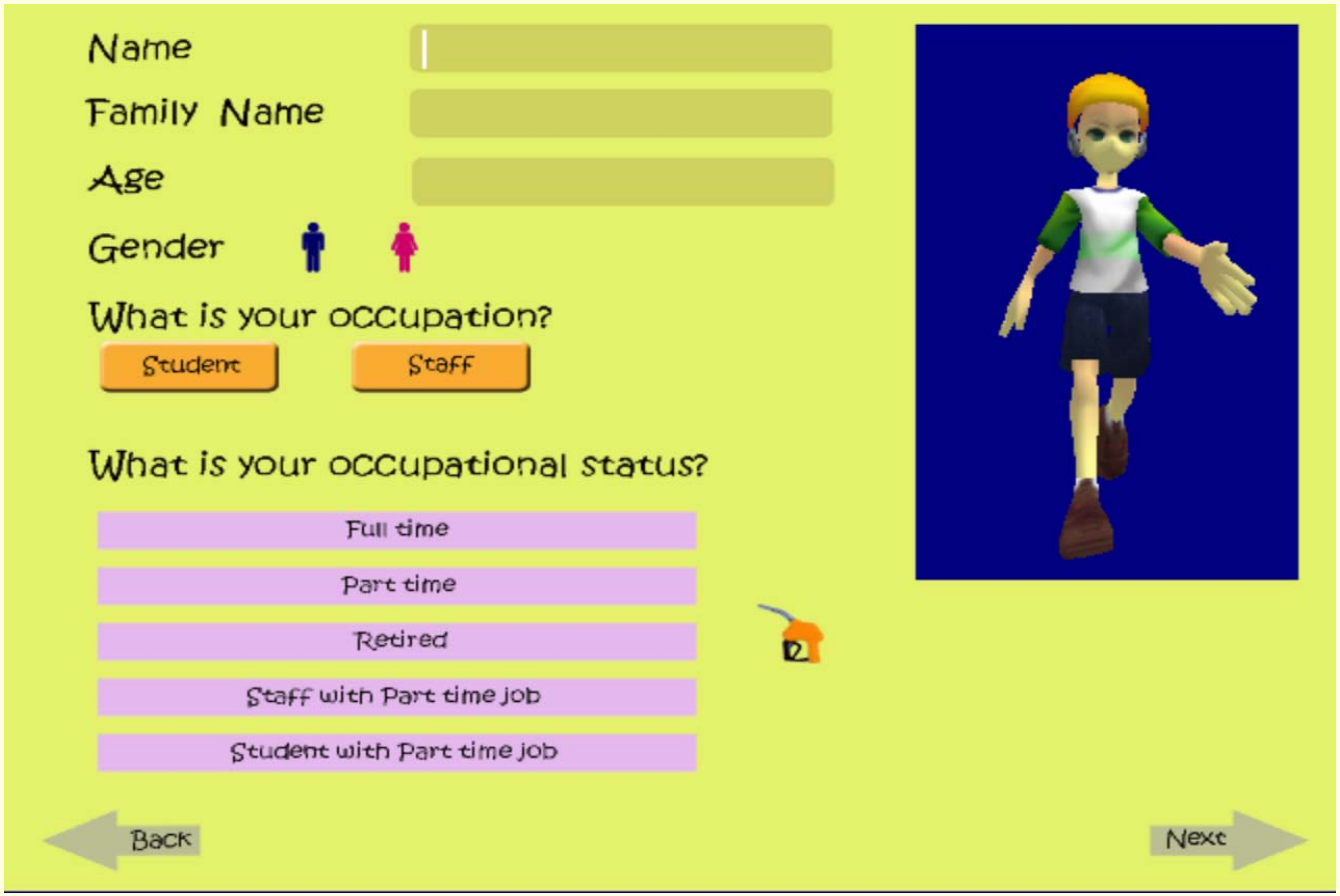
Help customers understand their travel,
how to reduce fuel use and
learn secure mode and destination options

Travel Activity Constraint Adaptability Simulation

TACA Sim

DSM & Adaptability

Rapid Travel Demand Assessment



Level 1: Personal Information

TACA Sim

DSM & Adaptability

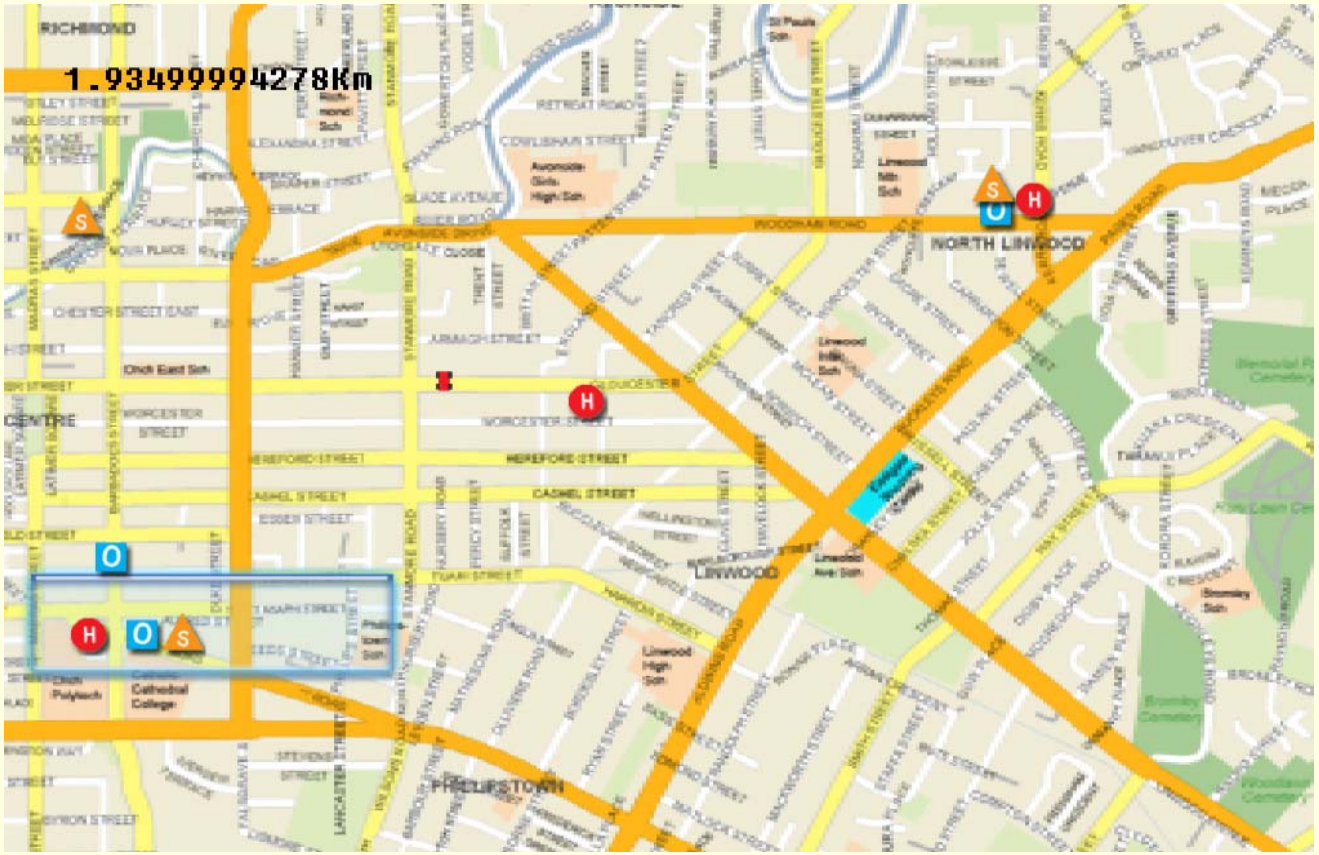
Rapid Travel Demand Assessment

Level 2: Travel Activities

TACA Sim

DSM & Adaptability

Rapid Travel Demand Assessment

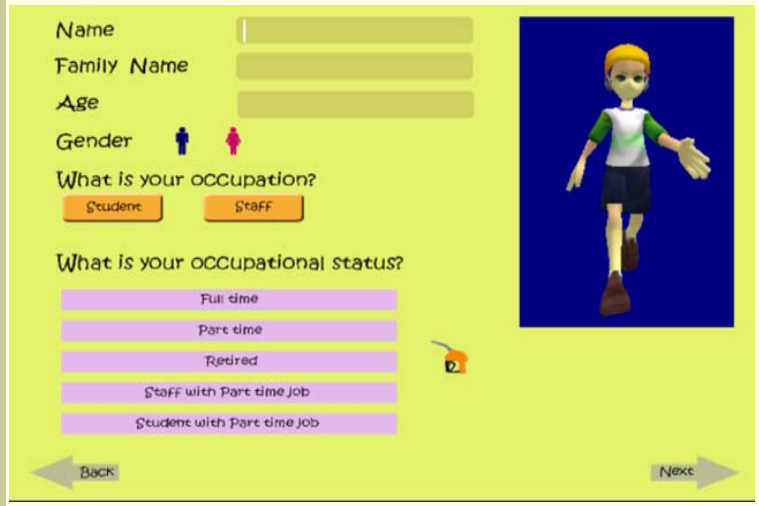


Level 2: Travel Destinations

TACA Sim

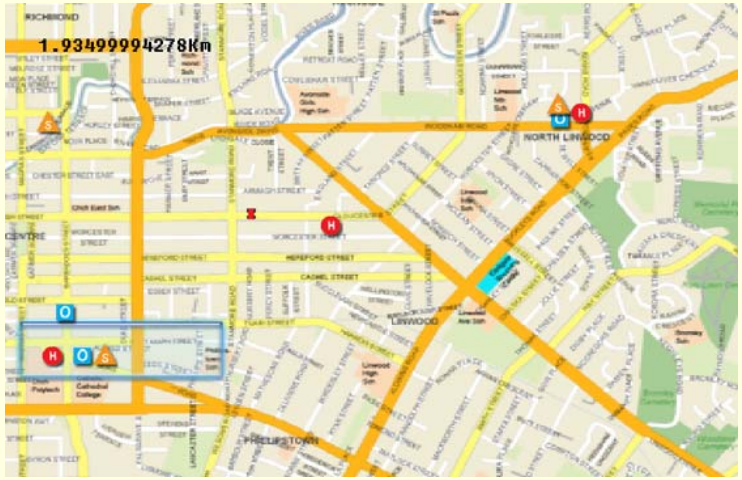
DSM & Adaptability

Options? Travel Behaviour Change -



Identify and Evaluate options for each activity

Learn new trip modes through role playing game



Transport Adaptability

What happens if you change your car or move to another place?

DSM & Adaptability

Mutually Beneficial Relationship

Supplier & Customers

Don't Panic

Conclusion:

Problems:

- *Unavoidable insecurity in Fossil Fuel supply*
- *Irreversible, unsustainable environmental impacts that threaten survival*

Solutions from Innovations in

Risk Assessment
Demand Side Management
Adaptation

Discussion

Survival

Safety
Individual
Immediate

Security
Organization
Long Term

Sustainability
System
Continuous