

Energy Risk to Essential Transport Activities

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What happens if we work together?

Mechanical Engineering



Civil Engineering

Reduce Fossil Fuel Consumption?

- As a Rational Response to Environmental Signals



Response to



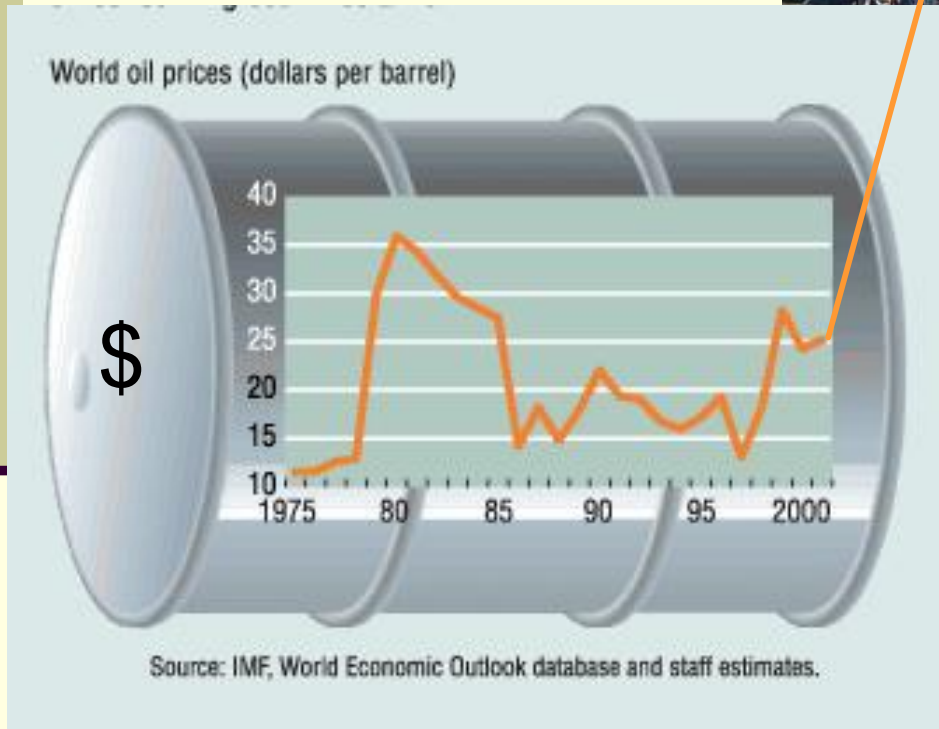
- As an Unplanned Consequence of Fuel Shortages



Are we prepared for these

There is a Possibility...

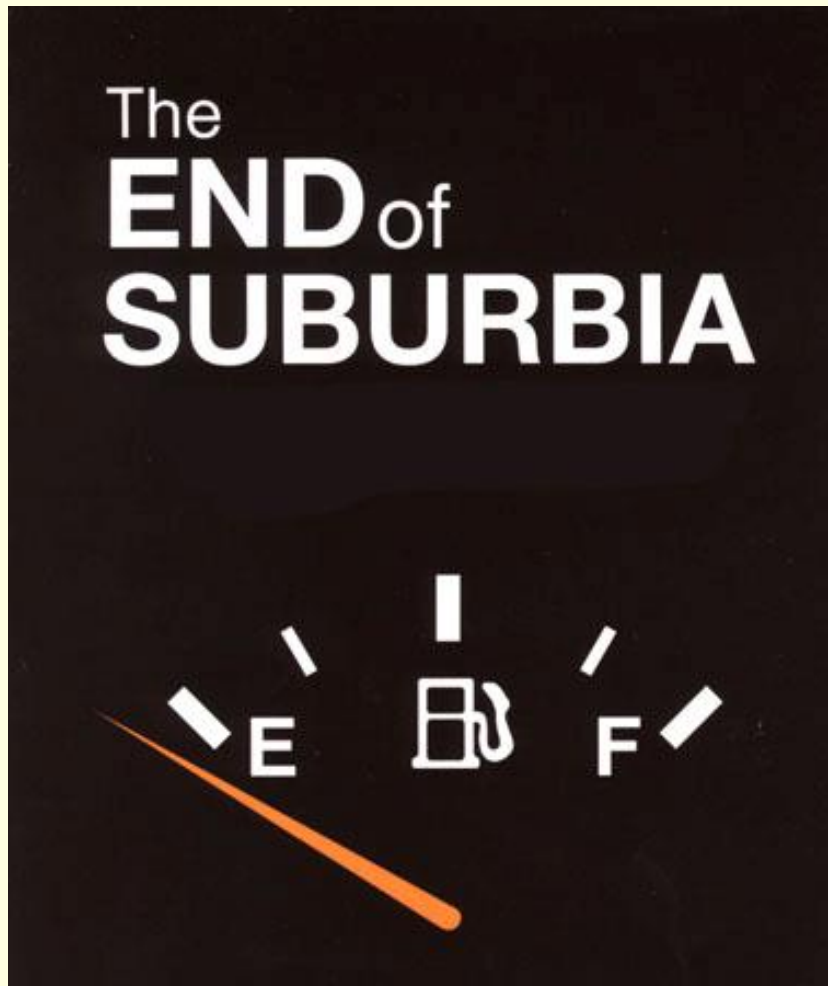
- Fuel Shortage
- High Price



Published January 14, 2003
2005 Minneapolis Star Tribune

That there will be a problem

Peak Oil is a problem because...



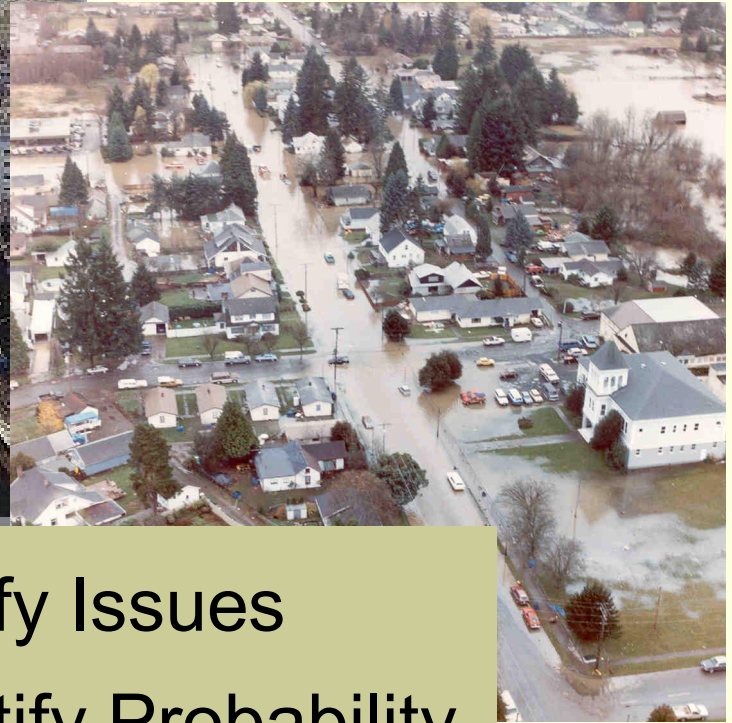
It's not accounted for in the original design and operation

It is an issue we don't have a plan to deal with

Therefore it poses a RISK

How do you deal with a Risk?

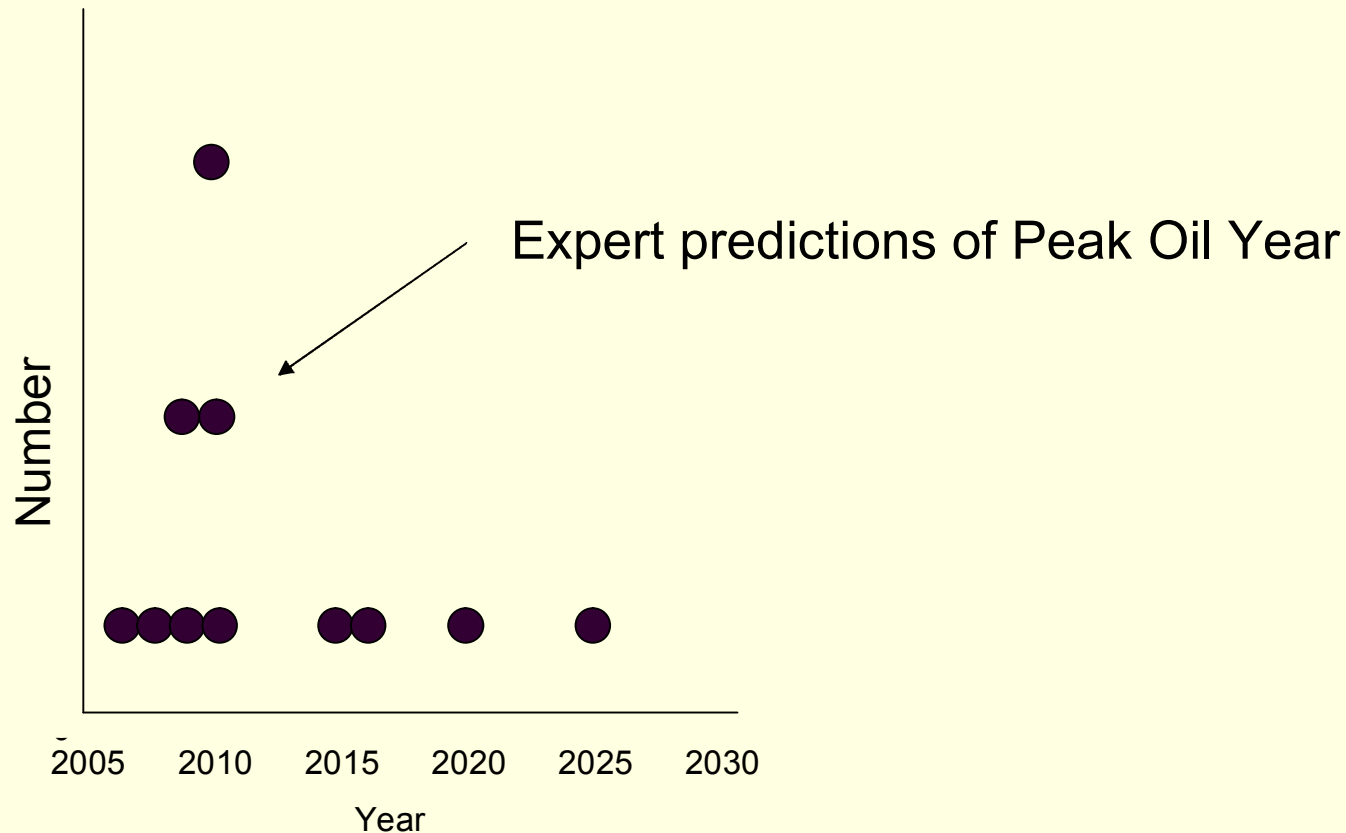
Risk Analysis and Mitigation



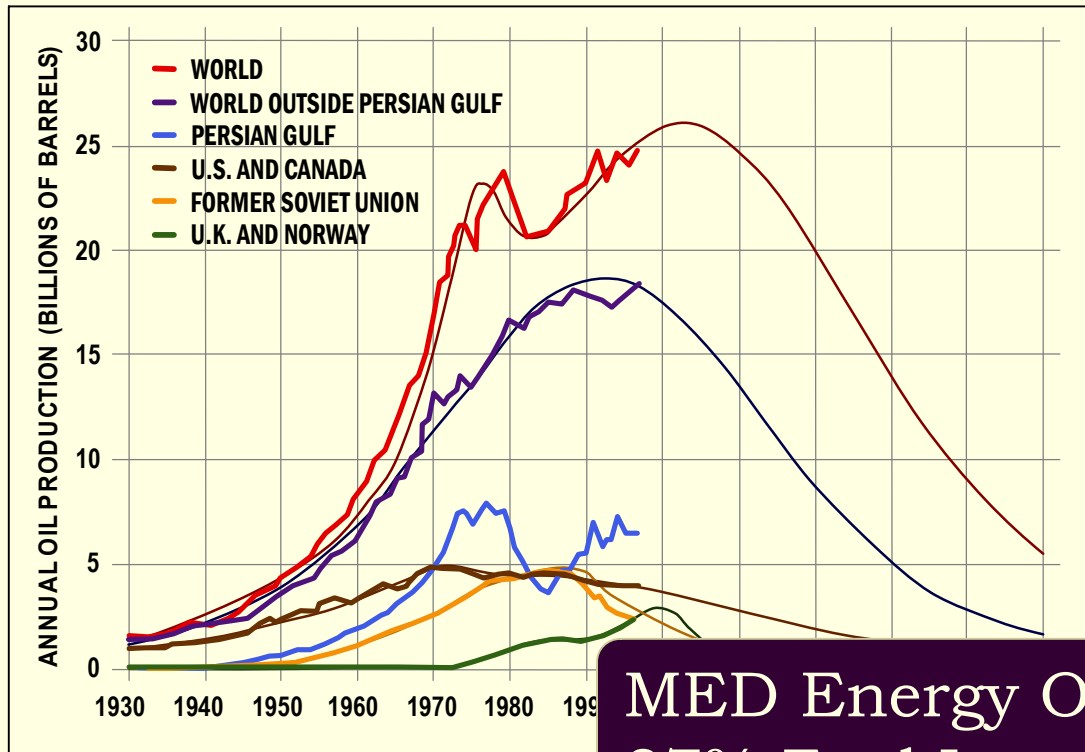
- Identify Issues
- Quantify Probability
- Evaluate Impacts
- Model Risk Events

Probability of Peak Oil

$$CP(X) = \sum_{Y=2005}^Y \left(\frac{(r + y - 1 - 2005)!}{(y - 2005)!(r - 1)!} \right) \rho^r (1 - \rho)^{y-2005}$$



Probability of Fuel Shortfall



Shortage
20% Below 2005

2020 **8%**

2025 **60%**

2030 **91%**

MED Energy Outlook: BAU
37% Fuel Increase by 2030

Post Peak Oil Supply Decline neglecting cost or panic induced shortages

Technology Substitutes or Alternatives?

- Alternative Vehicles
- Alternative Fuels



Alternatives don't change the fact that an oil shortage represents a change in the amount of oil currently being used.

Risk to Transportation Activities

BBC NEWS

Friday, 15 September, 2000, 11:44 GMT 12:44 UK

School closures worsen in fuel crisis



The number of closed schools has more than doubled. The fuel shortage has forced more schools than ever to close - with forecasts of worse to follow next week. The Department for Education says that there are 131 schools closed in England on Friday - affecting more than one in 10 local education authorities.

www.news.bbc.co.uk

Peak Oil and the subsequent Supply Decline

How does this impact
Wellbeing?

Transport Essentiality

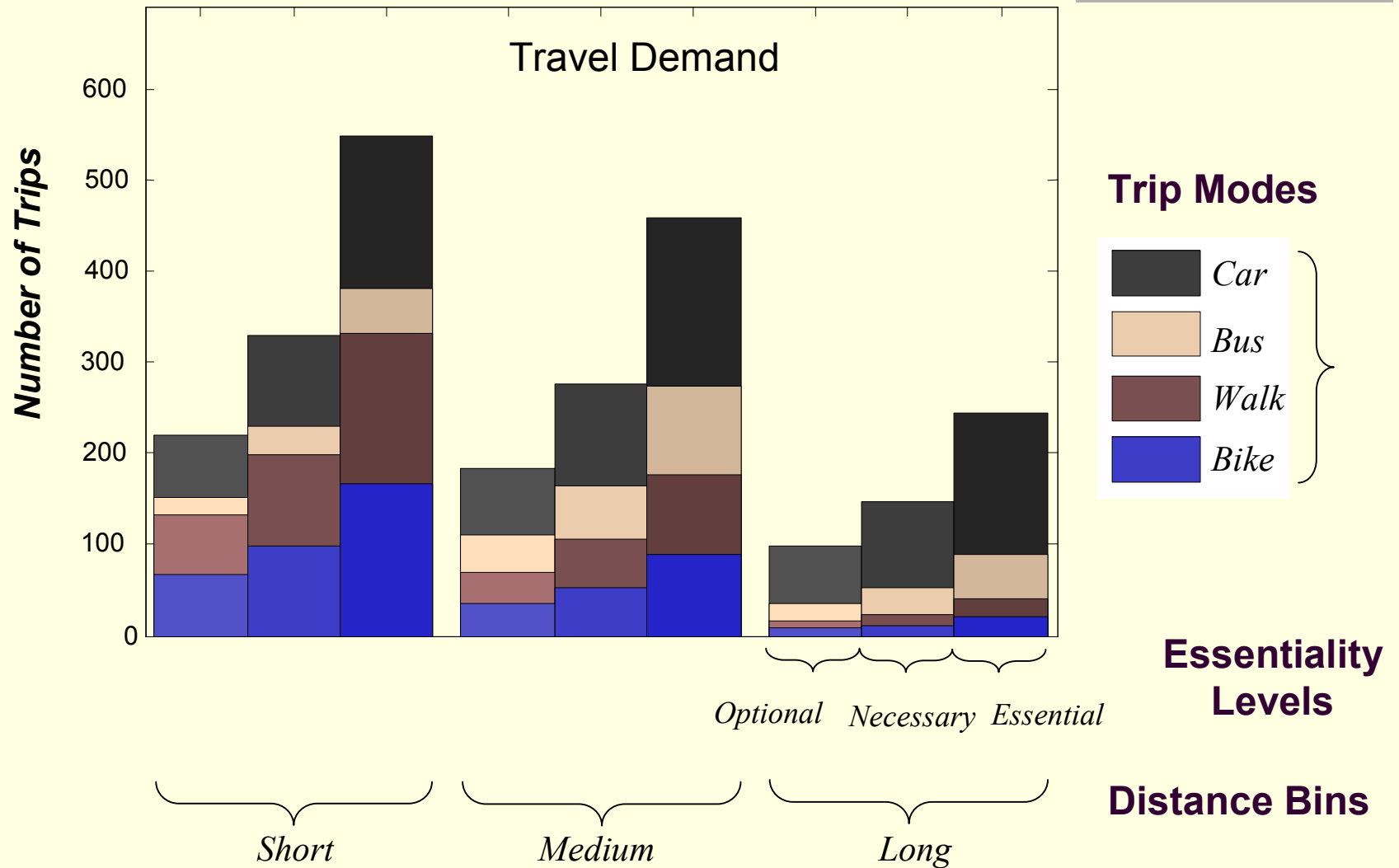


- Optional
- Necessary
- Essential



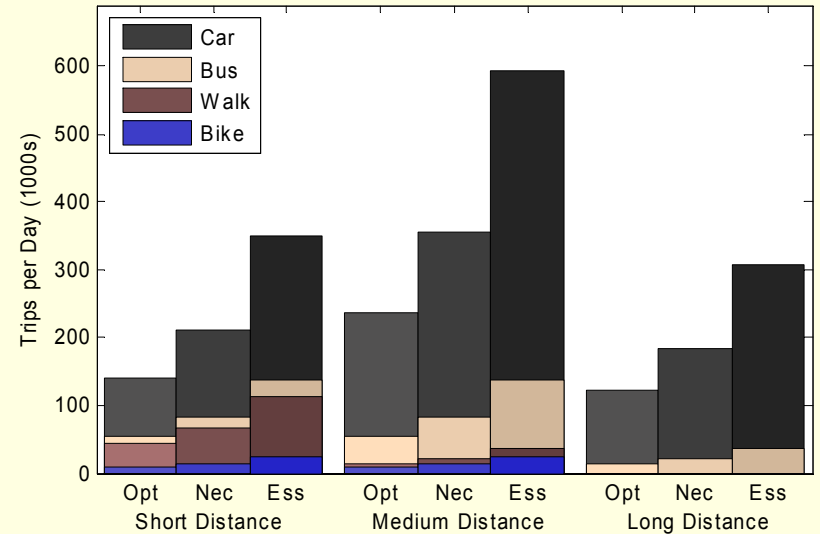
For Wellbeing

Travel Demand

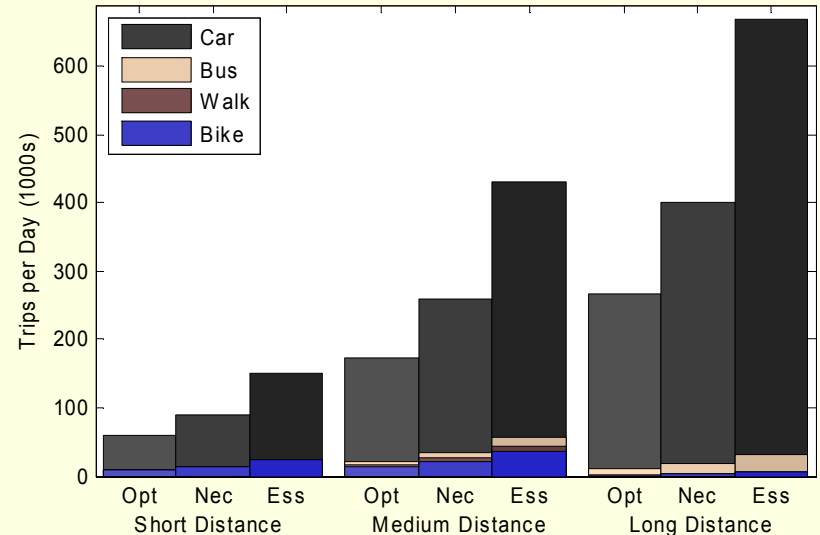


Travel Demand and Urban Form

High Density



Low Density



Energy Demand

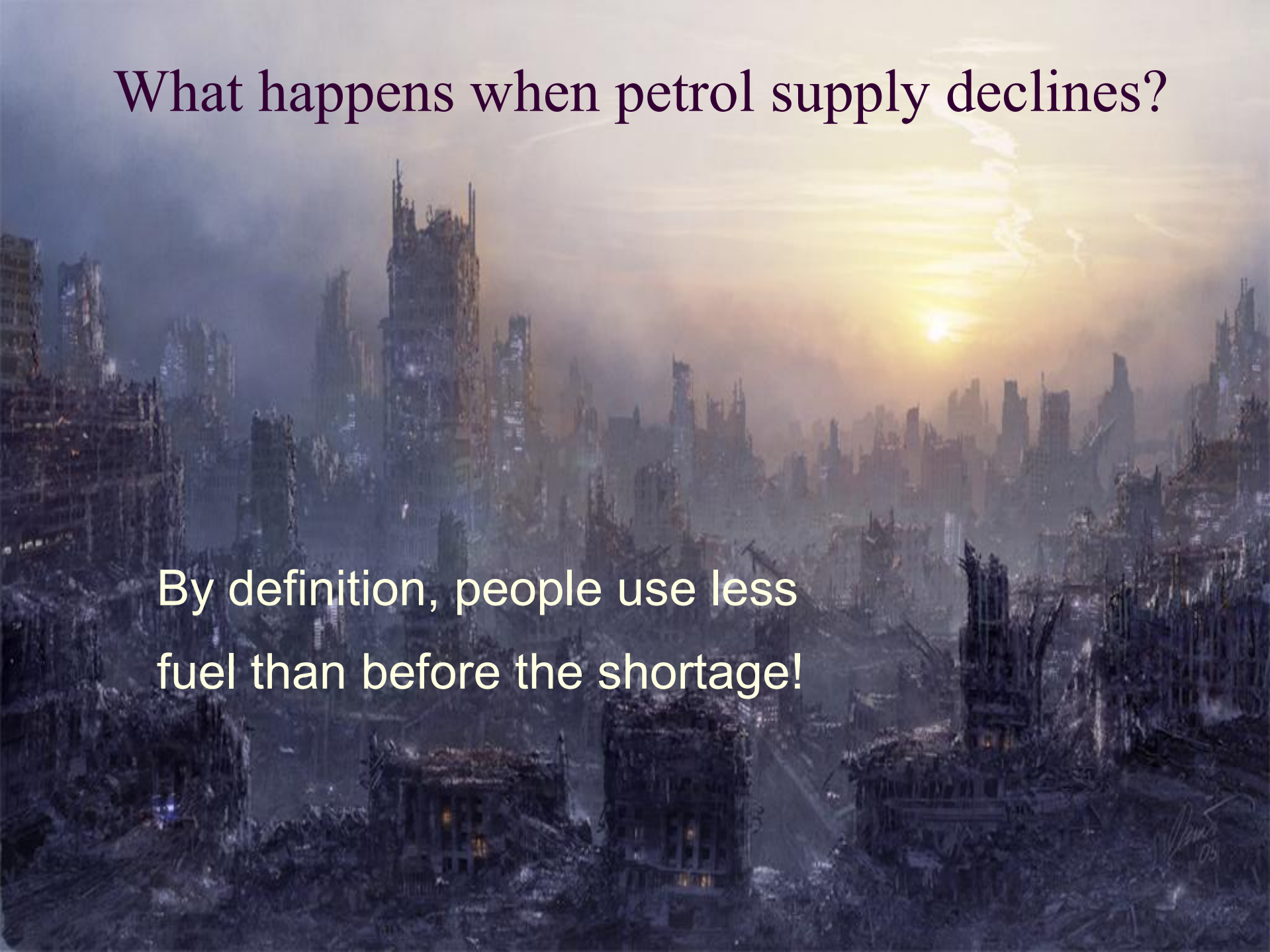


Sum of energy used for all the trips,
accounting for Mode and Distance

$$E = \sum_m \sum_d TD^{m,d} * EC^{m,d} DB^d$$

What happens when petrol supply declines?

By definition, people use less
fuel than before the shortage!



Adaptation to Reduced Fuel Use

People will act to preserve wellbeing



- Optional

Eliminate First

- Necessary

Eliminate Trips

- Essential

Eliminate Last

Mode Shifting

People will act to preserve participation in activities



- Walk
- Bike
- Bus (Public Transport)
- Car (Private Transport)

Function of Urban Form

Distance Shifting

People will act to preserve participation in activities



- Neighbourhood
- Area
- Region



Function of Urban Form

Efficiency Shifting

People will act to preserve participation in activities



- Share Rides
- Combine Trips or Modes
- Use or Purchase more Efficient Vehicle

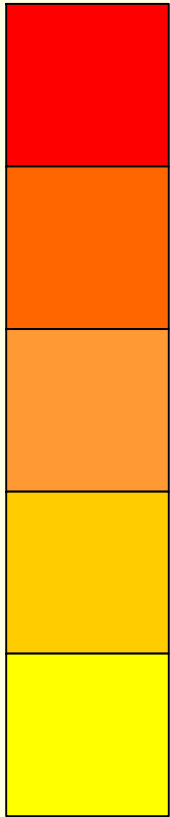


Function of Urban Form



Develop a Risk Analysis Method

Impact Assessment



- Loss of Essential Trip
- Loss of Necessary Trip
- Loss of Optional Trip
- Change of Mode
- Change of Destination

Modelling of Shortage Events

Year of Interest:

2015

Shortage Event

Fuel Rationing in
China's Manufacturing Heartland



Courtesy of China Daily

80%

■ Peak Oil

52%

■ 7% - Voluntary

30%

■ 10% - Rationing I

1.5%

■ 15% - Rationing II

0%

■ 20% - Rationing III

Exploring Energy Constraint Impacts

- Choose

- Mode

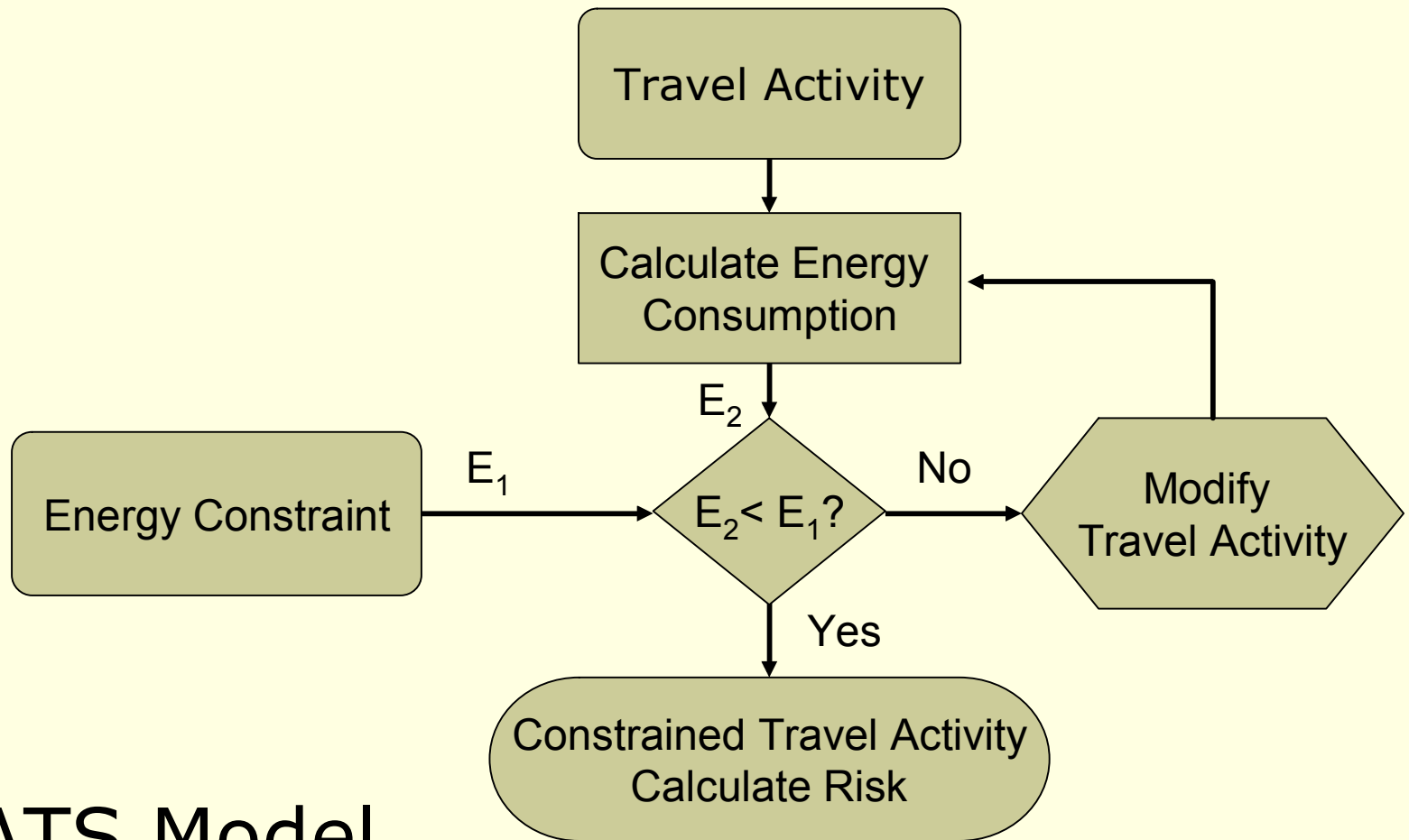
- Ca



- Model Travel Behaviour Change

- Until Energy Demand = Supply

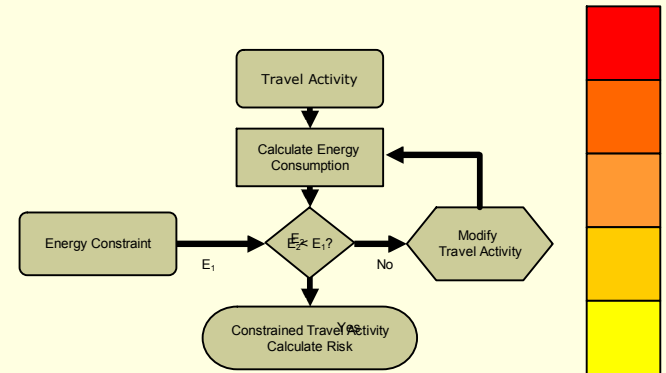
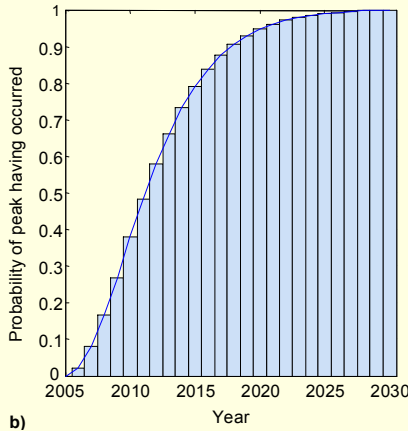
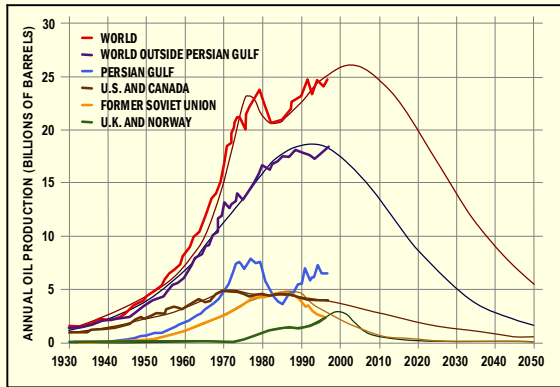
Energy Constrained Activity Model



RECATS Model

Implemented in MATLAB®

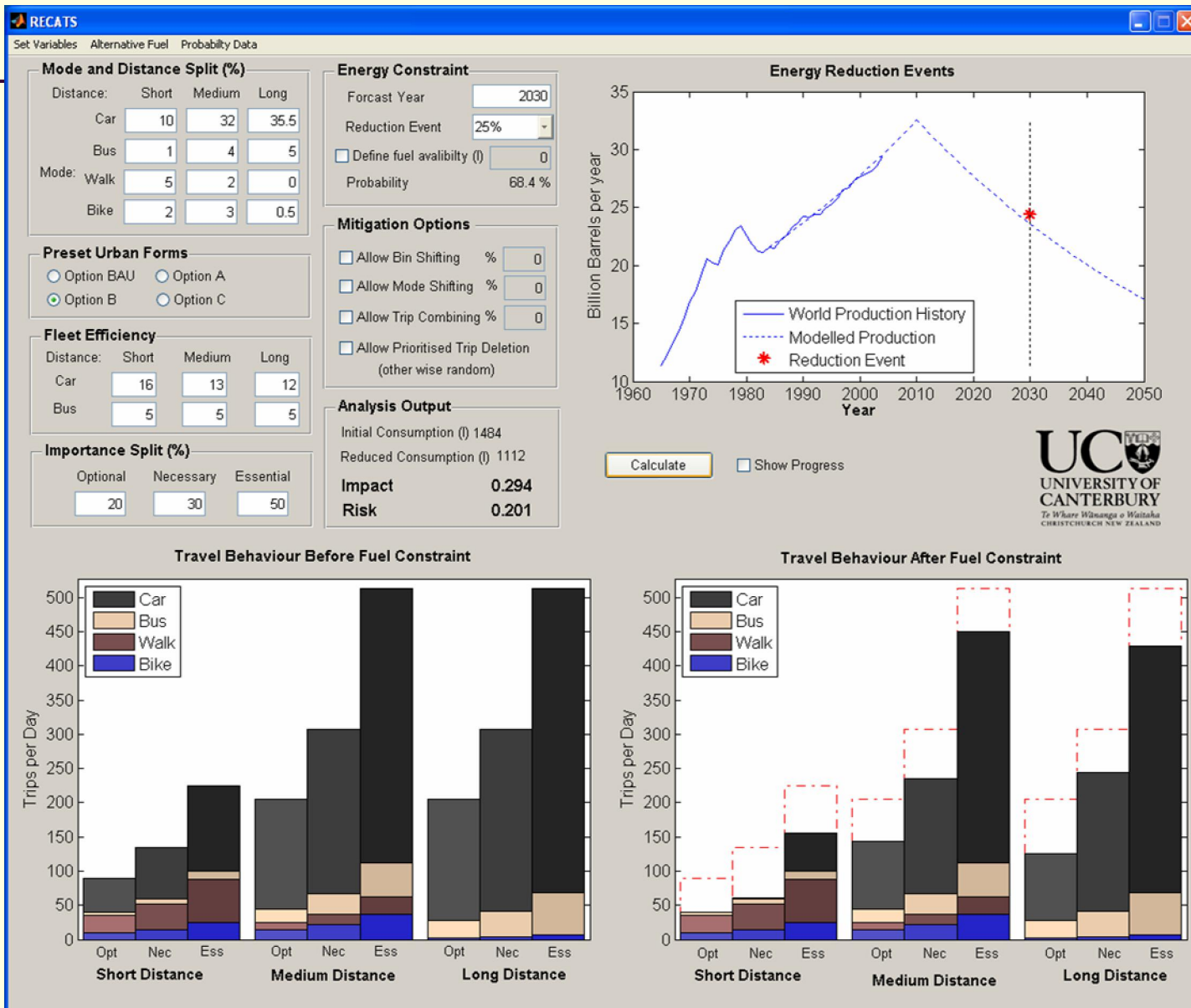
Risk Assessment



Risk = Probability * Impact

$$R_e = P_e * \left(\frac{\sum_m \sum_d \sum_s T^{m,d,s} * IW^s}{\sum_m \sum_d \sum_s \psi^{m,d,s} * IW^s} - 1 \right)$$

Software Modelling



RECATS

Case Studies – Proof of Concept



20% Fuel Shortage



High Density



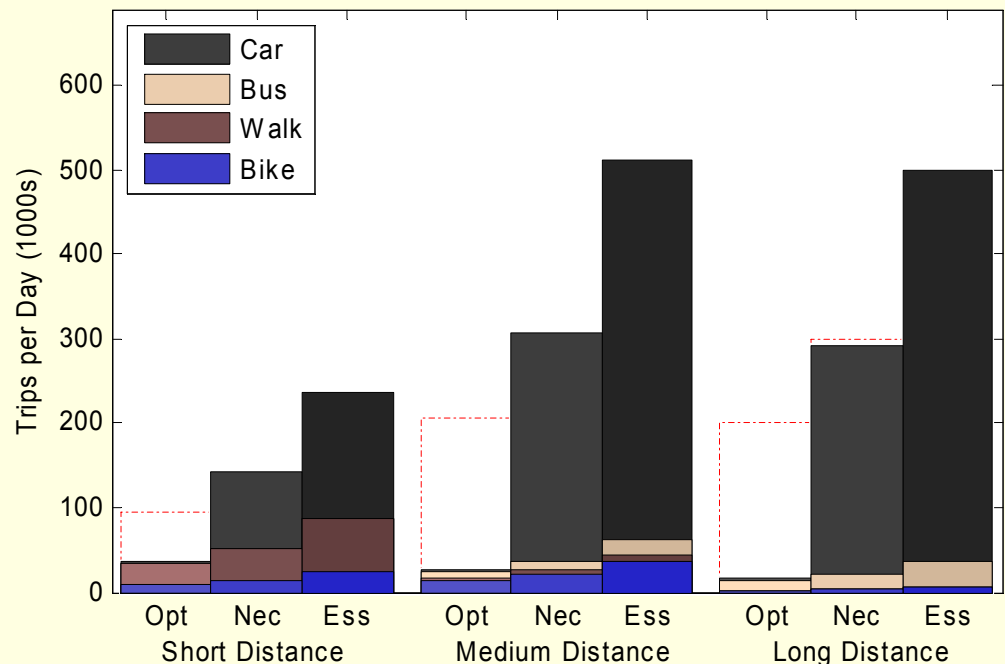
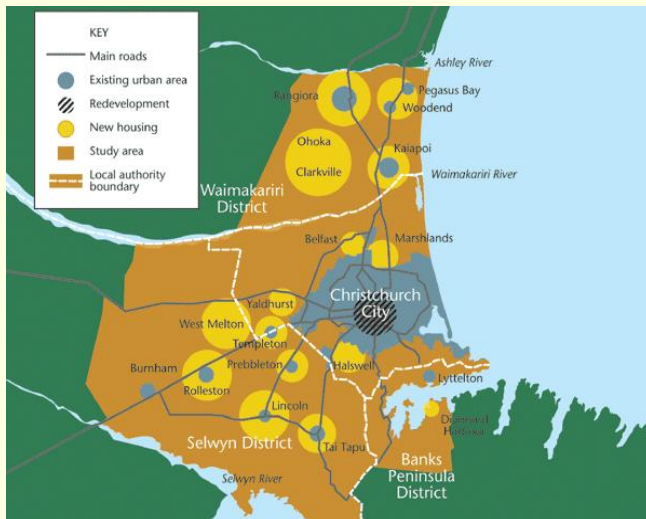
Sprawl

Christchurch – As Usual

- Optional Trips must be reduced by 84%
- Necessary trips must be reduced by 1%
- 17% reduction in car travel

Risk = 117

Business as Usual

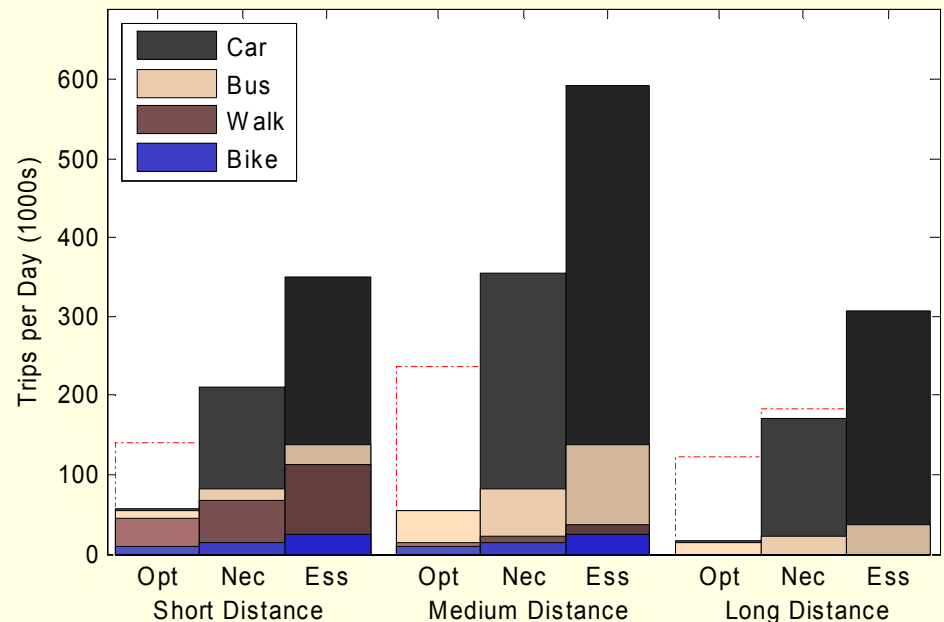
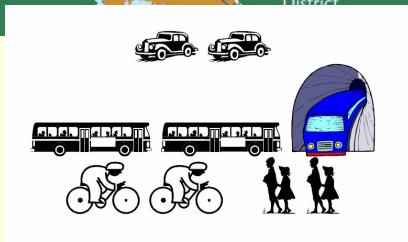
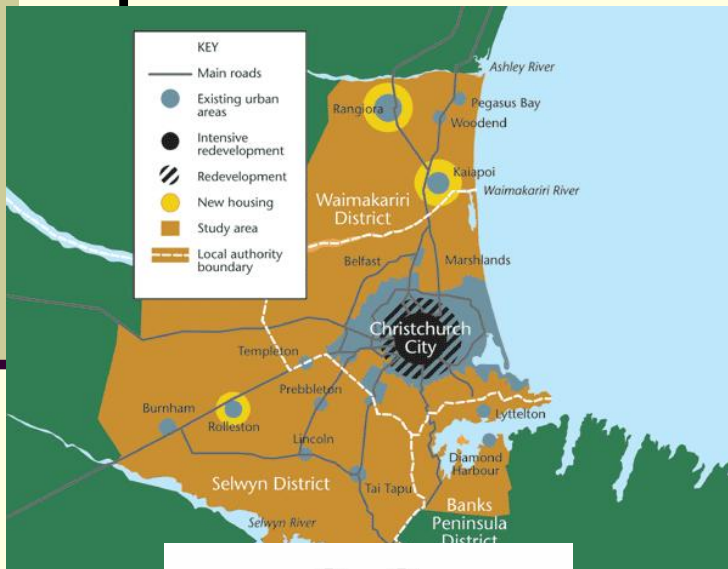


High Density Urban Center

- Optional Trips must be reduced by 74%
- Necessary trips must be reduced by 2%
- 15% reduction in car travel

Risk = 105

Option A

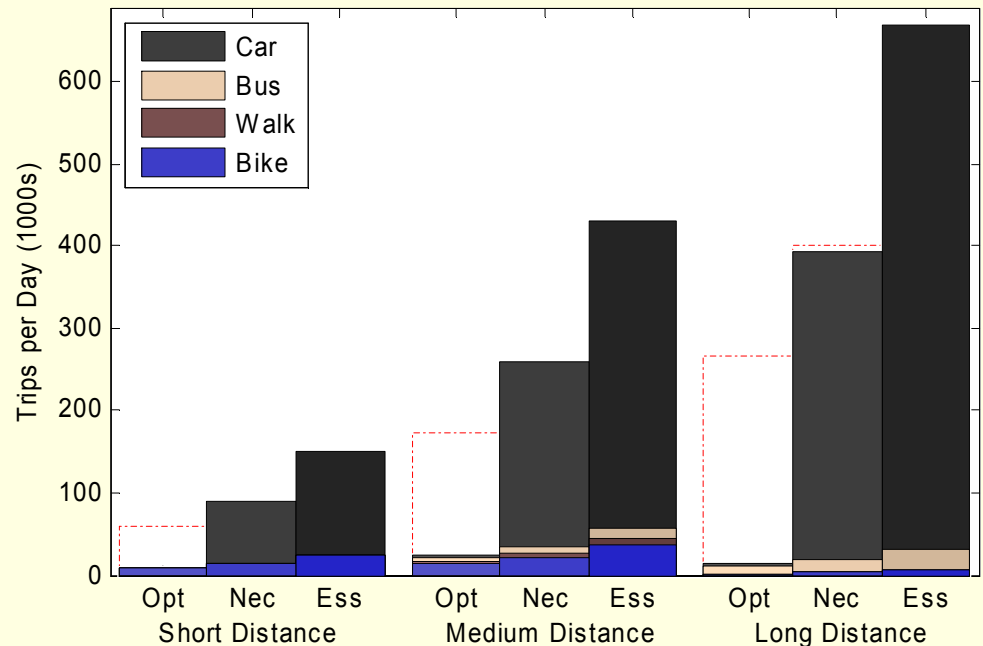


Urban Sprawl

- Optional Trips must be reduced by 90%
- Necessary trips must be reduced by 1%
- 18% reduction in car travel

Risk = 126

Option C



What have we learned?

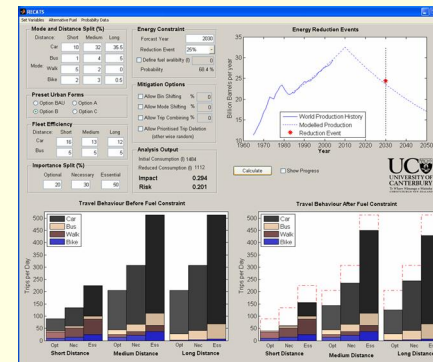
- Impact depends on:
 - Percentage of Optional Trips
 - Adaptation to Transport Mode Alternatives
 - Adaptation to Destination Alternatives
 - Information for Trip Planning
- The problem is
 - We don't really know any of these things



Future Research & Development

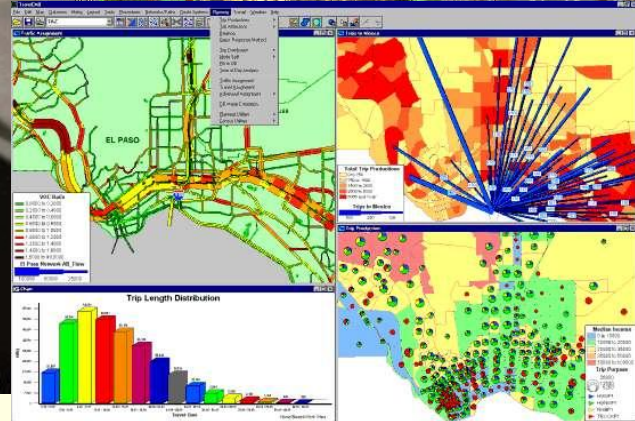
I. RECATS

- Rapid Assessment of Travel Demand
- Travel Demand Essentiality
- Travel Demand Adaptability
- Mode and Destination Switching
- Fuel Apportionment or Rationing Models



II. HICT

Human Interface Communication Technology

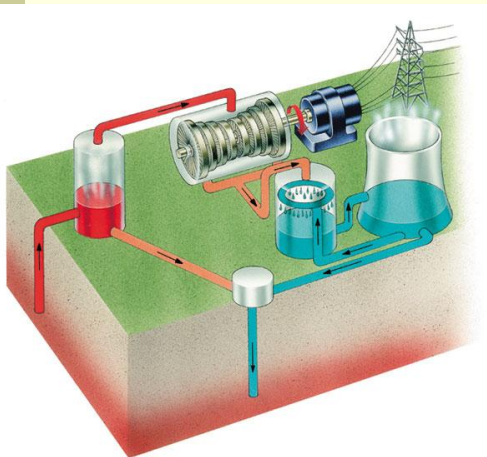
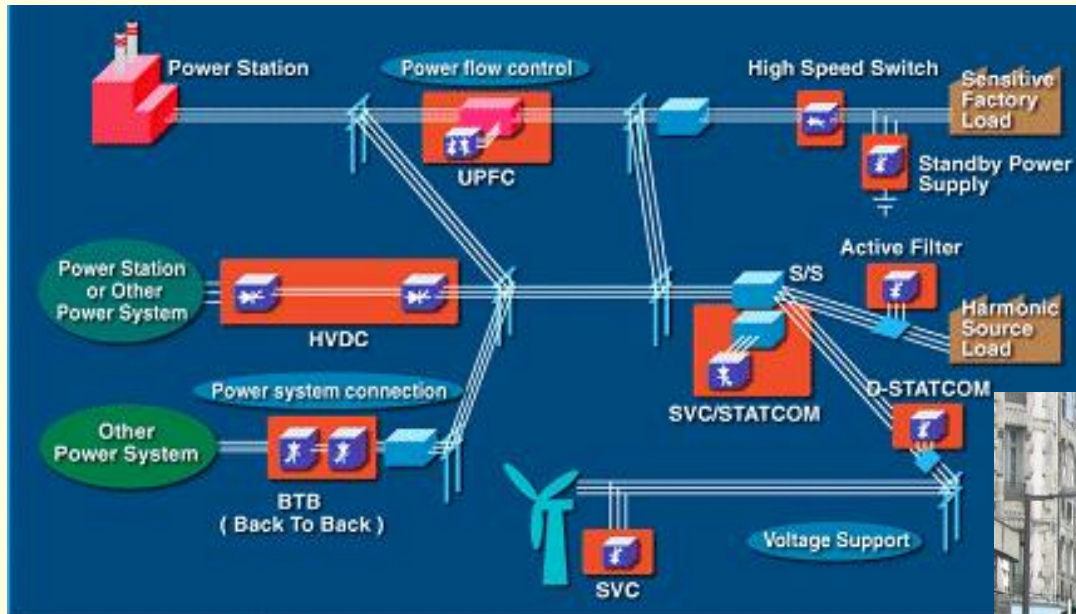


III. SDMS

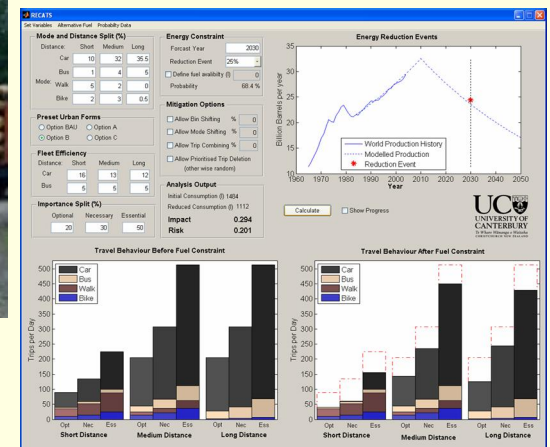
Supply – Demand Management System



IV. Renewable Energy Transport



V. Freight and Agriculture



Recommendations



Urgently need to get talented, creative engineers working on these problems!



Advanced Energy and Material Systems Lab