



# MET 2007

## RESEARCH PROJECT

### Sustainability through Technology: The Californian Model

23<sup>rd</sup> November 2007

Louise Bloom

Sustainability through Technology: The Californian Model



Introduction Drivers In California Conclusions Summary

Today

- Introduction
  - Topic of study
  - Why California
  - Definition
  - Vision
- Drivers
- What is being done in California
  - Emissions
  - Energy
  - Biofuels
  - Electronics
  - Environmental
  - Water
- Conclusions
  - Impacts within business
  - Is technology a good solution to sustainability?
  - What could California do better?
  - Can we learn anything to bring home to the UK?
- Summary

Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary

## Overseas research project

- o 2 weeks in July 2007
  - 40 MET2 Students - San Francisco and San Diego
    - o Intel
    - o Organic Architect
    - o Biofuel – Pacific Energy Center Conference
    - o Kunde Winery
    - o Jelly Belly
    - o Molecular Foundary
    - o Berkeley National Laboratory
    - o Linear Accelerator Center
    - o LS9
    - o Tesla Motors
    - o Maxwell Capacitors
    - o CalEnergy
    - o Water District
    - o Sony
    - o Oakley
    - o Wastewater Plant
    - o Solar Turbines

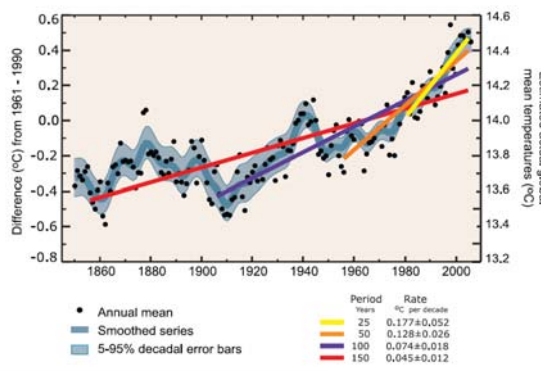


Sustainability through Technology: The Californian Model


Introduction Drivers In California Conclusions Summary

## Sustainability

- o Increasing area of interest/concern
  - Climate change
  - CO<sub>2</sub> levels
  - Corporate Social Responsibility



Period (Years)	Rate (°C per decade)
25	0.177 ± 0.052
50	0.128 ± 0.026
100	0.074 ± 0.018
150	0.045 ± 0.012



Sustainability through Technology: The Californian Model






Introduction Drivers In California Conclusions Summary

## Definitions

- Sustainability
  - Many definitions that have been around for decades
- Triple Bottom Line

- UN definition:
 

*Meeting the needs of the present without compromising the ability of future generations to meet their own needs*

---

Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary

## Manufacturing Engineering

- Visits in UK
  - Good contrast and broadening of experience
- Vol. of global manufactured production increased two-fold in the last 30 years.
  - In 2005 36% of CO2 emissions from energy industry and 18% from other industries
  - Sustainability issues are arising in the manufacturing industry
- Sustainability through Technology: The Californian Model








---


Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary

## Why California?

- EU behavioural change vs. Californian *techno-fixers*
- Largest populated state in the US
  - 37.3 million residents in 2006 (grown by over 17.5 million in the last 30 years)
- 12th largest emitter of carbon emissions globally (2<sup>nd</sup> largest in US)
- US Targets – decrease carbon by 20% (of 1990 levels) by 2020 and 33% by 2030.
  - California however has set its own targets to drop 25% by 2020 and to 80% by 2050.



 MET 2007 RESEARCH PROJECT

Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary

## Vision

- The State
  - “California leads the way on one of the most important issues’ that is facing our time, that is; the fight against global warming.”  
Gov. Schwarzenegger Sept. 2006
- Award schemes; Department of Energy, Environmental Protection Agency etc...
- Companies philanthropy – *Greenwash?*



 MET 2007 RESEARCH PROJECT

Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary




## Predicted drivers for sustainable practice

- Legislation
  - No choice
- Profitability
  - Might be main business aims
- Energy Security
  - Energy crisis 2000
  - Rising cost of oil
- Dissatisfaction
  - Air pollution (LA)
  - Geology and geography play a large part in this

 Sustainability through Technology: The Californian Model

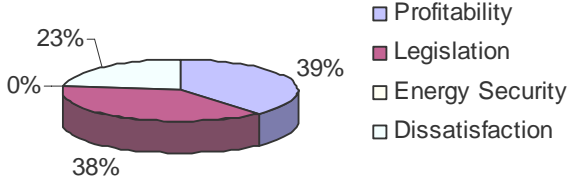
Introduction Drivers In California Conclusions Summary




## Driver importance

- Companies asked which they felt was the most significant driver

**Key Drivers for Sustainability in California**



Driver	Percentage
Profitability	39%
Legislation	38%
Energy Security	23%
Dissatisfaction	0%

 Sustainability through Technology: The Californian Model



Introduction Drivers In California Conclusions Summary

## Drivers for sustainability

Political
Social
Economical
Technological

\*CSR = Corporate Social Responsibility

**MET 2007**  
RESEARCH PROJECT

Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary

Emissions Energy Biofuels Electronics Environmental

## Examples

o Selection of some of the main sustainability challenges highlighted by our visits

- Emissions
  - Electric car
- Energy
  - Geothermal
  - Domestic
- Biofuels
  - Cooperatives
  - The biofuel debate
- Electronics
  - Sony
  - Maxwell Capacitors
- Environmental
  - Water

**MET 2007**  
RESEARCH PROJECT

Sustainability through Technology: The Californian Model

Introduction
Drivers
In California
Conclusions
Summary

Emissions
Energy
Biofuels
Electronics
Environmental

Emissions

- o The issue
  - LA in a valley
  - 30 million vehicle registrations in CA
  - 92% of the states CO<sub>2</sub> emissions are from transportation and energy production
- o What is being done?
  - 1959 – First state to impose air quality standards & Air Resources Board (ARB) was created in 1967
  - Global Warming Solutions Act 2006 (AB32)
    - \$36million from Gov. mostly to ARB
  - Tesla Motors

Sustainability through Technology: The Californian Model

Introduction
Drivers
In California
Conclusions
Summary

Emissions
Energy
Biofuels
Electronics
Environmental

Tesla Motors

- o 100% electric car
  - High-performance market
  - 100,000 miles on battery
  - Still quite expensive

Car Model	Well-to-Wheel Energy Efficiency (km/MJ)	Acceleration from 0 to 60 mph (sec)
Porsche Carrera GT	~0.2	~3.5
Lamborghini Murciélago	~0.2	~4.0
Porsche Carrera	~0.2	~4.5
Nissan 350Z	~0.3	~5.0
Toyota Celica	~0.3	~6.0
Nissan Maxima	~0.3	~7.0
Ford Focus	~0.3	~8.0
Honda Civic VTEC	~0.4	~9.0
Sabaru Legacy	~0.4	~10.0
Toyota Prius (Hybrid)	~0.4	~11.0
VW Jetta Diesel	~0.5	~12.0
Honda Civic (Natural Gas)	~0.5	~13.0
Honda FCX (Fuel Cell)	~0.6	~14.0
Tesla Roadster	~0.8	~4.0

Source: [www.teslamotors.com](http://www.teslamotors.com)

Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary  
Emissions Energy Biofuels Electronics Environmental

## Impacts

- o Californian emissions are decreasing
  - Still a long way to go

**Per Capita Carbon Dioxide Emissions**

Year	Rest of U.S. (metric tons)	California (metric tons)	California with imports (metric tons)
1975	22.0	15.5	15.5
1980	22.5	15.0	15.0
1985	20.0	11.5	11.5
1990	21.0	11.5	12.5
1995	21.5	10.5	11.5
2000	21.5	10.5	12.0

Source: NRDC 2006

MET 2007 RESEARCH PROJECT

Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary  
Emissions Energy Biofuels Electronics Environmental

## Energy

- o Energy Crisis 2000
  - Unexpected hot spring
  - Suppliers capacity too low
  - Price regulation meant energy providers left in debt
- o Targets set for renewable energy sources
  - 33% renewables by 2020







**California's Major Sources of Energy**

Energy Source	In-state (%)	Imports (%)
Petroleum	35	65
Electricity	75	25
Natural Gas	15	85

MET 2007 RESEARCH PROJECT

Sustainability through Technology: The Californian Model







     	Introduction	Drivers	In California	Conclusions	Summary
	Emissions	Energy	Biofuels	Electronics	Environmental

## What is being done?


- California's Mojave Desert is home to the world's largest concentrating solar power facility
- In 2004 wind power provided 1.5% of the states energy
  - Total of 10.9% of California's electricity is from renewable sources
- Examples on visits...

Sustainability through Technology: The Californian Model







     	Introduction	Drivers	In California	Conclusions	Summary
	Emissions	Energy	Biofuels	Electronics	Environmental

## Geothermal

- Salton Sea geothermal plant





Sustainability through Technology: The Californian Model







     	<a href="#">Introduction</a>	<a href="#">Drivers</a>	<a href="#">In California</a>	<a href="#">Conclusions</a>	<a href="#">Summary</a>
	<a href="#">Emissions</a>	<a href="#">Energy</a>	<a href="#">Biofuels</a>	<a href="#">Electronics</a>	<a href="#">Environmental</a>

## Geothermal plant

- Superheated fluid - magma thousands of feet under ground (5,000ft – 10,000ft) extracted through production well
- Solids are separated from the steam
- Steam is used to drive the turbines to generate electricity
- Fluid left is injected back into the underground reservoirs via injection wells









Sustainability through Technology: The Californian Model

     	<a href="#">Introduction</a>	<a href="#">Drivers</a>	<a href="#">In California</a>	<a href="#">Conclusions</a>	<a href="#">Summary</a>
	<a href="#">Emissions</a>	<a href="#">Energy</a>	<a href="#">Biofuels</a>	<a href="#">Electronics</a>	<a href="#">Environmental</a>

## Geothermal gains

- Advantages
  - Is not destructive to environment or agriculture.
  - Low CO2 emission in energy generation compared to coal and gas.
  - California has the largest geothermal resource in the world (approximately 20% of world capacity).
  - Geothermal potential in California alone is 3,465MW.
  - Creates jobs and energy price security for the state.
  - Produces the equivalent of 274,000bpd of oil (typical Saudi Arabian oil well produces 10,000bpd).







Sustainability through Technology: The Californian Model

     	Introduction	Drivers	In California	Conclusions	Summary
	Emissions	Energy	Biofuels	Electronics	Environmental

## Geothermal issues


- Problems
  - Getting the energy to the customer.
  - Expensive capital costs.
  - Four to five times more power needed than gas energy plants result in high operating costs.
  - High cost in pipes (titanium cased) to prevent or slow erosion.

Sustainability through Technology: The Californian Model


     	Introduction	Drivers	In California	Conclusions	Summary
	Emissions	Energy	Biofuels	Electronics	Environmental

## Domestic energy

- 40% of all energy use is in the home
- California Solar Initiative
  - \$2.9 billion over 10 years available for installation of solar panels
- Organic Architects
  - Small company providing sustainable designs for homes
  - Niche market created
  - Awareness building




Sustainability through Technology: The Californian Model

	<a href="#">Introduction</a>	<a href="#">Drivers</a>	<a href="#">In California</a>	<a href="#">Conclusions</a>	<a href="#">Summary</a>
	<a href="#">Emissions</a>	<a href="#">Energy</a>	<b>Biofuels</b>	<a href="#">Electronics</a>	<a href="#">Environmental</a>


## Biofuels

- Energy security is main driver for renewable energy solutions of this type
- Biofuels
  - Liquid fuels extracted from biomass
  - Used historically
  - Today are mixed with existing fuel
    - Since 1988 - US manufactured cars are legally required to be capable of using at least 20% biofuels (B20)
  - Come from food crops (first generation)
  - Agricultural crops and higher efficiency still being developed (second generation)




---

Sustainability through Technology: The Californian Model

	<a href="#">Introduction</a>	<a href="#">Drivers</a>	<a href="#">In California</a>	<a href="#">Conclusions</a>	<a href="#">Summary</a>
	<a href="#">Emissions</a>	<a href="#">Energy</a>	<b>Biofuels</b>	<a href="#">Electronics</a>	<a href="#">Environmental</a>

## Biofuels

- Department of Energy Biofuel Initiative 2006
  - Replace 30% of fuel usage with biofuels by 2030
- Conference
  - Hosted by Pacific Gas and Energy
  - Small biofuel organisations
  - San Francisco Biofuels Cooperative
    - One fuelling station
  - School bus project
  - Waste from restaurants
- Biotechnology company visited



---

Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary  
Emissions Energy Biofuels Electronics Environmental

## Alternative fuel solutions

**Alternative Fuel Solutions**

Natural Oils	-Glycerin -BioDiesel
Sugar/Starch	-Ethanol -Butanol -Renewable petroleum from diesel
Algae	-BioDiesel
Biomass	-Ethanol -BTL Diesel
Waste	-Gasification

Feedstock Supply volume increases

Feedstock Cost decreases and Technological difficulty increases

**MET 2007**  
RESEARCH PROJECT

Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary  
Emissions Energy Biofuels Electronics Environmental







## The biofuel debate

- o Amount of space required for growth
  - Competes with food supplies
  - Relatively small amount of energy from large space
  - Deforestation
- o Over use of soil
- o Damaging to car engines?
- o Has to be carried out appropriately
  - Can cause greater CO<sub>2</sub> emissions
- o UN paper
  - Regulations, definitions and measures are needed
  - Knowledge needs to be shared
- o Seen as a “*transitional fuel*”
  - Time and money better spent elsewhere?

**MET 2007**  
RESEARCH PROJECT

Sustainability through Technology: The Californian Model









     	Introduction	Drivers	In California	Conclusions	Summary
	Emissions	Energy	Biofuels	<b>Electronics</b>	Environmental

## Electronics

- Sony
  - Last TV manufacturer in US
  - “Vision” on website looks promising, but large companies like these need to make sure awareness is disseminated
  - Since the project Sony has launched a recycling management scheme
- Maxwell Capacitors
  - Ultra-capacitors
    - High-tech design (up to 3000F capacitors)
    - Used in addition to battery (increase surge capacity)
  - Good example
    - Energy saving product
    - Relatively low cost and low energy production
    - Profits made

Sustainability through Technology: The Californian Model







     	Introduction	Drivers	In California	Conclusions	Summary
	Emissions	Energy	Biofuels	<b>Electronics</b>	Environmental

## The future for electronics

- Environmental impact of this industry
- Technological advances more likely than behavioural change
- Better products
  - Higher efficiency & wider application (Maxwell capacitors)
  - Longer lifetime – less waste?

Sustainability through Technology: The Californian Model



     	Introduction	Drivers	In California	Conclusions	Summary
	Emissions	Energy	Biofuels	Electronics	Environmental
	<h2>Environmental</h2>				
	<ul style="list-style-type: none"> <li>○ Agriculture           <ul style="list-style-type: none"> <li>• Large industry in California</li> <li>• Winery               <ul style="list-style-type: none"> <li>• Sustainable agriculture</li> <li>• Looking after soil</li> <li>• More than just a profit making business</li> </ul> </li> <li>• Standards are not too well established</li> <li>• Organic vs. Sustainable?</li> </ul> </li> <li>○ Waste Control           <ul style="list-style-type: none"> <li>• Payback scheme for recycling</li> <li>• Plastic water bottle ban</li> <li>• Generally quite good,               <ul style="list-style-type: none"> <li>• Could maybe look more at recycling technologies</li> </ul> </li> </ul> </li> </ul>				
Sustainability through Technology: The Californian Model					

     	Introduction	Drivers	In California	Conclusions	Summary
	Emissions	Energy	Biofuels	Electronics	Environmental
	<h2>Water</h2>				
	<ul style="list-style-type: none"> <li>○ Valuable source in California           <ul style="list-style-type: none"> <li>• Battles over water common since Goldrush in 1849</li> <li>• Establishment of Water Resources Control Board 30 years ago</li> <li>• Early 20<sup>th</sup> Century constitution passed:               <ul style="list-style-type: none"> <li><i>Users shall put water to the highest beneficial use possible and shall not waste water or use it unreasonably</i></li> </ul> </li> </ul> </li> <li>○ Restoration of Salton Sea           <ul style="list-style-type: none"> <li>• Gov. project</li> <li>• Sustainable?</li> </ul> </li> <li>○ Desalination plants           <ul style="list-style-type: none"> <li>• Used a bit in California</li> <li>• Expensive</li> <li>• Damaging to marine life</li> </ul> </li> <li>○ Are California doing enough?</li> </ul>				
Sustainability through Technology: The Californian Model					

Introduction Drivers In California Conclusions Summary

## Impacts within a business

- o Opportunities
  - Access to new and growing markets
  - Economical benefits (emphasised by government)
- o Limitations
  - Attempts at sustainability make it difficult to balance overall aims of the organisation
  - Controversial issues
  - Legislation seen as a distraction or expense
  - Might be quite high risk



Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary

## Small vs. large companies

- o Gaps could be used to target efforts

	SME	Large Company
Easy to change	✓	x
Has good government support	x	✓
Easy access to resources	x	✓
Innovation	✓	x
Flexibility	✓	x
Business experience	x	✓
Long term strategies considered	x	✓
Personal satisfaction	✓	?
Easy to get IPR	?	✓

Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary




## Is technology a good solution?

- Complex topic
- Tragedy of the commons
  - One main issue seen throughout the challenges posed in sustainability
- California struggles to keep up with demand (water & energy)
- Technology helps to aid the problems
- California seems to be waiting for market to open up
  - Could push harder
- Not enough on its own


 Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary



## What is the alternative?

- High-tech solutions should not be a limiting factor
  - Correct diffusion and dissemination
  - Appropriate technologies
  - Life Cycle Analysis & Design for the Environment
    - Often decoupled from manufacturing practice
- Performance measurements
  - Identify un-sustainable practice as well as measure sustainability practice

 Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary



## What could California do better?

- Technology responsibility
  - Appropriate use of existing and new technologies
- Longer term focus
  - Transitional or minimal solutions currently
- More support at federal level
- Education
  - Understanding global impacts
  - Redesigning systems
- Californian “Anti-Drivers”
  - Attitude and lifestyle
  - Lack of understanding

 MET 2007 RESEARCH PROJECT

Sustainability through Technology: The Californian Model

Introduction Drivers In California Conclusions Summary



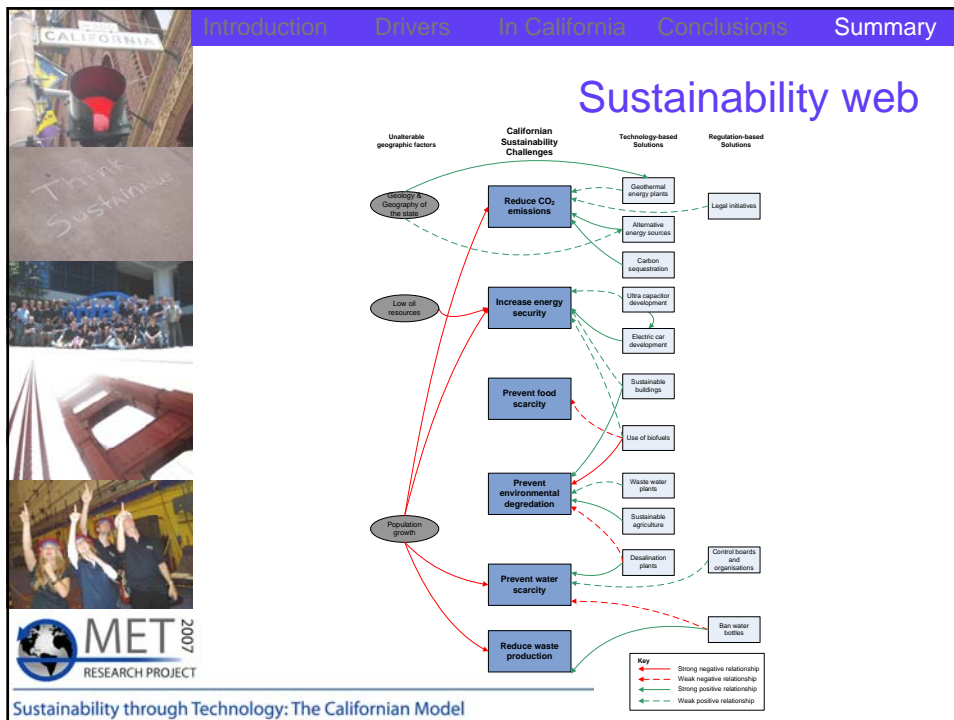
## Can we learn anything to bring home to the UK?

- Report by Ove Arup
  - UK industry is fully aware of environmental responsibilities
  - Not taking advantage of consumer-driven market
- Strong pioneering spirit in California
  - Silicon Valley
  - Positive attitude
  - Drive for success
- EU more business cautious
  - We are an older nation – more time to learn from mistakes than US
  - More risk averse – innovation can't reach market
- They can learn from us as well

 MET 2007 RESEARCH PROJECT

Sustainability through Technology: The Californian Model





## Questions?



- Report online soon:
  - <http://www.ifm.eng.cam.ac.uk/met/tour07/>
- Email:
  - lab46@cam.ac.uk