# Greening-Up the Star of Life: Toward Sustainable EMS Systems

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## A Point of Clarification …

- I am not a climate scientist.
  - I am a paramedic.
- This is not about climate change.
  - This is a health services issue.

## Overview

- Background
- Literature Review
- Scope 1 & 2 Emissions
- Complete Life Cycle Emissions
- Impact of Energy Costs
- Directions for the Future

*Image source: Google images*

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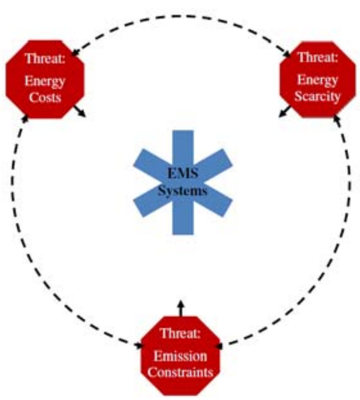
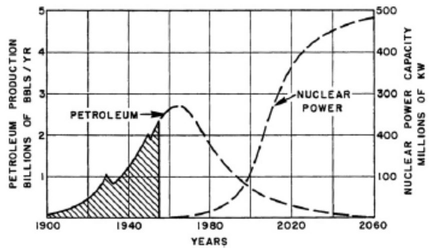
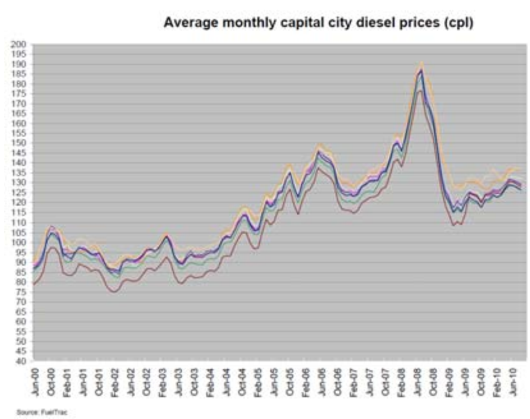


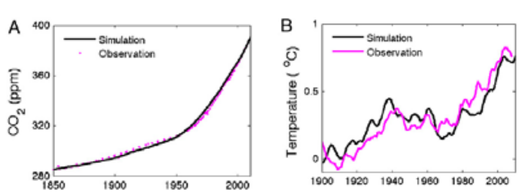
## Peak Oil



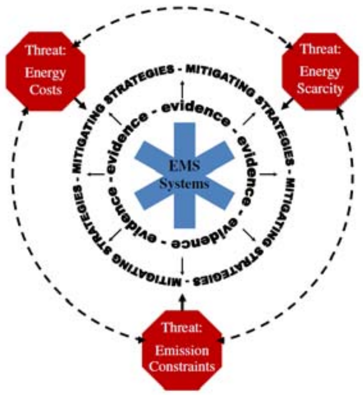

*Hubbert ,1956, as reproduced in Mason et al, 2011*




## Global Warming




*Ramanathan & Xu, 2010*




## The ‘Big’ Question

How can EMS systems be sustained in an economic, political and social environment in which energy is increasingly scarce and costly, and energy consumption is increasingly constrained due to concerns about greenhouse gas emissions?

## A Note on Nomenclature

- Scope 1
  - Direct energy consumption and emissions
  - e.g., diesel fuel, petrol, natural gas
- Scope 2
  - Purchased energy consumption and emissions
  - e.g., electricity, commercial travel
- Scope 3
  - upstream and downstream energy consumption and emissions
  - e.g., emissions from factories producing supplies; waste disposal
- Complete Life Cycle
  - Sum of Scope 1, Scope 2 and Scope 3

*Purman, 2008*

## And A Note on Volume


- 1 g $CO_2$ ≈ 0.5 L $CO_2$
- 1 t $CO_2$ = X 1 Million
- 1,000 t $CO_2$ = X 1 Billion

*Image source: Google images*

## Literature Review

| Setting | | Annual Energy Intensity (kWh/m$^2$) | Source |
|---|---|---|---|
| Greece | Hospitals, health centers & clinics, 1980 | 235 | Gaglia et al, 2007 |
| | Hospitals, health centers & clinics, 2001 | 233 | |
| | Hospitals, health centers & clinics, 2010 (projected) | 236 | |
| Scotland | small health buildings, 2001 | 310 | Murray et al, 2008 |
| Poland | university hospital, heat/hot water only, 2005-2008 | 268 | Bujak, 2010 |
| | provincial hospital, heat/hot water only, 2005-2008 | 327 | |
| Malaysia | public hospital, 2008 | 234 | Saidur et al, 2010 |
| Spain | hospital, total, ~2005 | 494 | Renedo et al, 2006 |
| | hospital, electricity only, ~2005 | 169 | |
| Thailand | average of 79 hospitals, electricity only, 1996-2006 | 149 | Chirarattananon et al, 2010 |

## Literature Review

| Service / Procedure | | Impact | Source |
|---|---|---|---|
| Health Care | Emits | 21.3 million metric tons $CO_2$e per year (England) | SDC-SEI, 2008 |
| | Emits | 426 kg $CO_2$e per capita (England) | |
| | Emits | 545.5 million metric tons $CO_2$e per year (United States) | Chung & Meltzer, 2009 |
| | Emits | 1510 kg $CO_2$e per capita (United States) | |
| Surgical Reflux Control | Emits | 1,081 kg $CO_2$e per patient, + 30.8 kg $CO_2$e per year thereafter | Gatenby, 2011 |
| Medical Reflux Control | Emits | 164 kg $CO_2$e per patient, + 100 kg $CO_2$e per year thereafter | |
| Cataract Surgery | Emits | 37.3 kg $CO_2$ per operation (business as usual) | Somner et al, 2009 |
| | Emits | 7.5 kg $CO_2$ per operation using a 1-stop strategy | |
| | Avoids | 29.8 kg $CO_2$ per operation using 1-stop vs. business as usual | |
| Laparoscopic Surgery | Emits | 0.23 kg $CO_2$ per operation (from $CO_2$ gas cylinders) | Gilliam et al, 2008 |
| Anesthetic Gases | Emit | 7 - 187 kg $CO_2$e per hour of administration | Ryan & Nielsen, 2010 |
| Small Health Buildings | Emit | 86 kg $CO_2$e/m$^2$ annually | Murray et al, 2008 |
| Hospitals Wards | Emit | 48 - 171 kg $CO_2$e/m$^2$ annually (varies by ventilation system) | Lomas & Ji, 2009 |
| Clinical Trials | Emit | 63kg $CO_2$e per participant | Burnett et al, 2007 |
| | Emit | 324 kg $CO_2$e per primary endpoint event | |
| Telemedicine | Avoids | 39 kg $CO_2$ per consultation | Smith et al, 2007* |
| | Avoids | 2.9 kg $CO_2$e per home health visit avoided | |
| | Avoids | 131 kg $CO_2$ per consultation | Yellowlees et al, 2010* |
| Medical Society Meetings | Emit | 723 kg $CO_2$e per participant (American Thoracic Society) | Callister & Griffiths, 2007* |
| | Emit | 227 kg $CO_2$e per participant (European Respiratory Society) | Crane & Caldwell, 2006* |
| Specialty Training | Emits | 480 kg $CO_2$e per applicant | Hewitt, 2008* |

*Image source: Google images*

## Scope 1 and 2 Inventory

$$CO_2e_{total} = \sum_{j=1}^{j}\sum_{i=1}^{i}(E_i)(CO_2e_i)$$

*E – energy consumption*
*i – type of fuel*
*j – participating system*

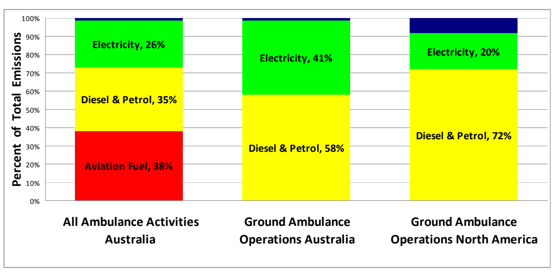
## Scope 1 and 2 Inventory

- North America
  - 45.5 kg $CO_2e$ per ambulance response
  - 3.7 kg $CO_2e$ per capita
  - 660,000 to 1,600,000 metric tons $CO_2e$ / year
- Australia
  - 22 kg $CO_2e$ per ambulance response
  - 3 kg $CO_2e$ per capita
  - 110,000 to 120,000 metric tons $CO_2e$ / year

## Scope 1 and 2 Inventory

- Air Ambulance Operations
  - North America
    - 1t $CO_2e$ per air ambulance mission
  - Australia
    - 5.3 t $CO_2e$ per air ambulance mission

## Scope 1 and 2 Inventory

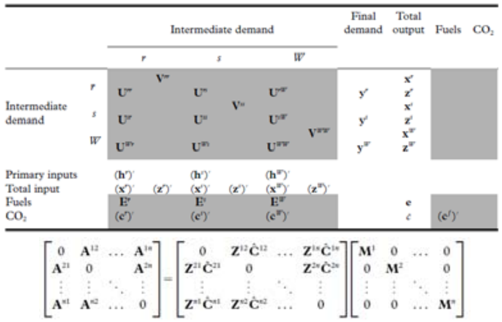



## For Comparison…

Ownership of dwellings: 82,000 t
Clothing: 83,000 t
Electronic equipment: 84,000 t
Ambulance Services: 85,000 t
Silver & Zinc: 89,000 t
Education: 88,000 t
Services to Mining: 91,000 t
Brown coal: 93,000 t

*Foran et al, 2005*

# EMS Life Cycle Emissions - Australia




*From: Lenzen, Pade & Munksgaard, 2004*

# EMS Life Cycle Emissions - Australia

| Sector | Direct TBL Multiplier | Total TBL Multiplier | % from 1st Order Electricity Consumption |
|---|---|---|---|
| Health (Hs) | 0.02 | 0.15 | 32% |
| Other (Os) | 0.11 | 0.36 | 25% |
| Gov't (Gv) | 0.01 | 0.33 | 27% |

Triple-bottom-line (TBL) CO2e multipliers (kg per $ GNE) and first order electricity consumption for the Health Services, Other Services, and Government Services sectors of the Australian economy.

*(Foran et al., 2005)*

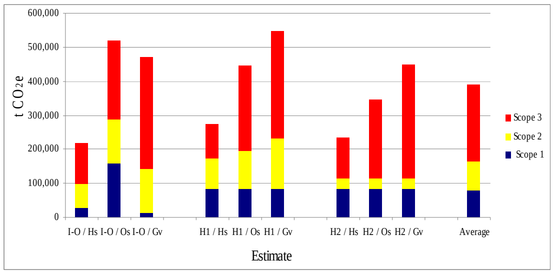
Total expenditures on Ambulance services, 2009-2010 = $2.1 billion

*(Council of Ambulance Authorities, 2010)*

# EMS Life Cycle Emissions - Australia

| TBL Multiplier | | Direct (Scope 1) | Electricity (Scope 2) | (Scope 3) | Total |
|---|---|---|---|---|---|
| I-O Based Estimate | Hs | 28,849 | 69,238 | 118,282 | 216,369 |
| | Os | 158,671 | 129,822 | 230,794 | 519,286 |
| | Gv | 14,425 | 128,523 | 330,064 | 476,012 |
| Hybrid Approach 1 (H1) Estimate | Hs | **85,100** | 87,238 | 100,282 | 272,620 |
| | Os | **85,100** | 111,429 | 249,186 | 445,715 |
| | Gv | **85,100** | 147,606 | 313,982 | 546,688 |
| Hybrid Approach 2 (H2) Estimate | Hs | **85,100** | **29,900** | 118,282 | 233,282 |
| | Os | **85,100** | **29,900** | 230,794 | 345,794 |
| | Gv | **85,100** | **29,900** | 333,064 | 448,064 |
| Mean of I-O, H1 and H2 Estimates | n/a | 79,172 | 84,840 | 225,353 | 389,315 |

## EMS Life Cycle Emissions - Australia




## Energy Costs and EMS Performance

- Data:
  - National and state-specific financial and operational data from annual reports.
  - Energy price data from:
    - Australian Petroleum Institute (diesel)
    - Australian Energy Market Operator (electricity)
    - U.S. Energy Information Agency (crude oil)

## Energy Costs and EMS Performance

| Performance Indicator | Calculation |
|---|---|
| ***Resource Indicators*** | |
| Expenditures / Response | Total Expenditures / Total Responses |
| Employee to Total Expenditure Ratio | Labour Expenditure / Total Expenditures |
| FTE / 10,000 Responses | FTE / Total Responses X 10,000 |
| Average Salary | Labour Expenditures / FTE |
| ***Operational Indicators*** | |
| Median Response Time | As Reported |
| 90th Percentile Response Time | As Reported |
| Patient Satisfaction with Response Time | As Reported |
| ***Safety Indicators*** | |
| Compensation Claims / 10,000 Responses | Claims / Total Responses X 10,000 |
| Workers Compensation Claims / 100 FTE | Compensation Claims / FTE X 100 |

## Energy Costs and EMS Performance

| Change in Price | Associated Change in Indicator* | Timing of Effect |
|---|---|---|
| 10¢/L ↑ Diesel$ | 1% higher labour to total expenditure ratio | 1 year lag |
| | $7,200 lower average salary | 1year lag |
| | 12 second longer median response time | 1 year lag |
| | 29 second longer 90th percentile response time | contemporaneous |
| | 18 second longer 90th percentile response time | 1 year lag |
| 1¢/kWh ↑ Elect$ | $32 higher expenditure / ambulance response | contemporaneous |
| | 1% higher labour to total expenditure ratio | contemporaneous |
| | ~1.5% higher labour to total expenditure ratio | 1 year lag |
| | $3,800 - $6,600 higher average salary | contemporaneous |
| | 3 more injury claims / 100 FTE | contemporaneous |
| | 6 more injury claims / 100 FTE | 1 year lag |
| $10/barrel↑ Oil$ | $40 lower expenditure / ambulance response | 1year lag |
| | ~1 fewer FTE / 10,000 ambulance responses | 1year lag |
| | $6,800 lower average salary | 1 year lag |

## So, what do we now know?

## Health Systems

- Health system emissions not widely studied.
- Per event or per patient health related emissions are small.
- Aggregate health sector emissions are substantial: 3% of England's and 8% of U.S. emissions.

*(SDC-SEI, 2008)*
*(Chung & Meltzer, 2009)*

## EMS Systems

- Scope 1 and 2 emissions ≈ 22 - 45 kg $CO_2e$ per response.
- Aggregate Scope 1 emissions of the same order as other important subsectors of the economy.
- Scope 1 emissions ≈ 20%.
- Scope 2 electricity consumption ≈ 22%.
- Scope 3 emissions ≈ 58%.

## Energy Costs

- Increased diesel price is associated with:
  - increase in median response time
- Increased electricity price is associated with:
  - Increased injury claims
- Increased oil price is associated with:
  - decrease in ambulance service expenditures
  - decrease in staffing

## A Framework

- IPAT

(Impact) = *f* (Production)x(Affluence)x(Technology)

- Emissions = *f* (production)x(structure)x(technology)

*Waggoner and Ausubel, 2002*
*York et al., 2003*

## Production

- Fewer transports
  - (Hess and Greenberg, 2011)
- Specialty centres
  - (Zander et al., 2011)

*Image source: ASNSW*

- Limited air medical response

## Affluence / Structure

- Static vs. dynamic deployment
- Response time standards
- Reduced idling

*Image source: Google images*

## Technology

- Hybrid/Hydrogen/Electric vehicles
  - (Burtt, 2008; Hawkins, 2008)
- Bio-diesel
  - (Searchinger, 2008; Solomon, 2010)
- Telemedicine
  - (Smith et al., 2007; Yellowlees, 2010)

*Image source: Google images*

## Technology

*Image source: Google images*

## Advocacy

## Take Home Points

This is about the future EMS.

Take a “life cycle” perspective.

Think “quadruple bottom line.”


*Image source: Google images*

Thank You

# Greening-Up the Star of Life


Blanchard IE, Brown LH:**Carbon Footprinting of EMS Systems: A Proof of Concept Study.** *Prehospital Emergency Care* 2009;13:546-549.

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