The role of rail in a transport system to limit the impact of global warming

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Gerard Drew, Beyond Zero Emissions
Tilo Schumann, German Aerospace Centre (DLR)
Overview

**CONTEXT**
- Character of Australian transport
- Options for reducing emissions

**METHOD**
- Australian transport system
- Simulations

**RESULTS**
- Change in travel activity
- Potential for rail services
Trend of transport emissions

- Average increase of 1.7% p.a. despite improvements in technological efficiency

[BITRE, 2012]

[National Greenhouse Gas Inventory, 2013]
Regional passenger travel

- Rail
- Passenger Car
- Air
- Bus

GHG emissions
- 55.9%
- 43.4%
- 0.4%
- 0.3%

Tonnes CO2e (million)

Sydney Australia
WCRR 2013
Beyond Zero Emissions
DLR
Automobiles

Battery electric vehicle performance

- Battery range a limiting factor for regional travel
- Current range typically 160km, modeled to increase to 220km
- Range covers 86% of all current car journeys but only 49% of Pkm
- Recharging becomes a considerable time burden beyond this point

(20kW ‘fast charging’ rates applied in model)
Aircraft

Climate compatible Air Transport System (CATS)

- Combustion emissions at cruise altitude have double the warming impact as at sea level
- Response to change in altitude and cruise speed have been simulated [Koch, A., et al., 2011]
- Optimised conditions indicate >50% reductions to Atmospheric Temperature Response (ATR)
- Position modeled corresponding to 50% reduction (red), eliminating the multiplier effect
- This results in a 22% increase in Direct Operating Cost (DOC) and a cruise speed of Ma=0.52 which increases travel times

[Figures from Koch, A., et al., 2011]
Development of a transport simulation model

Network model

- Regional transport network model created for all modes
- Necessary for determination of travel time, distance and accomplishment of assignments
- Focus on trunk routes, because only long-distance traffic will be calculated
- 49 300 km road
- 88 flight routes
- 15 700 km rail
- Population: 17.8 Mio inhabitants included in the model
Development of a transport simulation model

Traffic data

- Data about national traffic gathered from National Census for commuter data and National and International Visitor Survey 2009-11 for business and other purposes

Forecast of population, economy and price data

- Population will grow to 28.1 Mio in 2030, 90% of them will live in urban areas
- Sydney and Melbourne both will have almost 5 Mio inhabitants
- Increase of GDP per capita during the forecast period
- Moderate increase of fuel price
Development of a transport simulation model

Modal split analysis

- Approach with Generalized Cost (GC), which consists of Real price and Time Cost
- Value of Time (VoT):
  - 3-4 times higher for Business travel (60 – 80 $/hour)
  - Higher for car, lower for rail and HSR (time can be used)
- Use of multinomial logit model
Development of a transport simulation model

Trip generation and distribution

- Using modified gravity model of the Australian Bureau of Infrastructure, Transport and Regional Economics [BITRE, 2009]
- 31% of relations (OD pairs) of the NVS data included, but 84% of journeys

\[ T_{ij} = A_{ij} \frac{(P_i \cdot P_j \cdot 2Y)^\alpha}{(C_{ij})^\beta} \]

<table>
<thead>
<tr>
<th>Relation</th>
<th>2010 Pax (million)</th>
<th>2030 Pax with HSR (million)</th>
<th>Increase</th>
<th>2030 HSR share (of all)</th>
<th>2010 GC Air Business</th>
<th>2030 GC Air Business</th>
<th>2030 GC HSR Business</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melbourne – Sydney</td>
<td>7.8</td>
<td>14.1</td>
<td>+ 81%</td>
<td>58 %</td>
<td>$ 697</td>
<td>$ 751</td>
<td>$ 527</td>
</tr>
<tr>
<td>Sydney – Brisbane</td>
<td>4.1</td>
<td>7.7</td>
<td>+ 88 %</td>
<td>62 %</td>
<td>$ 712</td>
<td>$ 767</td>
<td>$ 537</td>
</tr>
<tr>
<td>Sydney – Canberra</td>
<td>4.2</td>
<td>6.8</td>
<td>+ 62%</td>
<td>32 %</td>
<td>$ 483</td>
<td>$ 530</td>
<td>$ 207</td>
</tr>
<tr>
<td>Melbourne – Brisbane</td>
<td>2.2</td>
<td>3.5</td>
<td>+ 59%</td>
<td>8 %</td>
<td>$ 905</td>
<td>$ 969</td>
<td>$ 955</td>
</tr>
</tbody>
</table>
High Speed System for Australia

**Mode share: High Speed Rail / Air**

- Calibration of HSR not possible, because mode doesn’t exist yet
- Approach with comparison of Generalized Cost for HSR and Air
- Blue graph indicates a “rational decision”, evidence with time-based analysis from Europe [Jorritsma, 2009]
- Fare only (green): poor results, time plays a significant role for mode choice
- Time only (red): demand overstated for Other purposes
- Generalized Cost with Time Sensitivity: good matching of results with blue curve
High Speed System for Australia

Operational concept

- Development of train routes with minimized changing necessity and maximized average speed
- But: at least one train/hour everywhere
- Special regional high speed services to Central Coast, Newcastle and Gold Coast
Scenarios modelled

1. 2012 BAU – baseline
2. 2030 BAU – projection
3. 2030 HSR(base) – Melbourne to Brisbane network
4. 2030 HSR(full) – Adelaide to Cairns network
5. 2030 EV & CATS – no HSR
6. 2030 EV & CATS + Rail – includes HSR(full) network and upgrades of classic rail network
Scenarios

1. 2012 Baseline
   - PAX: 489 million
   - Pkm: 127 billion
   - CO2e 20.5 MT

2. 2030 BAU
   - PAX: 720 million
   - Pkm: 192 billion
   - CO2e 31.6 MT
   - 51.1% Pkm increase

5. 2030 EV + CATS
   - PAX: 729 million
   - Pkm: 170 billion
   - CO2e 0.3 MT
   - (7.1 MT without aviation biofuel)
   - 33.8% Pkm increase

6. 2030 EV + CATS + Rail
   - PAX: 744 million
   - Pkm: 178 billion
   - CO2e 0.1 MT
   - (5.3 MT without aviation biofuel)
   - 40.2% Pkm increase
Change in travel activity

- Change in Air and Car travel from 2012 Baseline to Scenario 5
- Change in Air and Car travel from 2030 BAU to Scenario 5
Rail system potential

Modal passenger density

Scenario 6
2030 EV + CATS + Rail
Rail system potential

Scenario 6
2030 EV + CATS + Rail

Rail passenger density

- 2010 rail passenger density
- 2030 rail passenger density (with EV & CATS)
- 2030 HSR passenger density (with EV & CATS)
Conclusions

• Continuing trend will lead to increasing emissions

• Solutions are available to make significant reductions

• Taking measures to reduce emissions of existing transport system will increase travel friction across regional Australia

• Investment in rail will reduce this travel friction

• Demographic development and topography justify HSR in the southeast of Australia
References


• Koch A., et al., Climate impact assessment of varying cruise flight altitudes applying the CATS simulation approach, 3rd CEAS Air&Space Conference, Venice, Italy, 2011.

• Bureau of Infrastructure Transport and Regional Economics, National road network intercity traffic projections to 2030. 2009: Canberra, Australia.