Post-Occupancy Performance Assessment of BASIX-Affected Dwellings in NSW, Australia

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Overview

This research project carries out post-occupancy investigations of new residential buildings in NSW. It compares BASIX modelled results to monitoring data in real-life environments for each type of energy use in homes, and identifies performance issues in building condition, appliances and consumer behaviour.

The findings of this research will assist to identify areas for improvement of the BASIX assessment models, establish the links between government regulations, design options and post-occupancy behaviour and inform future sustainability strategies and policy.
BASIX Assessment Components
NSW Department of Planning and Environment, Australia
2002/2003 Benchmark: 3292 kg CO$_2$ emissions per person per year
Confirmed Stage 02 Dwellings vs Dwelling Age

0-5 years - 28 single dwellings.
5-10 years - 23 single dwellings, 3 multi-unit dwellings.
20+ years - 10 single dwellings, 1 multi-unit dwelling.

Map shows 63 out of 65 confirmed dwellings.
BASIX Estimation
(Energy, Water & Thermal)

Electricity & Gas
• Cooling
• Heating
• Lighting
• Ventilation
• Hot water
• Pool & spa
• Alternative energy supply
• Others (cooking, fridge, dishwasher, clothes washer, clothes dryer, other internal use)
• Common space services at multi-unit dwellings

Building Design

Behaviour Assumption

Measured Performance
(Energy)

Electricity & Gas
• Cooling
• Heating
• Lighting (& ceiling fans)
• Hot water
• Pool & spa
• Alternative energy supply
• Others (aggregate)

Energy Use Behaviour
• Energy use
• Adaptive behaviour
• Investment behaviour

Building Implementation
• Building changes
• Insulation, etc

Influential Factors
• Thermal perception
• Attitudes, preferences, etc
• Cost
• Knowledge, government education program, etc

Human Behaviour
(Occupants)

Socio-Demographics
• Occupancy
• Age, income, employment, etc

Building Diagnostics
• Air leakage
• Building envelope thermal performance, etc
Comparison of Energy Use between BASIX Estimation and Measured Performance
Comparison of **Cooling** Energy Use between BASIX Estimation and Measured Performance

Comparison of **Heating** Energy Use between BASIX Estimation and Measured Performance
Comparison of **Lighting** (& fan) Energy Use between BASIX Estimation and Measured Performance

![Bar graph showing energy consumption for Lighting and fan in different dwelling types.]

Comparison of **Plug-in Appliances** Energy Use between BASIX Estimation and Measured Performance

![Bar graph showing energy consumption for plug-in appliances in different dwelling types.]

**Note:** The graphs display energy consumption in kWh/Year for both BASIX estimated and actual (monitored) energy use across different dwelling types, including single storey houses, double storey houses, and apartment units.
High Cooling and Heating Energy Use (Compared to BASIX Estimation)

Low Cooling and Heating Energy Use (Compared to BASIX Estimation)
Lighting (& Fan) Energy Use (Daily)

- Average of all single storey houses: 52.1 Wh
- High energy consumption than BASIX estimation: 116.5 Wh
- Low energy consumption than BASIX estimation: 44.92 Wh
Outdoor/Indoor temperature and cooling energy usage (in January 2016) in a double storey house (#15)
Case example: House ID #8

<table>
<thead>
<tr>
<th>Dwelling ID</th>
<th>Number of occupants</th>
<th>Children</th>
<th>Elderly over 65</th>
<th>Home office</th>
<th>Single/double storied</th>
<th>Total floor area (m²)</th>
<th>Orientation</th>
<th>BASIX estimate kWh/yr.</th>
<th>Actual energy consumption kWh/yr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>yes</td>
<td>single</td>
<td>148</td>
<td>West facing Living: South</td>
<td>6603.83</td>
<td>7613</td>
</tr>
</tbody>
</table>

**Energy use behaviour in space cooling**

- Use air conditioner for cooling over 10 hours during weekends and 3-5 hours on weekday afternoons
- Turn on the air conditioner to cool air before it gets too hot
- Often use two operational zones of the air conditioner covering master bedroom and living/dining space for cooling

**Adaptive behaviour in space cooling**

- Close window blinds in the master bedroom facing west
- Use water sprinkler to cool alfresco area

**Influential attributes**

- Personal – Residents are heat sensitive and prefer cool environment
- Social- Due to the home office and young children age below five, house is occupied for at least 5 days per week
- Physical environmental- Master bedroom gets too warm due to the western orientation
Findings on Occupant Behaviour from Dwellings with High Cooling Energy Use (Compared with BASIX Estimations)

Energy use behaviour

- Keep a window open while air conditioner is in use
- More parties during summer that simultaneously use indoor-outdoor spaces
- Children’s movements restrict sealing spaces when air conditioner is in use
- No ceiling fans
- House gets unbearably hot
- Expect electricity bills to be covered up by solar
- Use air conditioner as the main source of cooling
- Routine use of air conditioner
- Use of air conditioner for long hours per day
- Use air conditioner in low thermostat settings
- Use air conditioner on large spaces (living/dining hall)
- Open plan layout
- Home-office
- Turn on the air conditioner before dwelling gets hot
- Unintentional use of air conditioner
- Limited air conditioner operational zones
- Elderly occupants forget to turn off air conditioner

Adaptive behaviour

- High use of electricity for cooling than BASIX estimations in free-standing dwellings
- Two storey houses: ground floor is cooler
- Change activities for comfort
- Change space utilisation in the house
- Cool the body
- Cool the external elements of the dwelling
- Shade the openings from exterior
- Shade the openings from interior
- Open windows to capture breeze
- Dwelling orientation

- Very common (>50% of dwellings)
- Common (25-50% of dwellings)
- Sometimes (<25% of dwellings)
Findings on Changes of Dwelling #8 after Implementation

House ID #8
Emu Plains, 2750
As-Built Design Changes from BASIX Estimations

- Heating and cooling systems added to the house – BASIX estimations did not include any heating or cooling systems.
Discrepancies between BASIX and AccuRate data (as-built form) are a result of design changes made to the house after the BASIX Certification was completed.
Actual Building Energy Consumption

Discrepancies between BASIX and actual building energy use data are impacted by building condition and behavioural factors.
Factors Influencing Actual Building Energy Consumption

• Building condition:
  – Thermal irregularities due to insulation performance/installation.
  – Infiltration/Exfiltration – 8.76ACH @ 50Pa.

• Behaviour:
  • 4 people living in house - two adults and two small children (< 5yrs).
  • Home office and always someone at home to look after the children.
  • Occupants are heat sensitive and prefer cool environments.
  • Master bedroom gets too warm due to the western orientation.
  • Often use air conditioner for cooling over 10 hours during weekends and 3 - 5 hours on weekday afternoons.
  • Often use two operational zones covering master bedroom and living/dining space for cooling
Thank you

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