Energy efficiency upgrade potential of existing Victorian houses

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VICTORIA State Government

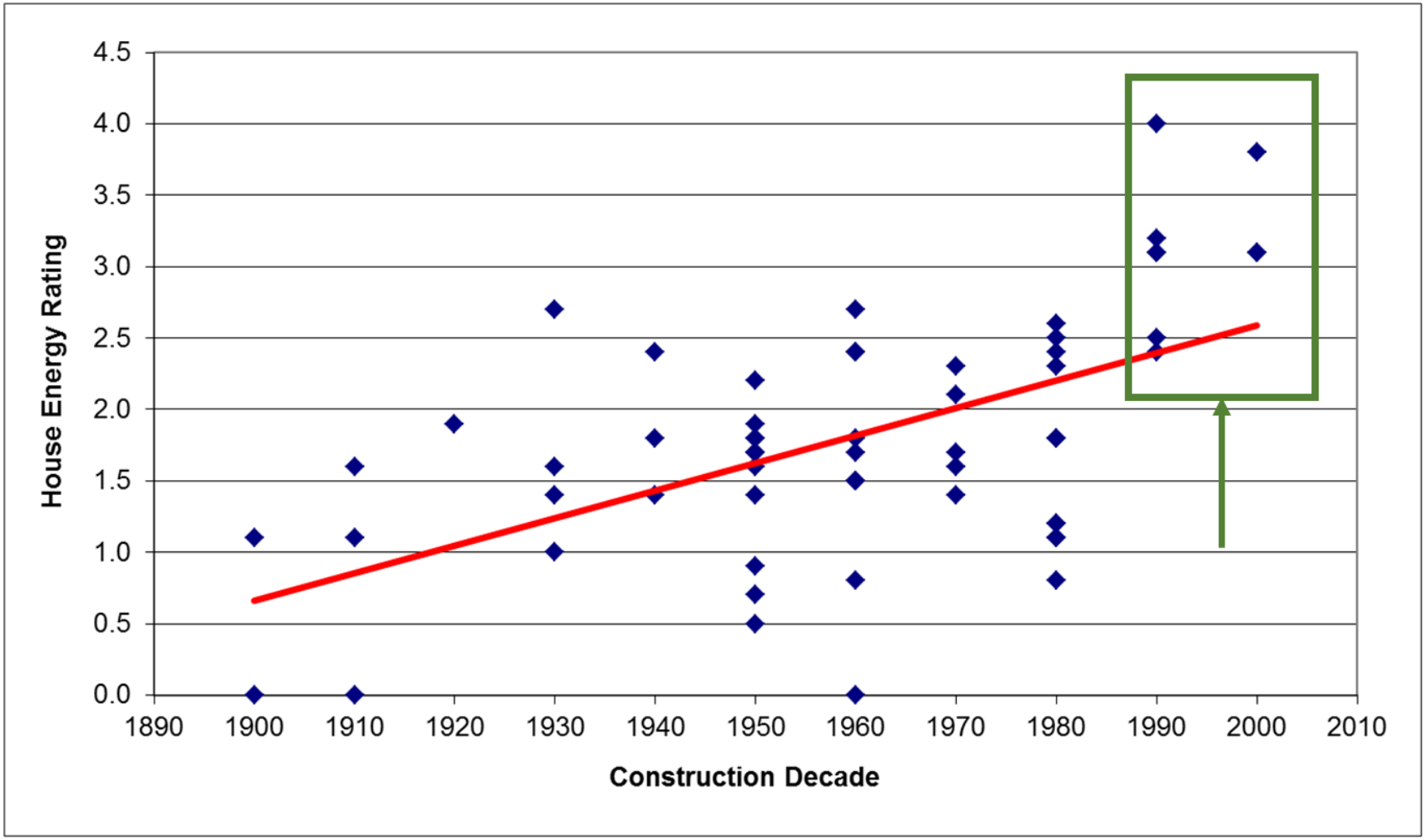
SV's research on upgrading existing houses

- The existing housing stock represents the biggest potential for energy & greenhouse savings in the residential sector
- **On-Ground Assessment** study – investigated reasonably representative sample of 60 existing (pre-2005) houses to identify their efficiency status, assess their practical upgrade potential, and *model* the costs and savings of the upgrades
- **Retrofit Trials** – undertook key energy efficiency upgrades in houses to assess the actual costs and qualitative and quantitative impacts, identify practical issues, and explore the rebound effect

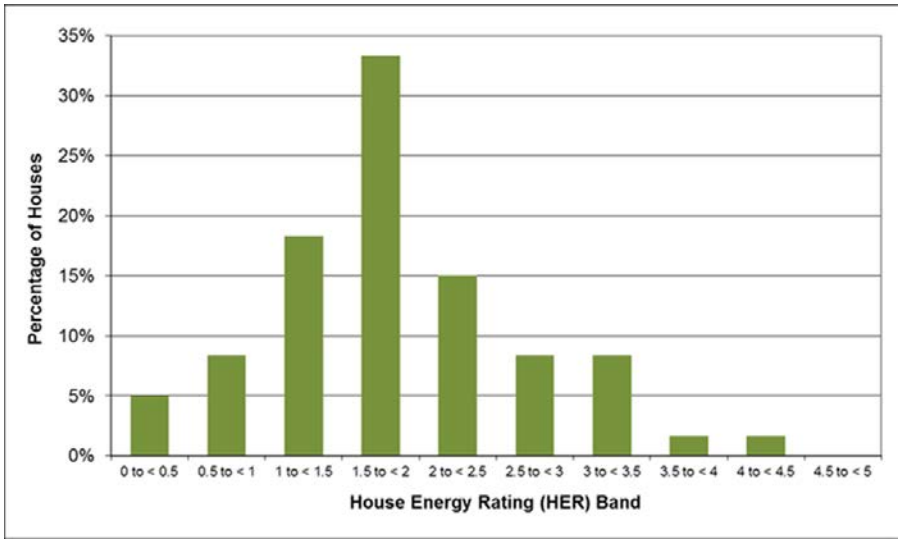
On-Ground Assessment study

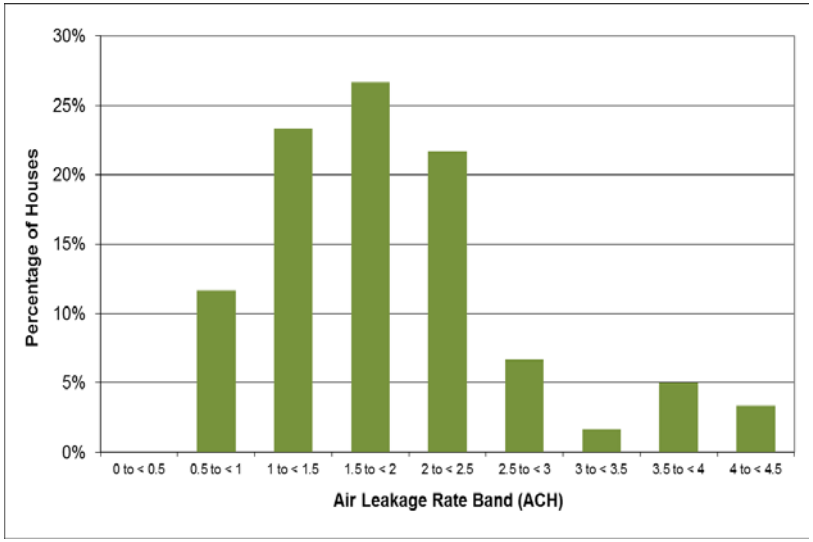
- A range of on-site data was collected from the houses for use in the modelling and analysis
  - Demographic data
  - Architectural measure up & drawings for FirsRate5
  - Blower door test used to measure the air leakage rate
  - Appliance, lighting & shower rose data
  - Historical energy billing data
- House Energy Rating, before & after retrofits, incorporating the measured air leakage rate
  - Actual heating energy use estimated from gas billing data, and percentage savings applied
  - Appliance & lighting analysis
- Upgrade analysis & cost curves

House energy rating of existing houses



Efficiency of existing (pre-2005) houses

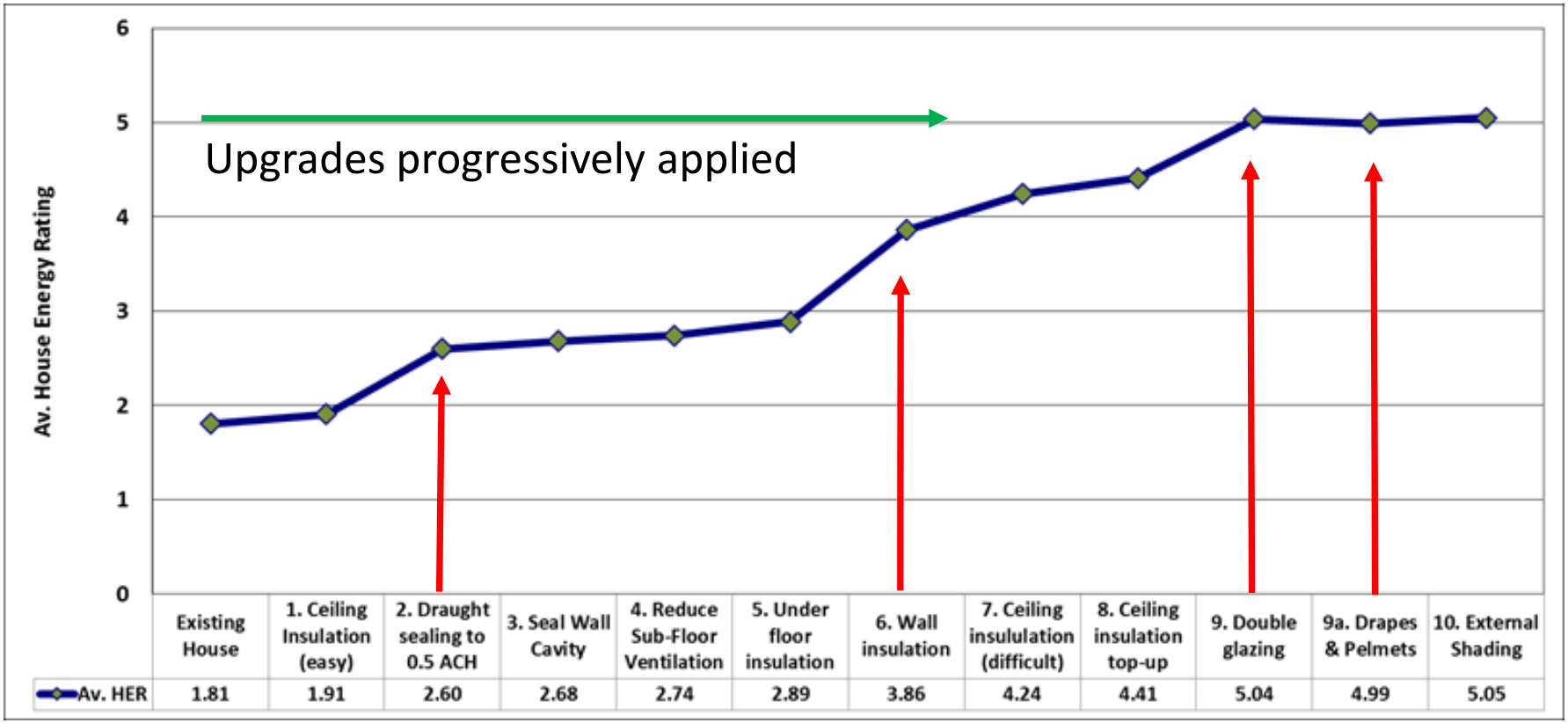




- Av HER is 1.81 stars
  - 1.57 stars for pre-1990
  - 3.14 stars for 1990 to 2004
  - New houses are 6 star
- Av natural air leakage rate of 1.9 ACH
  - 2.0 ACH for pre-1990
  - 1.2 ACH for 1990 to 2004

- The average efficiency of the lighting and appliances found in the houses was much lower than new high efficiency products

Impact of building shell upgrades



	Existing House	1. Ceiling Insulation (easy)	2. Draught sealing to 0.5 ACH	3. Seal Wall Cavity	4. Reduce Sub-Floor Ventilation	5. Under floor insulation	6. Wall insulation	7. Ceiling insululation (difficult)	8. Ceiling insulation top-up	9. Double glazing	9a. Drapes & Pelmets	10. External Shading
Av. HER	1.81	1.91	2.60	2.68	2.74	2.89	3.86	4.24	4.41	5.04	4.99	5.05

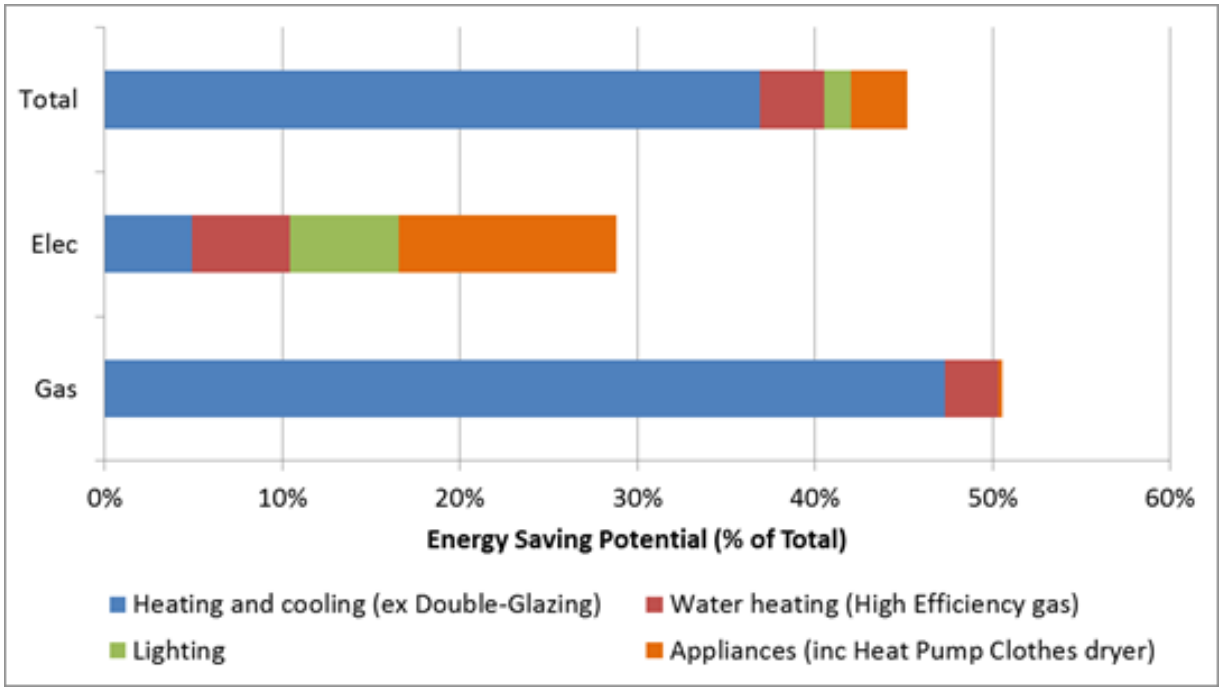
> Average House Energy Rating of 60 houses increased from 1.81 stars to around 5 stars once all relevant building shell upgrades had been applied

> Key measures were wall insulation (0.97 stars), draught sealing (0.69), double-glazing (0.63) or drapes and boxed pelmet (0.58).

Costs and benefits of shell and appliance upgrades

Upgrade	% Houses Applied to	Energy saving (MJ/yr)	GHG saving (kg/yr)	Bill saving ($/yr)	Cost ($)	Payback (yrs)
Low flow shower rose	56.7%	1,402	95	$57.9	$48.8	0.8
Ceiling insulation (easy)	11.7%	990	64	$19.3	$78.6	4.1
Lighting	93.3%	1,202	365	$93.5	$535.8	5.7
Draught sealing	98.3%	8,030	496	$153.9	$1,019.8	6.6
Clothes washer	55.0%	152	12	$24.9	$190.9	7.7
Water heater – High Efficiency Gas	58.3%	1,463	330	$58.2	$477.3	8.2
Ceiling insulation (difficult)	33.3%	1,698	111	$33.8	$278.2	8.2
Heating	80.0%	6,454	411	$125.9	$1,110.6	8.8
Refrigerator	86.7%	1,202	365	$93.5	$1,103.7	11.8
Reduce sub-floor ventilation	21.7%	601	36	$11.2	$116.7	14.9
Seal wall cavity	50.0%	927	57	$17.6	$270.4	15.3
Television	95.0%	696	273	$54.1	$964.3	17.8
Ceiling insulation top-up	43.3%	875	54	$16.6	$335.3	20.2
Underfloor insulation	40.0%	1,813	102	$32.4	$784.7	24.3
Dishwasher	43.3%	112	34	$10.4	$258.1	24.9
Clothes dryer – heat pump	45.0%	353	107	$27.5	$727.7	26.5
Cooling	40.0%	160	49	$12.5	$464.8	37.3
Wall insulation	95.0%	5,412	331	$102.5	$3,958.7	38.6
Drapes & pelmets	100.0%	2,263	139	$42.9	$2,035.9	47.5
Double glazing (full replacement)	100.0%	2,344	146	$45.0	$12,145.0	270
External shading	31.7%	9	3	$0.7	$346.6	694
Total (excluding Double glazing)		**35,813**	**3,434**	**$989**	**$15,274**	**15.4**
Total (excluding Drapes & pelmets)		**35,894**	**3,441**	**$991**	**$25,383**	**25.6**

Energy efficiency upgrade potential



- Estimated energy saving potential of 45.2% of total elec and gas use of the average Victorian house, 50.5% of gas and 28.8% of electricity
- Total and gas saving potential is dominated by building shell and heating upgrade measures. Electricity saving potential is dominated by appliance upgrades, with lighting and water heating also important.
- OGA study did not cover all possible energy efficiency upgrades, so larger savings are possible.

Residential energy efficiency retrofit trials

> A total of 12 different retrofits trialled (96 houses), plus comprehensive retrofits in 14 houses. Reports on 9 trials published to date

> The various trials involved

- Recruitment of suitable households
- Collection of on-site data
- Pre- and post-retrofit householder surveys
- Metering equipment to monitor energy use and level of energy service provided – 4 to 5 weeks before and 5 to 6 weeks afterwards

> Used a “differential analysis” methodology to estimate savings and extrapolate to annual savings.

Retrofit trials - building shell upgrades

> **Draught sealing** – comprehensive sealing of 16 houses, with blower door testing to measure differential impact. Av impact - 54% reduction in air leakage, $1,001 cost, 10.5% heating energy saving and 7.5 year payback

> **Cavity wall insulation** – granulated rockwool pumped into the wall cavity of 15 houses. Av impact - $4,440 cost, 15.5% heating energy saving and 29 year payback

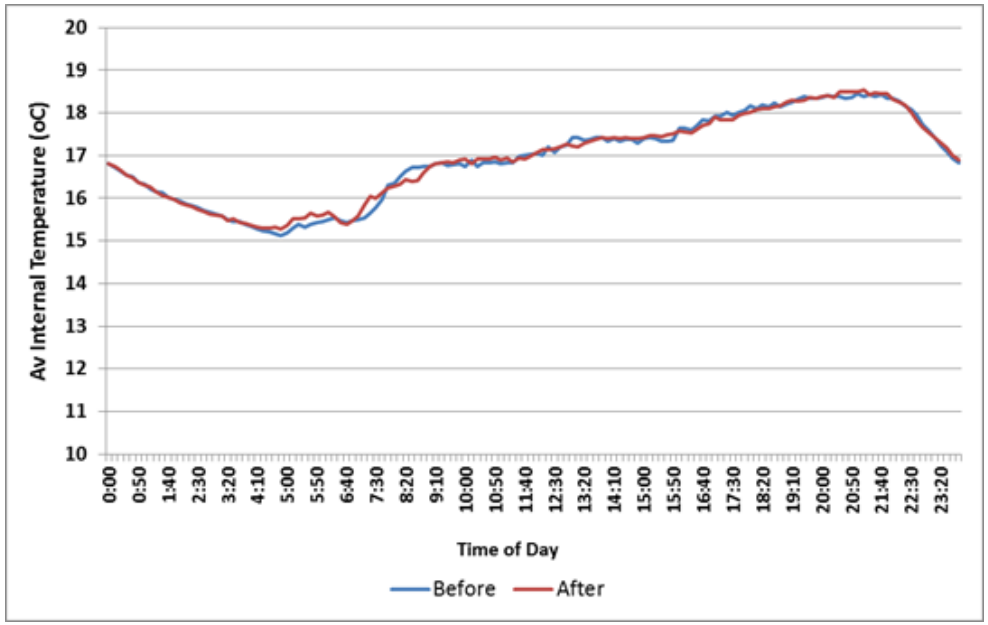
> **Gas heating ductwork** – old ductwork replaced with new high efficiency ducts at 8 houses. Thermal imaging shows duct surface temperature reduced by around 7^{o}C plus leaks eliminated. Av impact - $2,849 cost, 14.1% heating energy saving and payback of 16.1 years

> **Window film secondary glazing** – heat shrink window film applied to windows in main living areas of 8 houses to create a double glazing effect. Modest heating energy savings of 2 to 4%, although payback under 2 years if DIY

Retrofit trials - appliance replacements

- **Halogen downlights** – replaced with low energy lighting (CFL / LEDs) in 16 houses. Light levels compared and operating time monitored. LEDs performed much better than CFLs – better light levels and larger energy savings (80% vs 57%)
- **Gas water heaters** – old storage systems replaced with new high efficiency units at 6 houses. Actual hot water use was much less than the 200 L/day used for gas labelling. Av gas saving of 18.8%, but new instantaneous gas unit performed much better than new gas storage systems
- **Clothes dryers** – old conventional clothes dryer replaced with heat pump system at 4 houses. Av energy savings of 59%, 623 kWh per year, but most houses were high users. Av size of load dried only 1.5 kg. The cost of heat pump dryers is decreasing.
- **Refrigerators** – old fridges replaced with new high efficiency models at 7 houses. Av energy saving of 67%, 616 kWh per year. At 14 other houses the householders chose the fridge, but still got a 53% saving.
- **Swimming pool pumps** – Old single speed pumps replaced with high efficiency 3-speed pumps at 8 houses. Average energy savings of 50% achieved, 1,040 kWh per year and 2 year payback. Savings higher where can run the new pump on its lowest speed.

Is there a rebound effect?



Graph shows average internal temperature profile in heated areas for the 8 houses in the gas heating ductwork trial.

> Data was collected on the level of energy service being provided and used to assess the level of rebound

> In most cases there did not seem to be any (net) rebound effect, with some exceptions:

- Use of lighting increased where CFL downlights used, but not LEDs
- The average load of clothes dried increased after the retrofits in the clothes dryer trial
- Hot water use increased at 2 houses in the gas water heater trial, but at one this was because the existing water heater was faulty

Key learnings

- Energy savings measured during the Retrofit Trials are broadly consistent with estimates from the *OGA* study
- Appliance and lighting upgrades are generally more cost effective than building shell upgrades
- There is a high level of diversity between how households use energy, so also a high level of diversity in the impacts and cost effectiveness
- How appliances are used in practice is quite different than how they are tested for energy labelling
- Quite challenging to measure the actual energy savings achieved in most cases

Questions?

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Copies of all reports available at:

http://www.sustainability.vic.gov.au/services-and-advice/households/energy-efficiency/toolbox/reports/technical-reports