How do Smart Cylinders save?

A Smart Cylinder can save people substantial costs on their hot water bills. The Smart Cylinder draws on 3 primary methods that can be employed to different degrees, separately or jointly depending on the circumstances.

1. Reduce Standing Losses;

Heat radiated from your cylinder, pipe work and fittings add up to lost hot water energy which has to be replaced by additional heating. A traditional storage hot water cylinder is constantly attempting to heat the entire cylinder to 60°C hot water. This is very hot water and while good for sterilising the stored water against dangerous Legionella bacteria it is also wasteful as most hot water is ultimately delivered at around 38°C by mixing cold water.

The Smart Cylinder controller uses advanced techniques to heat only the water you need by allowing cold and hot water to co-exist in the same cylinder. Hot water sitting on top of cold water is called stratification and a critical control technique employed by the Smart Cylinder controller. The controller also evaluates the hot water temperature and volume remaining then considers what minimum temperature is required to maintain the supply of hot water you require.

There are less radiated losses because;

1) There is less of the cylinder heated well above room temperature to radiate
2) Cold water connected pipes conduct away less heat as the water is cold. Whereas in a fully heated tank the cold inlet pipes are often warm or even sometimes hot
3) Heat once radiated from the upper hot part of the cylinder is normally lost. With a stratified tank some of this ‘lost heat’ is reabsorbed by the cold water portion of the cylinder via the material inside the cylinder and the outer cladding[1]. Thus requiring less energy to heat the cold water when required
4) The temperature of the hot water portion will tend to be lower than 60°C most of the time and will radiate to a lesser degree
5) With an average lower total hot water volume the cylinder will be subject to much lower peaks of water pressure. Therefore there will be less excess hot water discharge especially at night. In low pressure cylinders this can be 10 litres a day and to a lesser extent mains pressure cylinders (typ 2-3% cylinder volume per day)

2. Use lower price electricity

It is possible to use lower price electricity to heat your hot water. There are two primary tariffs that can be used.

a. **Time of Use**; (the power is never interrupted by the utility) this tariff charges lower power prices at night than during the day for the entire house. The day prices per unit are higher than standard but the lower night prices offer a considerable incentive if you can make use of this.

b. **Night Rate**; Similar to above but the power is only available on the Night Rate circuit (feeding the cylinder) from 11:00pm to 7:00am next morning. The night tariff is usually substantially cheaper than the standard tariff, sometimes ½ price. Some utilities offer another 1 or 2 hour 'Boost' time between 3:00pm and 4:00pm

I. Any Smart Cylinder controller can easily work with 'Time of Use'.
II. Night Rate requires a dual element Smart Cylinder in 'Night Rate' mode. This mode will endeavour to use Night Rate power as much as possible. If there is an unusual large hot water draw off, the user can still avoid running out of hot water. A major point to note is the Smart Cylinder controller will still only heat what is required; usually no need to heat an entire tank to maximum every night. So dual savings of standing losses and reduced power costs.

This is of especially good value for higher volume hot water users.
Example;
A daily hot water draw-off requiring 18kWh (higher use 4 – 6 occupants);

1) Standard charges 30 cents a unit (average tariff for now and some years into the future for a fair average) = 18 x 0.3 x 365
   = $1971 cost per year
2) Night-rate tariff on Smart Cylinder at 50% discount* and other savings mechanisms (typically another 10% at least) employed by Smart Cylinder technology = 18x (0.3x 0.4) x 365 = $788 cost per year
3) Savings of $1183 per year

Note: Low tariff power (or 'off peak') is generally considered 'green' or 'greener' power than peak tariff as it tends to be generated more from renewable sources.

3. Change in culture of energy use

We developed an early version of this controller in 2009 and started to receive reports that some people where saving far more than we expected based on Standing Loss savings alone[2].

Fast forward to 2012 and after years of substantial team effort involving 4 engineers and substantial R+D investment the 'Smart Hot Water' control method was developed and released in a new controller.
With a much improved visual and information rich colour interface, simplification of the user controls and substantially improved algorithm we knew we had a great hot water tool.

As the number of installations rose we received more and more reports of substantial user savings far beyond what we expected. We understood that some of them were because the cylinders had faulty thermostats and the cylinder was effectively out of control and 'boiling' before an Smart Cylinder controller was installed. But that only explained a few of these great results.

As more and more Smart Cylinder controllers have been installed we have come to realise that the power of visual feedback (of an already intelligent

system) and decisions on user behaviour is played out in the following sequence;

1) Accurate hot water measurements are obtained and conditioned by the controller
2) Relevant useful hot water storage information using the fuel gauge is displayed for the user in real-time with trending feedback of (remaining) stored hot water.
3) Hot water on hand is evaluated by the user based on their experience and expectations. Too much, too little or just right?
4) Decisions are made by the user on hot water usage (or controller adjustment) which at this stage might change from past behaviour

These four stages are known as a feedback loop[3] and is a well known psychological phenomenon

Other situations;

1) Solar electric grid-tie installations;
   a) It has become poor value to feed your surplus micro-generated power into the grid
   b) The Smart Cylinder controller is so versatile that you can intelligently control when your hot water is heated to best match usage of your surplus power generation. Thus 'storing' energy in your hot water cylinder, like a liquid battery, for later use
   c) The Smart Cylinder controller can create extra storage capacity by (safely) elevating the stored hot water above 60°C
   d) Best possible value return for your solar electric system
   e) We have users saving substantial amounts of money this way. Savings of $60 to $100 a month have been reported to us by people who added an Smart Cylinder controller to their hot water cylinder after they have had solar electric installed

2) Faulty thermostats
   a) Most people have no idea how well their 'faceless grey cylinder' is operating. The tempering valve will mix cold water with the excessively hot water as it leaves the cylinder so the user might be unaware of excessive heating.
   b) If a thermostat is faulty or is not making contact with the tank inner wall then the cylinder will heat excessively, even to the point of boiling
   c) Smart Cylinder controllers will bring such faults back under control with resultant large savings
   d) Savings <u>over</u> $100 a month have been traced to faulty thermostats

      In New Zealand hot water cylinders are usually set to 60°C but some run much higher due to poor thermostat accuracy
      (BRANZ HEEP 2010 and Statistics NZ 2015);

      i) 70°C to 80°C = 10% (135,000 cylinders)
      ii) 80°C to 90°C = 5% (67,500 cylinders)

iii) 90°C and above = 1% (13,500 cylinders)

e) Temperatures elevated above 60°C will result in substantially increased standing losses on cylinders. Correcting this will have larger savings compared to the expected standard.

3) Future proof
   a) A Smart Cylinder (and to some extent a retrofitted Smart controller) offers options for future installation or application of other energy sources;
      i) Wetback
      ii) Solar Thermal (Smart Cylinder can manage solar pump and collector sensor)
      iii) Solar Electric load shifting, avoid feed-in – use it yourself
      iv) Time of use power tariffs
      v) Smart Cylinder controller can be removed from an old cylinder and installed onto a new cylinder

4) Legionella protection
   a) It is required under New Zealand law that any (management) device for domestic hot water services must keep the hot water safe from dangerous Legionella infection. There are 3 solutions allowed under The New Zealand Building Code clause G12
   b) When power is interrupted to the cylinder then the 'safety' of the water over time can only be determined by temperature sensor/s on the cylinder.
   c) The Smart Cylinder controller manages Legionella sterilisation using a system known as BioSafe©. This is an acceptable solution of sterilising at least once a week, the entire cylinder for 1 hour.
   d) A cost effective way to keep hot water safe over holidays or absences (one off heating once a week is typ $2.24 per week). To leave a traditional cylinder on for the entire week would lose <u>at least</u> typically $5.58[5]. Note: once a cylinder is turned off it will become unacceptably cold in typically 2 – 3 days[6]
   e) Ideal for batches
   f) Any device that fails to measure tank temperature to ensure protection from Legionella and then automatically heat to ensure sterilisation, except for a continuously energised (traditional) cylinder, is illegal
      i) Timers are illegal, or if retrofitted then very unwise
      ii) The maximum time between sterilisations is one week
      iii) Any hot water system not complying with the NZ building code is illegal and dangerous
   g) It is very poor advice to tell someone to simply 'turn down' their thermostat for savings without measuring what the water temperature is. In New Zealand this has lead to at least two cases of Legionnaires Disease and in one case septic shock resulting in a month in intensive care following infection from hot water cylinders that had been 'turned down' (July 2015). At a pure cost of hospital treatment alone this is $3000 per day for intensive care, or $90,000 for one month. However this would have only been a part of the overall cost as other

tests, treatments and rehabilitation would have multiplied these expenses a number of times over.

Comparing Apples with Apples;

The question is asked “what is the payback time of a Smart Cylinder controller”?

The Smart Cylinder controller is an energy efficiency device. In this respect it has more in common with a Hot Water Heat Pump or other Smart Cylinders than a solar hot water system. Although even this is a difficult comparison as it can manage most hot water storage systems irrespective of the heating source.

Therefore it is less of a case of an Smart Cylinder **or** other options and more like Smart Cylinder **and** other options.

The advantages of a Smart Cylinder controller are best observed as quantity of money saved as this is the only real common denominator that defines a devices value for the end user

All values should be converted to money saved for a fair comparison.

When a Hot Water Heat Pump specification is quoted it is usually in the form of C.O.P or %. This looks impressive at claimed figures like 400% or so.

However this is not the full story; The BRANZ heat pump study (SR 237 2010) revealed that heatpumps can only attain the impressive quoted figures of efficiency under some circumstances, as the air becomes cooler and storage tank becomes hotter there is a reduction in efficiency. Such that on average (across all conditions of operation and heat pump models) the efficiency is 150% or a C.O.P of 1.5 can be expected.

This needs to be translated into payback for a fair comparison with the Smart Cylinder controller.

Simple Payback in years = Cost of HWHP ÷ Savings per year

So as an example a $5000 HWHP saving 74% on hot water heating bills (verified figure of best HWHP);

I. Saving on standard hot water bill = $605p.a.
II. $5000÷ $605 = 8years 3 months payback
III. If someone is a low user of hot water then a HWHP is not cost effective
IV. If someone is a high user of hot water then HWHP is more attractive

Note; Smart Cylinder at $1500 ÷ 8 years 3 months = $180 p.a. = $15.00 per month saved to
be same payback as a HWHP

Note; High volume hot water users would greatly benefit from low power tariffs and an Smart Cylinder

How does the Smart Cylinder save?

1. Typically: Standing losses + Change in culture

a) Standing losses are probably higher than expected because BRANZ reference tables are based on a full cylinder at 60°C. There are other losses for an installed domestic hot water cylinder compared to a fully heated stand alone cylinder in a laboratory;

   I. Excess water pressure release; a full cylinder of 60°C water will be at a higher pressure than a cylinder with thermal stratification and lower temperatures. When pressure builds a standard low pressure cylinder can vent 10 litres of hot water a night

   II. Pipe work thermal conduction; we have noted some tanks even the cold inlet pipes are warm, well above ambient. Especially with copper piping

b) There is some energy recovery with a stratified cylinder[2] compared to an un-stratified cylinder

   I. Once the thermal energy has radiated from the upper section of the inner cylinder, it transfers into the internal space of the cylinder between the inner and outer skins, from there to the outer cladding where it is normally radiated into the atmosphere

   II. With a stratified cylinder some of this heat is re-absorbed by the cold part of the inner cylinder and not as much is lost into the atmosphere. Therefore the cold water section takes less energy to bring up to temperature later

c) Instead of $5 - $10 a month based on BRANZ figures[4] we expect more like $15 a month is saved for a correctly set up user, based on the reasons given and assuming a 50% stratified cylinder

d) The remaining savings are therefore ‘Change in Culture’ of using less hot water

e) Typical reported savings of at least $30 a month saved = $15 standing losses + $15 change in culture

f) Many users are saving **more** than this value for various reasons including;

   I. Faulty thermostats - $80 to $150 per month

   II. Running even less than 50% stratified hot water (our figures assume 50%)

   III. Choosing to use substantially less hot water with the culture change than we have estimated.

2. Low power tariff option + Standing Losses

a) This is great value for higher users but also applicable to any user as the capital costs are usually the same as a standard Smart Cylinder installation. There is no installation premium for lower price hot water. The only issue to examine is if the low tariff option effects standard tariff prices (usually only applicable with time of use tariff) and if that extra cost is offset by hot water savings. Also not available in all areas.

b) Night rate power tariff can be around half price

c) Using HWHP terminology this is analogous to 200% savings. The average HWHP efficiency is 150% according to BRANZ

d) A higher user would save $1183 per year at 18kWh used per day (equivalent to just over 2 x 180 litre tanks hot water energy)

3. Other or non-standard

a) Solar electric and other micro-generators are becoming more common and will continue to rise in number. These users can benefit greatly from an Smart Cylinder Supplementary renewable energy source load shifting using hot water storage - $50 to $130 per month

b) Better electric element boost control for Wetback and Solar Thermal

So why have we claimed such savings?

We have been receiving consistent feedback and testimonials from our customers and users covering common and outlier savings. $30 per month is what we consider a conservative saving but we cannot ignore the many people that are saving substantially more.

The very first 8 installations uncovered 2 ‘out of control’ cylinders alone. These people saved well over $100 per month. This is obviously a real problem and one we think is a valid saving to put forward.

Night rate installations and Solar PV owners are reporting savings $50 to $130 a month

Our ‘average’ customer feedback (from all sources and options) works out $60 to $70 a month.

Is it worth it for everyone?

1) Smart controller expected lifespan is 25 years (also lifetime figure quoted by some heat pump manufactures) so $1500 ÷ 25 = $60 per year. Adjusted for averaging power cost rises over that time based on previous 25 year power price rise average of 7%; A per unit price median of 60 cents per unit is calculated for the next 25 years. To save $60 per year at $0.60 kWh the user would need to save 100kWh per year or 8.3 kWh per month (typically we are seeing well over 100 kWh per month)
2) This is easily achievable by just about every user. **Therefore the Smart Cylinder will always be at least cost neutral**
3) However there are some users who will benefit less than others and we are keen to identify these people and make it clear to them that with their present circumstances they are unlikely to see the savings at the levels we are saying an owner should expect. Those less likely to see full benefits;
    a) Very low hot water users
    b) High volume hot water users who nearly empty their cylinders of hot water each day and who do not have, cannot access, or do not want off peak power tariffs
    c) It is assumed the above 2 scenarios cannot benefit from any of the other examples of various savings options the Smart Cylinder can offer

Future Considerations;

1) Cylinders are trending larger. Expect 250 litres as new standard. The larger the cylinder the more it can benefit from intelligent control as the Smart Cylinder can effectively make the cylinder appear to ‘change in size’ through some simple adjustments. Full size for large family, smaller size for a working couple
2) Renewables and flexible power options will become more common place and load shifting using hot water is a cost effective and reliable option.

References

1. Adrian Kerr: Project Solar *Performance, and estimated savings from using the AlphaStat Plus 1 controller on domestic hot water cylinders in New Zealand.*2008

2. M.K. Dennis (2003) *Auxiliary Heating Methods for Hot Water Storage Tanks*. Destination Renewables – ANZSES 2003

3. First explored by Albert Bandura, a Stanford University psychologist in the 1960's. Now a powerful technique used in many disciplines from business to military planning. A common example today is the traffic speed displays without enforcement, just information and relevance to the legal speed limit.

4. Grade B and assuming 50 / 50 hot to cold stratification

5. A traditional hot water cylinder left powered on but with no draw off. Based on Grade B Climate 1 Outdoor. Based on a holiday home, no home heating while owner's away, usually less than ideal insulation etc. Losses on cylinder alone = 16.3 kWh per week. Add in excess water dumps and piping losses of around 4.7 kWh = 21 kWh. At 28 cents a unit = $5.58

6. A typical 180 litre cylinder takes 8kWh to heat and most people will find 38°C the minimum acceptable hot water temperature. This is 50% heat capacity so a 4kWh loss max is acceptable. Total daily losses for a domestic hot water cylinder, piping and excess water discharge are around 3kWh (BRANZ avg 2010 + pipework and water loss). So in just over 1 day the cylinder is too cold to use (but not 'stone cold'), due to reduced losses as the water temperature approaches closer to ambient this can be drawn out to 2 days. This is consistent with Senztek's wetlab experiments 2010 to 2012