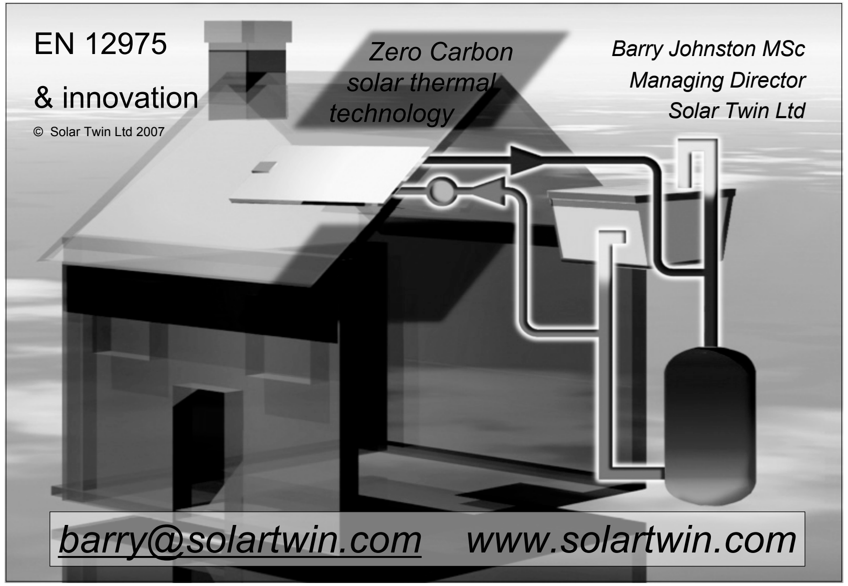

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Overview of EN 12975 Presentation

1. What is the position of EN 12975 today?
2. What does EN 12975 test?
3. Which technologies does it apply to?
4. Which assumptions are made?

5. Case study: Solartwin and EN 12975
6. Which innovations fit poorly?
7. Why do they fit poorly?
8. Polymer-specific issues of poor fit

9. What is the market effect of poor fit?
10. Discuss 4 possible ways forward.

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Today's thesis is:
that some <u>false assumptions</u> are made in EN 12975.

- That a quadratic equation will characterise collectors correctly (this is not the case with step change panels)
- That you only need one quadratic equation (this is not the case with low flow / variable speed panels)
- That peak temperature control cannot be achieved by heat export and that stagnation is the only means
- That the highest pressures are experienced at stagnation (pressure freeze tolerant collectors)
- That all polymers are organic (Silicone is inorganic)
- That optimising a generic "one size fits all" collector in isolation is a good thing to do.

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What is the position of EN 12975 in 2007?

- One of EN several Standards on solar thermal in Europe
- Almost unquestioned status as a "Gold Standard", to which industry must conform:
  - Exclusive gateway for "Solar Keymark"
  - Required / recommended for most national building codes
  - Main gateway for most market support programmes
- EN 12975 is why the rest of the world may soon <u>overtake Europe in areas of solar thermal innovation</u>.

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What does EN 12975 test?

- <u>Solar collectors</u> (only certain aspect of these)
  - Not systems
  - Not total annual system performance
  - Not sustainability (eg carbon input/output ratio)
  - Not independence capability (eg flatness of performance over a year)

- <u>It does test</u> 2 main areas:
  1) Performance (1 main outcome: quadratic equation, 3 figs)
  2) Durability (8-10 main tests: pass / fail on each)

We will look at these 2 main areas of test next.

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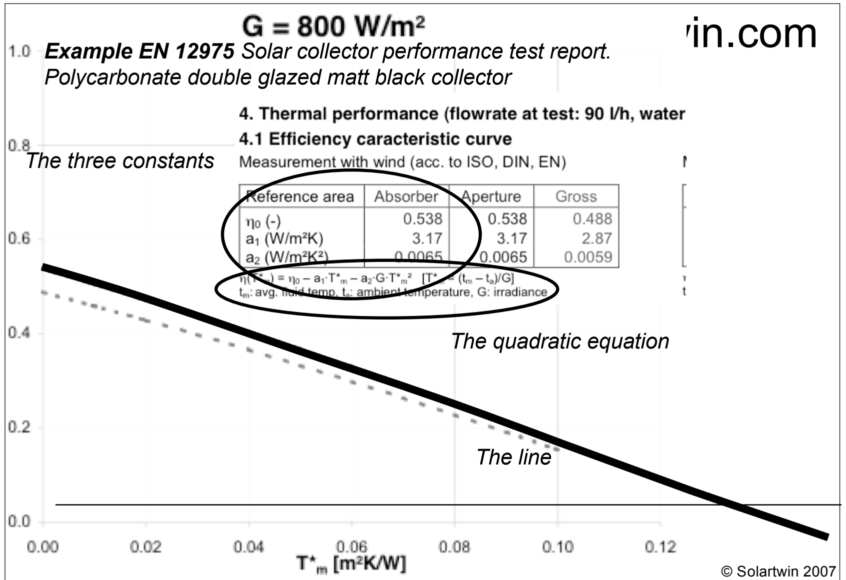
The EN 12975 <u>performance</u> tests

- Main outcome is to produce <u>one quadratic equation</u> mathematical model of instantaneous power output

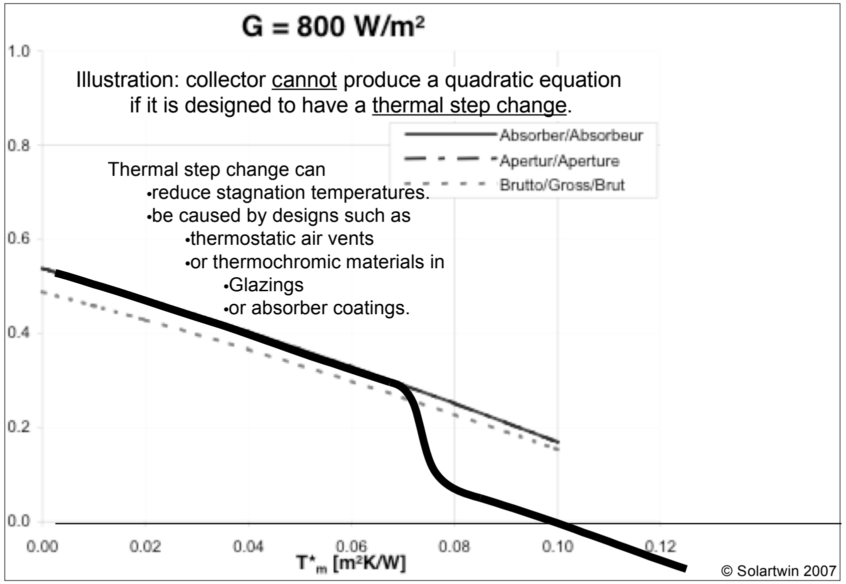
- <u>Inputs</u> to the model are:
  - Brightness
  - Temperature difference between inside and outside the panel

- <u>Outputs</u> are only 3 constants, required for any quadratic equation:
  - no Base (zero loss) efficiency (y intercept)
  - a1 Linear temperature related power loss (x term)
  - a2 Square temperature related power loss (x squared term)

- But what if the collector
  - does not produce one quadratic equation, but <u>several</u>?
  - <u>cannot</u> produce any quadratic equation at all?



Reference area	Absorber	Aperture	Gross
η_0 (-)	0.538	0.538	0.488
a_1 (W/m²K)	3.17	3.17	2.87
a_2 (W/m²K²)	0.0065	0.0065	0.0059



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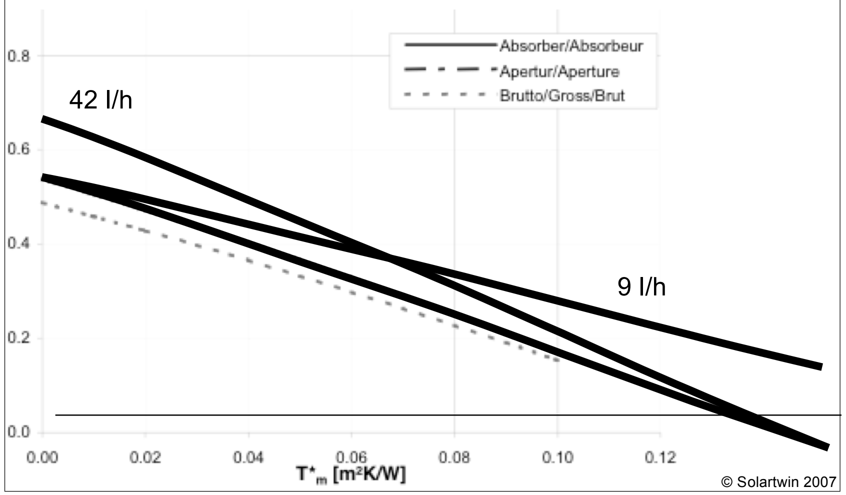
Collector delivers more than one performance equation if it uses low speed or variable speed pumping.

Flow rate (l/hr)	Base efficiency no	Linear decline a1
42	0:66	3.8
21	0.62	2.94
9	0.53	1.44

Data from "Design of a PV driven low flow solar domestic hot water system and modeling of the system collector outlet temperature". T. Grassie, K. MacGregor, T. Muneer, J. Kubie School of Engineering, Napier University, 10 Colinton Road, Edinburgh EH10 5DT, UK. Energy Conversion and Management 43 (2002) 1063–1078 Pergamon

General illustration of the multiple performance equation gained from low speed or variable speed pumping.



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Summary: which technologies does EN 12975 apply to?

- The performance test only applies to collectors which are conventional and design AND in use and which are:
  - *NOT thermal step change in performance*
  - *NOT low flow (if ever under say 30l / hr / sqm)*
- This is because one quadratic equation will not describe their performance properly
- But what about the durability test?

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The EN 12975 durability tests

- 5 Stagnation-related tests
  (these may not need to be quite so prominent in panels which only stagnate in abnormal conditions, and not routinely)
  - 5.2 Internal pressure
  - 5.3 High-temperature resistance
  - 5.4 Exposure
  - 5.5 External thermal shock
  - 5.6 Internal thermal shock
- 5 other tests
  - 5.7 Rain penetration
  - 5.8 Freeze resistance
  - 5.9 Mechanical load tests (2 tests, both up and down)
  - 5.10 Impact resistance (optional)
- Outcome is to make a durability pass/fail decision for the collector.

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The stagnation-related durability tests

- 5.2 Internal pressure and 5.3 High-temperature resistance
  - More than one combined test may be needed
  - May be highest pressure at freezing
  - May be highest temperature at stagnation
  - Pass-fail criteria should be functional, not absolute
- 5.4 Exposure
  - Should the panel be stagnated for 30 days if this is not part of normal operation?
  - Pass-fail criteria should be functional, not absolute
- 5.5 External thermal shock
- 5.6 Internal thermal shock
  - May barely be relevant for panels with flexible polymer absorbers

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Now the other durability tests

- 5.7 Rain penetration - OK
- 5.8 Freeze resistance
  - Perhaps 3 freeze-melt cycles are not enough?
  - Perhaps the freezing needs to be very slow to make larger (more damaging) ice crystals?
- 5.9 Mechanical load tests (2 tests, both up and down)
  - Perhaps pass-fail criteria should be functional not absolute
- 5.10 Impact resistance (optional) - OK
- *What's missing? Perhaps more work needs to be done on polymers being compatible with heat transfer fluids?*

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Which technologies does EN 12975 apply to?

- The performance test only applies to collectors which are conventional and design AND in use and which are:
  - *NOT thermal step change in performance*
  - *NOT low flow (if ever under say 30l / hr / sqm)*
- The durability test only applies to collectors which:
  - Are NOT inorganic polymers (certain panels apparently do not exist)
  - Are routinely stagnated as a means of high temperature control
  - Experience the peak temperatures and pressures at the same time
- (But the standard does not say any of the above explicitly.)

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Case study: Solartwin and EN 12975

- Case study outline
  - The broad menu of solar thermal technologies
  - How Solartwin operates
  - Commercial impacts

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On the broad solar water heating menu:

- Collector geometry - vacuum tubes or flat panels?
- Low or zero carbon - mains or PV control / pump?
- Heat transfer medium - air, oil, antifreeze, water?

- Freezing - antifreeze, drain down, flexible pipes?
- Venting - temperature/pressure valves or open vent?
- Materials - metals, metals, polymers?

- Flow rates - fast or slow? On-off or variable speed?
- Pipe diameters - 22mm, 15mm or microbore?
- Bubble removal - use valves or entrain them to open vents?

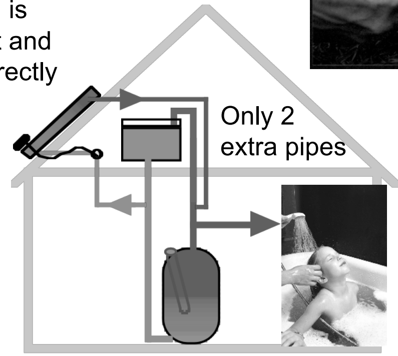
- Stratification in hot water store - reduce or promote it?
- Heat exchanger - direct or indirect heating?
- Hot water cylinder - replace or reuse it?

- Dedicated solar volume - in space or in time?
- Overheat handling - pump off = stagnation / thermochromics / thermostatic air venting / heat export?
- Design starting point - tweak existing designs or restart from scratch?

- Design goals - area-efficiency, cost-efficiency, eco-efficiency?
- Problem solve by - resist them or accommodate or design problems out in the first place?
- Winter optimise by - single glazed selective / double glazed non-selective / steepness?

Solartwin: simply different

Solartwin heat collector panel is freeze-tolerant and heats water directly



Safe low voltage variable speed low flow pump and photovoltaic panel

Hot water out to baths and sinks from stratified storage

Simple design concept and operation.

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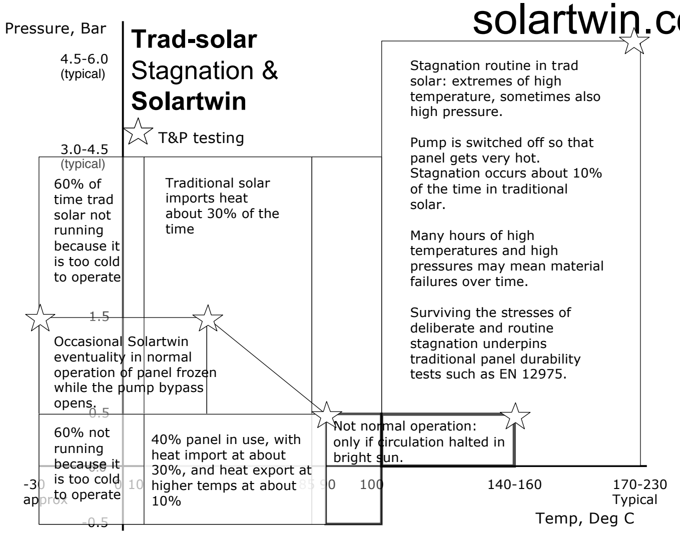

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Which innovations fit poorly?

1. Thermal step changes in performance
2. Low flow / variable flows
3. Non-stagnating in normal use
4. Flexible or polymer based collectors
5. Systems containing silicone rubber
6. Collectors designed only for dedicated components or limited types of operation.

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Why do they fit poorly?

1. Collectors with thermal step changes in performance (thermotropics / active vents) do not fit the performance equation at all.
2. Low flow / variable flow systems, which tend to be PV pumped (zero carbon) need multiple performance equations. Only one is allowed.
3. Systems which use heat export, not stagnation as a means of overtemperature control may be over-tested.
4. Flexible or polymer based systems because the pass/fail criteria are absolute, not functional.
5. Systems containing silicone rubber because it is an inorganic rubber and it apparently does not exist
6. Dedicated components, such as dedicated pumps, pipes, vents and control systems may be carefully matched to certain collectors. The "generic to all installations" approach of the standard is inappropriate.

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All six may be polymer-specific problems

1. Thermal step changes are more likely to be found in polymer collectors because of the need to minimise stagnation temperature.
2. Low flow / variable flow systems, may be linked to future integrated polymers PV frames.
3. Systems which use heat export are suited to polymer collectors because this approach minimises high temperature exposure.
4. Flexible or polymer based systems face problems today because the pass/fail criteria are absolute, not functional.
5. Systems containing silicone rubber are non-existent in the standard.
6. Dedicated components, will become more likely, because of the trend towards well optimised systems (rather than just individually optimised collectors).

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Four possible ways forward

1. Do nothing and risk innovation leave Europe for US and Australasia.
2. Rewrite the scope of the standard to be narrower (so it actually fits what it was probably designed for).
3. Make the standard wider, perhaps using a matrix approach.
4. Move away from a panel focus and towards a system sustainability / performance focus.