23/3/2015

Introduction to Energy Audits

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What is an Energy Audit?

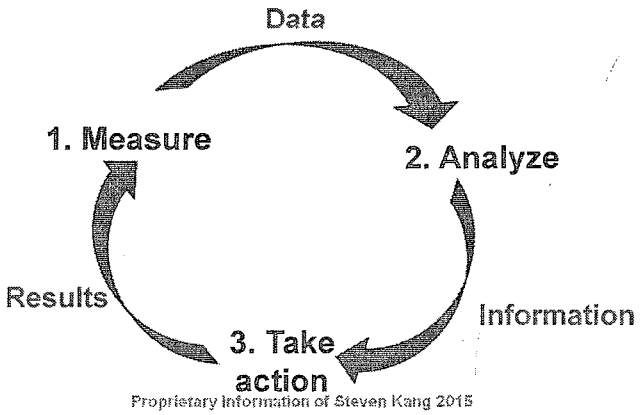
An Energy Audit can be simply defined as a process to evaluate where a building or plant uses energy, and to identify opportunities to reduce consumption.

-Handbook of Energy Audits, 7th edition, Albert Thumann & William Younger

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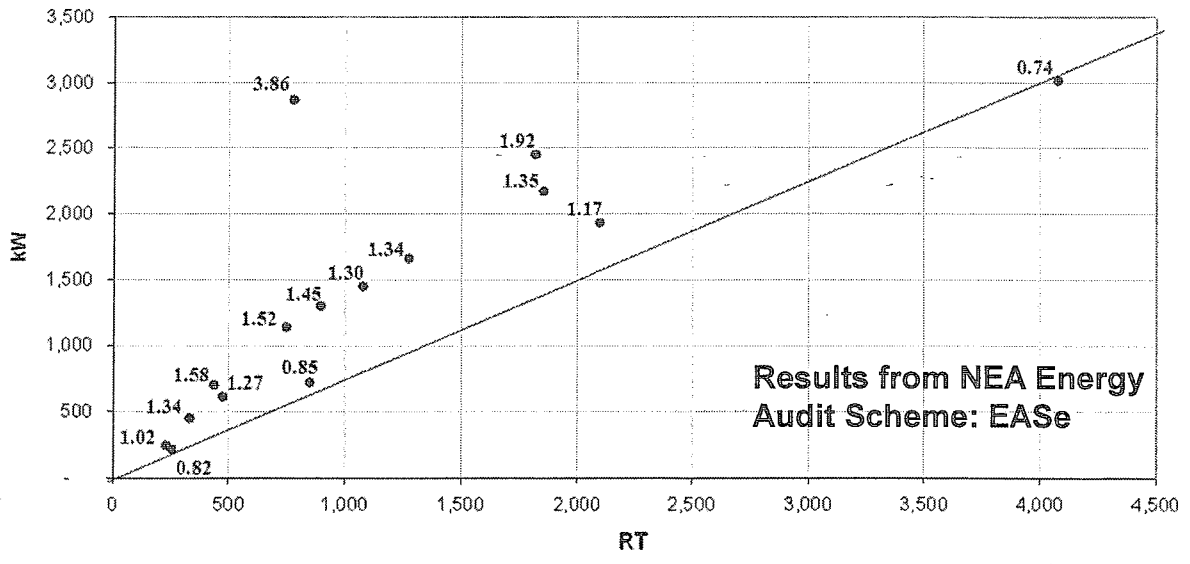
Why conduct energy audits?

- **You cannot manage what you do not measure.**
  Jack Welsh
- **What gets measured gets done.**
  Tom Peters
- **Accurate measurement……. is the foundation of any sustainable energy program.**



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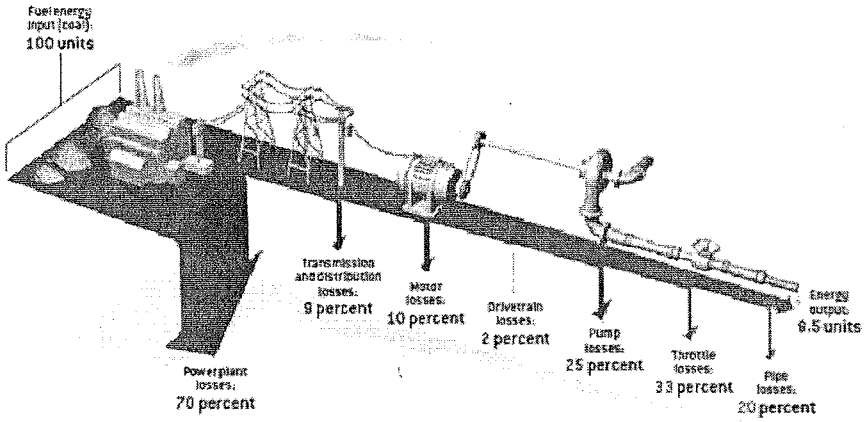
Water Cooled Chiller Plant Efficiency (KW/RT)



National Environment Agency

Absence of continuous M&V often leads to poor performance

The energy value chain

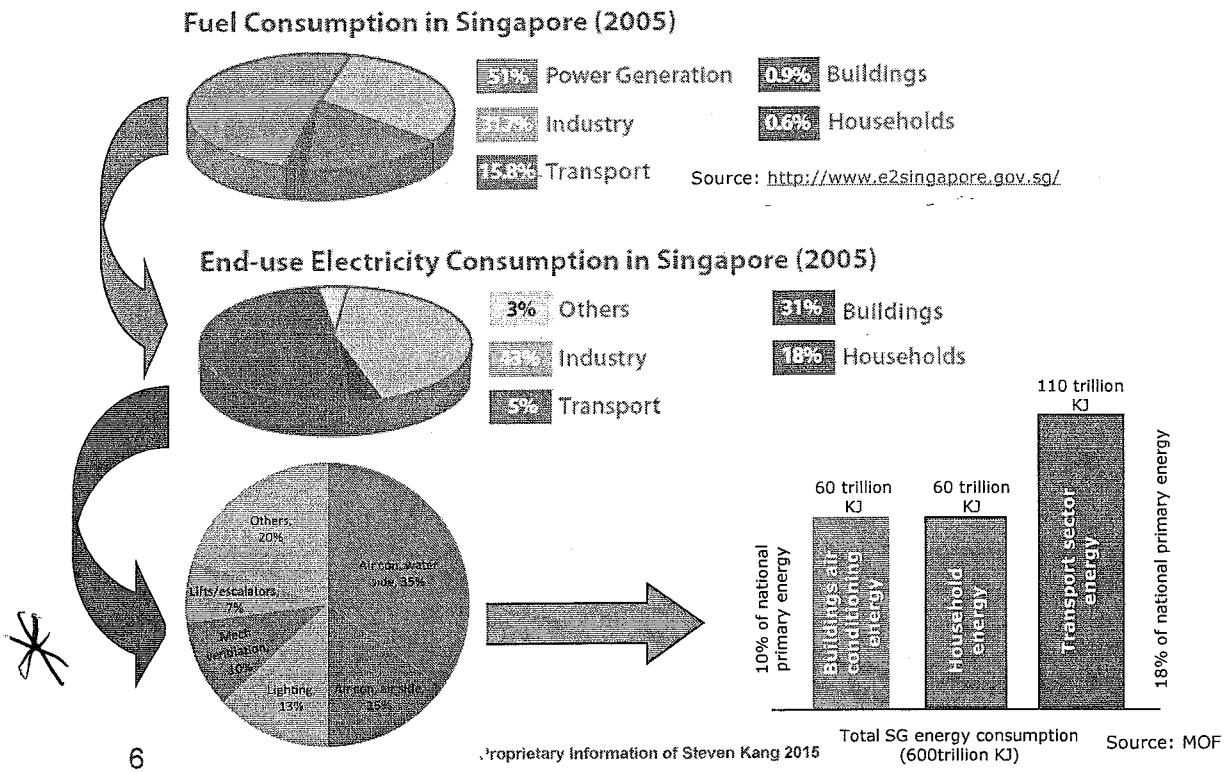


Every unit of flow (or friction) saved in the pipe will save approximately ten units of fuel, cost, and pollution at the power station

To save the most primary energy and the most capital cost, therefore, efficiency efforts should start all the way downstream, by asking: How little flow can actually deliver the desired service? How small can the piping friction become? How small, well-matched to the flow regime, and efficient can the pump be made? Its coupling? Its motor? Its controls and electrical supplies?

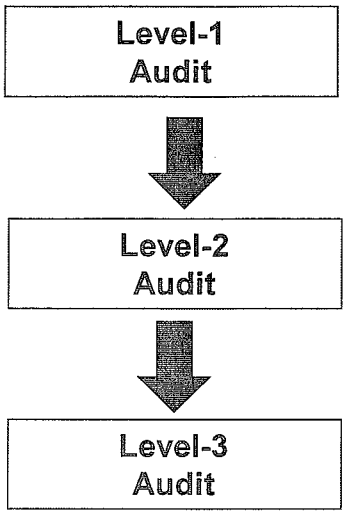
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Singapore building & cooling energy consumption



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3-Levels of Energy Audits



Walk through audit

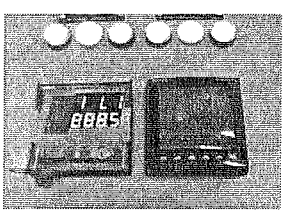
Standard audit

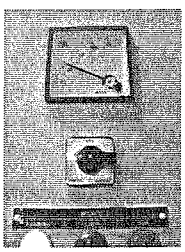
Investment grade audit

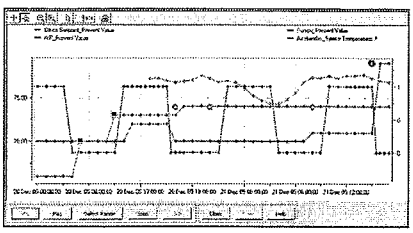
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Types of Energy Audits
Level 1 – Walk through audit

- Walk through the facility to visually inspect each energy using system to identify areas of waste and inefficiencies.
- Gather operating data from utility bills, existing meters and BMS.
- Analyze energy consumption data, compare to original design and industry benchmarks (EEIs, KW/RT, W/CMH etc).
- Identify low cost Energy Conservation Measures (ECMs) that can be implemented readily.
- List down possible capital intensive improvement projects that merits further consideration.



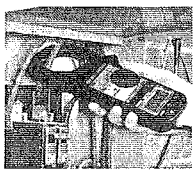
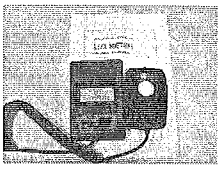




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Types of Energy Audits
Level 2 – Standard audit

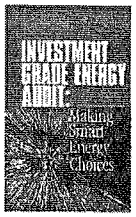
- Level 2 audits are usually "snapshots" of a particular condition in time.
- Validate and quantify findings in Level-1 audit with spot measurements using standard grade handheld instruments.
- Breakdown the building energy use into major sub-systems and quantify the consumption and efficiency for each sub-system.
- Identify all practical ECMs and estimate the retrofit cost and energy cost savings for each ECMs.
- Include risks and interruption to operations and economic analysis of recommended ECMs.
- Prioritize capital intensive ECMs that require thorough data collection and analysis with an initial estimate of potential cost and savings.

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Types of Energy Audits
Level 3 – Investment grade audit (IGA)

- Focus on Capital Intensive ECMs that require detail data collection, financial and engineering analysis. Typically carried out by an Accredited ESCO.
- IGA attempts energy usage/efficiency accuracy of +/- 5% tolerance for existing system and post retrofit performance projection.
- Extensive deployment of high accuracy instruments and data loggers to continuously measure, at 1 minute interval, energy use and efficiency over a period of 1 to 2 months.
- Deliverables include a detail energy report with detail cost, financial analysis and engineering analysis for each recommended ECMs with high level of confidence.
- Retrofit with Performance Guarantees often expected from ESCOs thereafter.
- IGA is the heart of a "bankable" project.



Investment Grade Energy Audit, Dr Shirley Hanson

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Practical recommendations for performance M&V

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Practical audit recommendations

- Focus audit on energy intensive system such as air conditioning, lighting and hot-water.
- Identify opportunities to reduce consumption 1st.
  - Over cooling, over lighting, over ventilating.
- Identify opportunities to increase efficiency next.
  - Chiller plant: KW/RT
  - Airside: W/CMH
  - Lighting: W/m^2 to achieve working level LUX
  - Hot-water: COP
- Specify for accurate & continuous monitoring especially for chiller plant.
- Specify for measurement system's accuracy validation
  - Consistency check for temp, flow & energy.

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Chiller plant example



Chiller plant electricity consumption cost $ =

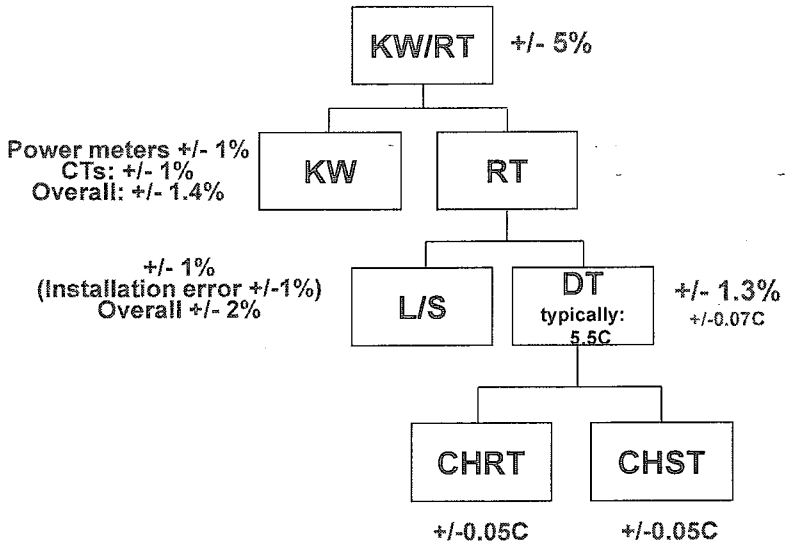
Cooling load x Hrs Operation x KWi/RT x $/KWH

	Cooling load	Hrs Operation	KWi/RT	$/KWH
Dependents :	Weather, vacancy rate, occupant type room temp, OA, infiltration etc	Business cycle, occupant type , start/stop controls etc	Design, installation, equipment, optimization, maintenance, weather etc	Power provider, oil prices, govt regulations etc
	Consumption factors		Efficiency factors	
	Try to reduce wastage		Try to reduce losses	

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Chiller Plant M&V accuracy

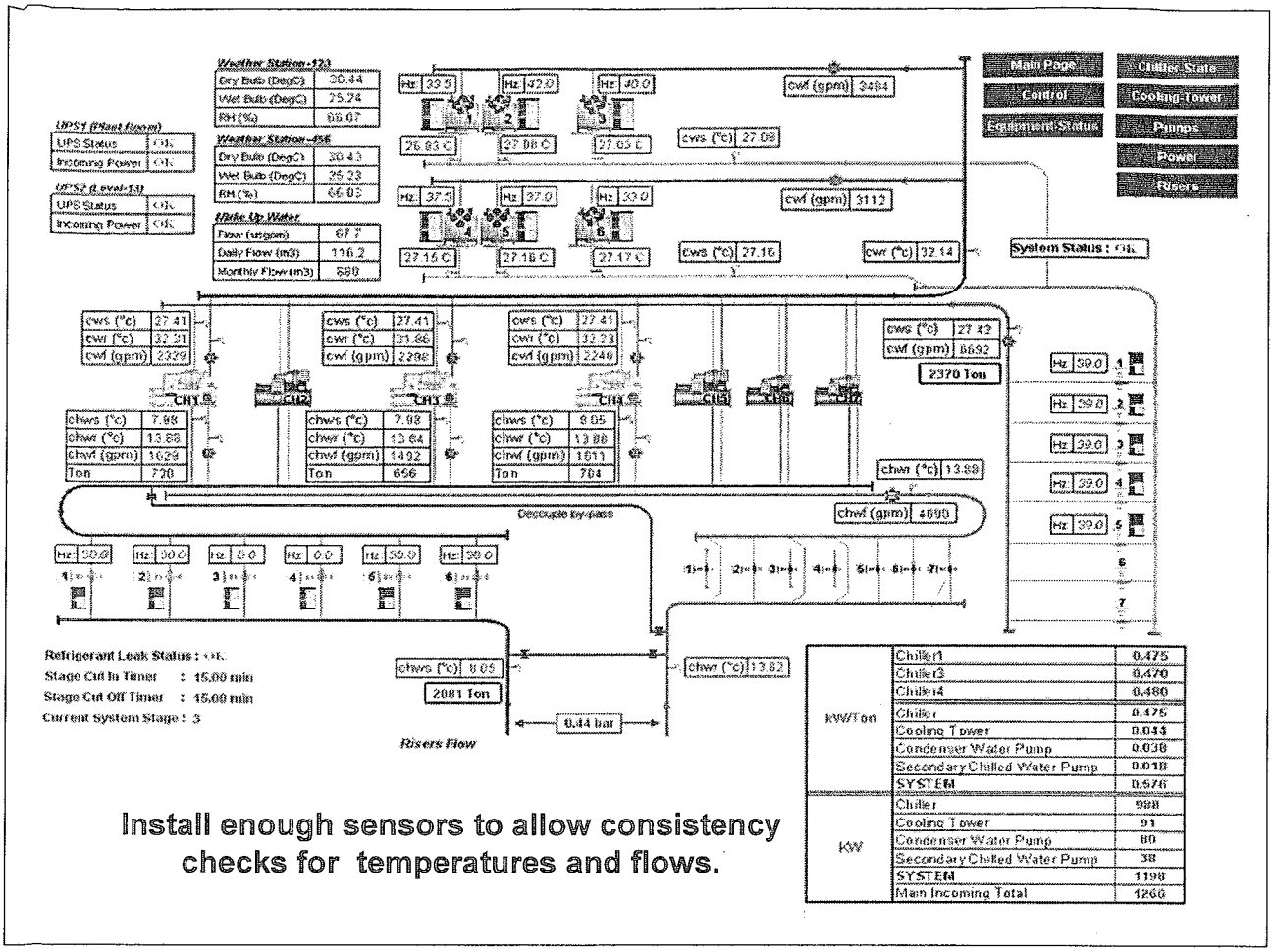
Root Sum Square error calculation (Green Mark)



$$Error_{rms} = \sqrt{2^2 + 1.4^2 + 1.3^2}$$

$$= 2.8\%$$

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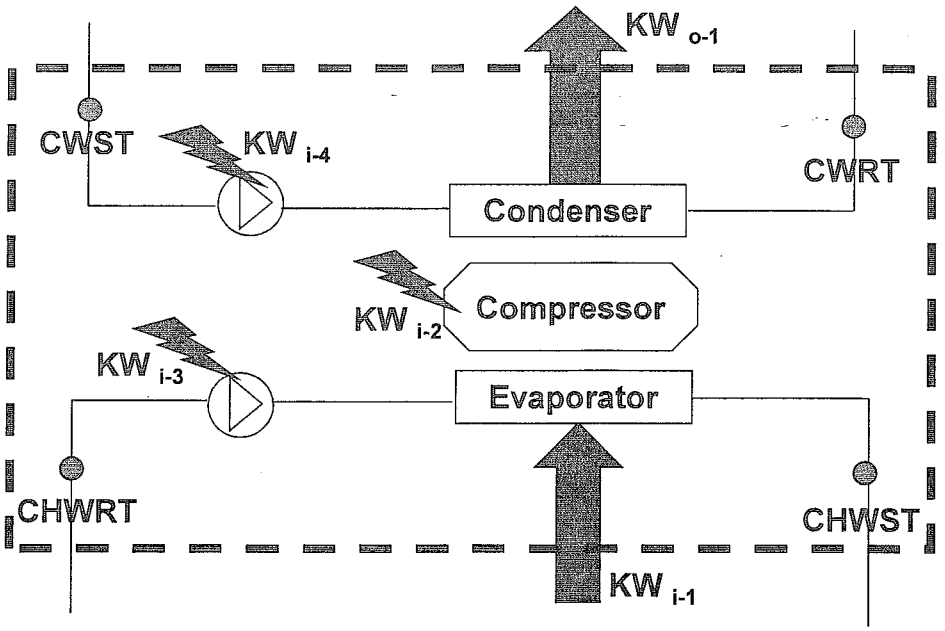


Install enough sensors to allow consistency checks for temperatures and flows.

Heat Balance

Energy cannot be created or destroyed

Heat in = Heat out



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Heat Balance Equation

Energy IN = $KW_{i-1} + KW_{i-2} + KW_{i-3} + KW_{i-4}$

Energy OUT = KW_{o-1}

The heat balance is represented by the following equation:

$$\frac{\text{Energy IN} - \text{Energy OUT}}{\text{Energy OUT}} \times 100\% \quad <= \quad +/- 5\%$$

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Thank you for your attention.

Questions?

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