

Industrial Energy Efficiency Improvement Potential



- Introduction and Summary of Results
- Description of Methodology
- Industry Sector Case Study Results
- Factors Influencing EEI Potential Estimates



- Scope of Work
 - Identify readily achievable energy efficiency measures in the selected sub-sectors
 - Estimate the energy efficiency improvement (EEI) potential based on case study materials
 - Develop cumulative curves of EEI potential and cost relationships
 - Estimate BAU uptake and beyond-BAU EEI potential over 12-year study period



- The key sub-sectors that have been studied are:
 - B: Mining
 - C211: Meat and Meat Product Manufacturing
 - C212: Dairy Product Manufacturing
 - C215: Flour Mill and Cereal Food Manufacturing
 - C216: Bakery Product Manufacturing
 - C233: Pulp, Paper & Paper Product Manufacturing
 - C252-256: Chemical Products Manufacturing
 - C262: Ceramic Products
 - C2631: Cement & Lime Manufacturing (Cement manufacturing sub-sector)
 - C271: Iron & Steel Manufacturing
 - C2721: Bauxite Mining & Alumina Refining
 - C2722: Aluminium Smelting & Semi-Fabrication

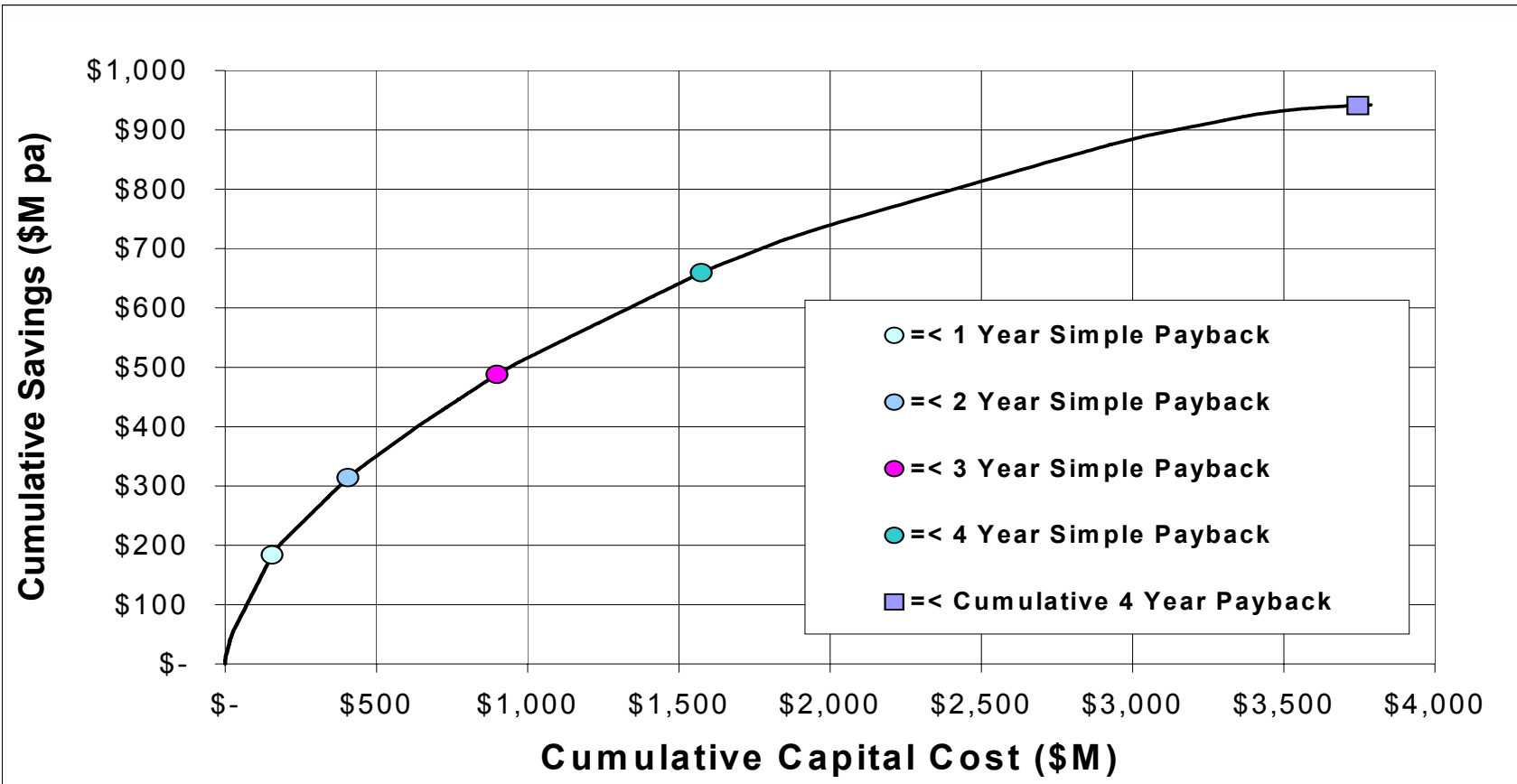


Summary of Results

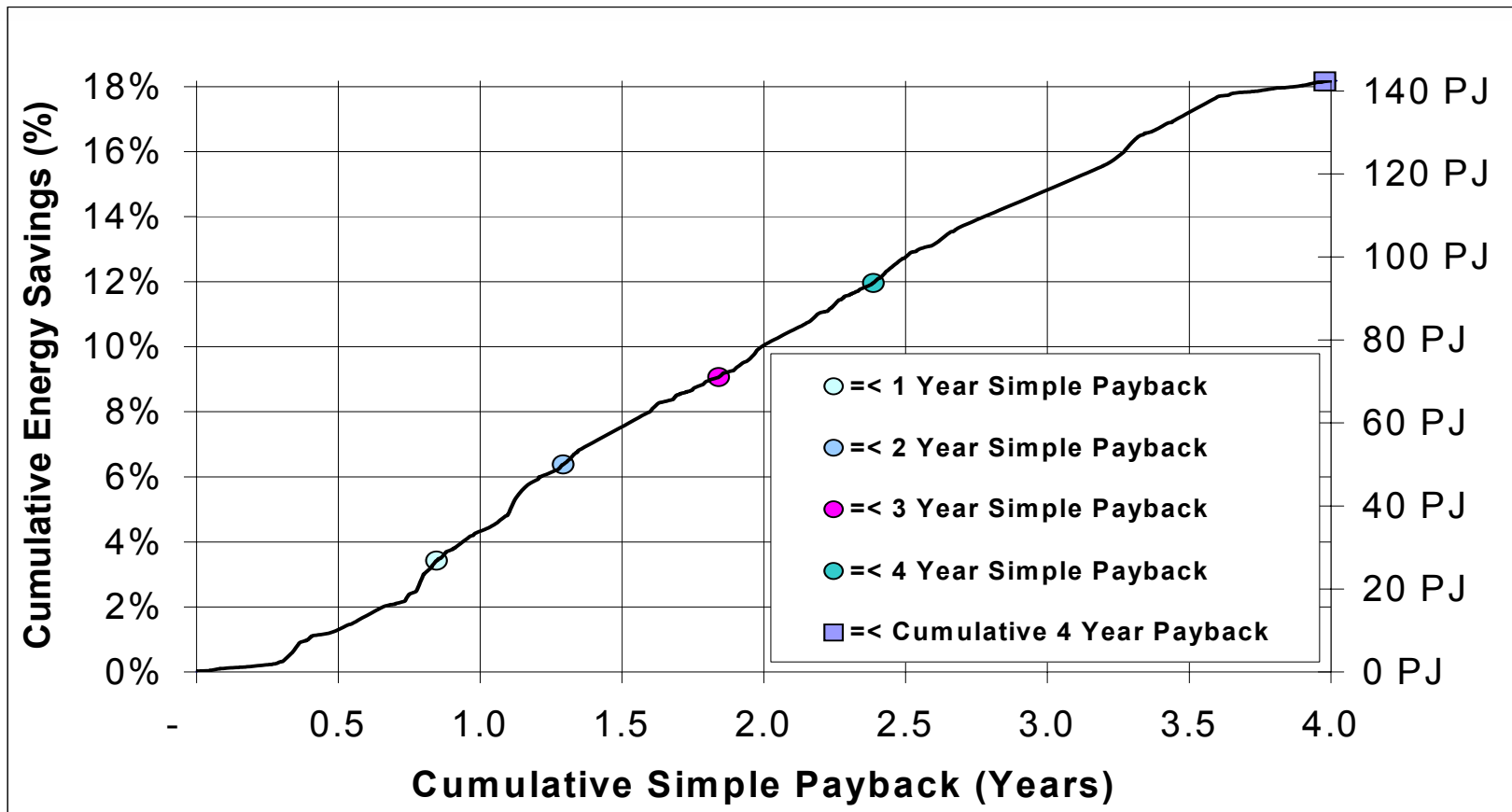
Simple Payback	Cumulative Capital Cost (\$M)	Total Savings (\$M pa)	Average Payback (Years)	Total Savings (PJ pa)	Savings (%)
=< 1 Year Payback	\$ 155	\$ 184	0.85 Years	26.8	3.4%
=< 2 Year Payback	\$ 406	\$ 314	1.29 Years	50.0	6.4%
=< 3 Year Payback	\$ 899	\$ 488	1.84 Years	71.1	9.1%
=< 4 Year Payback	\$ 1,574	\$ 659	2.39 Years	93.7	12.0%
> 4 Year Payback	\$ 3,788	\$ 942	4.02 Years	142.5	18.2%
Cumulative Payback	Cumulative Capital Cost (\$M)	Total Savings (\$M pa)	Average Payback (Years)	Total Savings (PJ pa)	Savings (%)
=< 1 Year Payback	\$ 214	\$ 218	0.98 Years	33.4	4.3%
=< 2 Year Payback	\$ 1,057	\$ 530	1.99 Years	78.4	10.0%
=< 3 Year Payback	\$ 1,990	\$ 738	2.69 Years	107.3	13.7%
=< 4 Year Payback	\$ 3,745	\$ 941	3.98 Years	142.3	18.2%
> 4 Year Payback	\$ 3,788	\$ 942	4.02 Years	142.5	18.2%
Beyond BAU EEI Potential by 2015		EEI Potential	BAU Potential	Net EEI Potential (PJ)	Net Savings (%)
=< 4 Year Simple Payback EEI		93.75 PJ	44.87 PJ	48.88 PJ	6.2%
=< 4 Year Cumulative Payback EEI		142.29 PJ		97.42 PJ	12.4%



Raw EEI Potential – Selected Case Studies



Raw EEI Potential – Selected Case Studies



Raw EEI Potential – All Industry Sectors

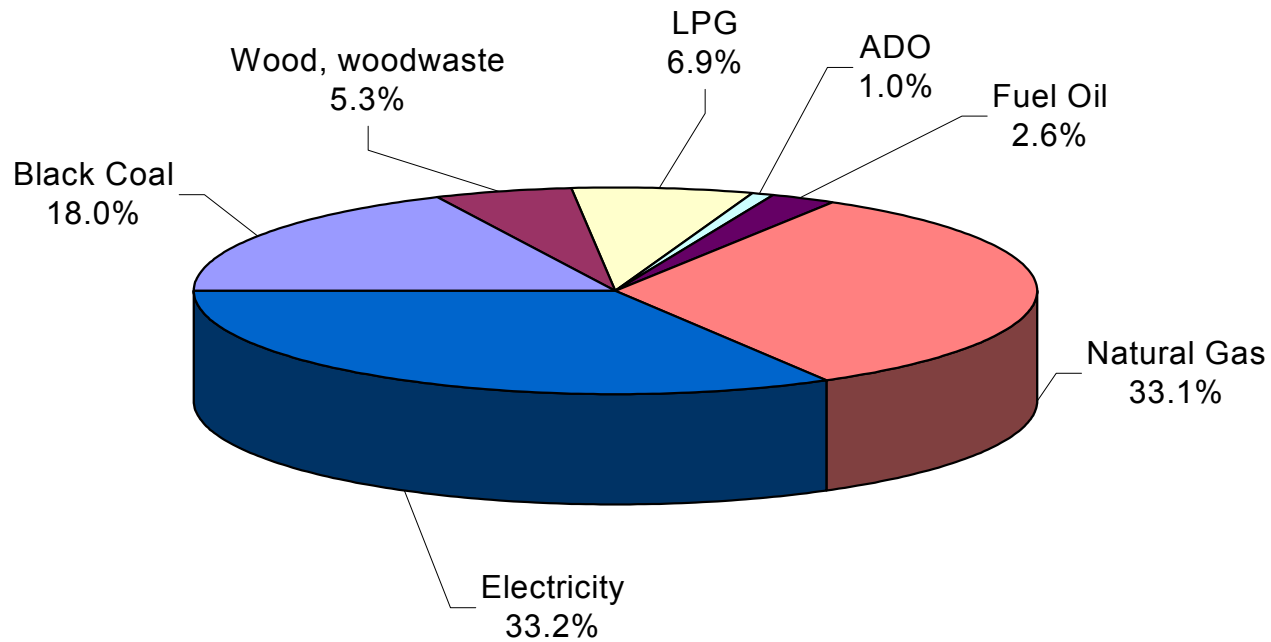
ANZSIC	Sub-Sector	Extrapolated 4-Year EEI Potential (PJ)		Extrapolated 4-Year EEI Potential (%)	
		4-Year Simple Payback	4-Year Cumulative Payback	4-Year Simple Payback	4-Year Cumulative Payback
B	Mining	20.79 PJ	23.17 PJ	9%	10%
C21	Food & Beverage (excl bagasse)	11.89 PJ	16.64 PJ	17%	24%
C21	Bagasse	12.93 PJ	18.01 PJ	12%	17%
C22	Textiles	1.86 PJ	2.59 PJ	12%	17%
C23-24	Wood, Paper & Printing	9.12 PJ	14.42 PJ	13%	20%
C252-256	Chemical (excl petroleum & feedstock)	17.26 PJ	25.71 PJ	12%	18%
C26	Non-Metallic Minerals (excl Cement)	5.47 PJ	8.18 PJ	9%	13%
C2631	Cement Manufacturing	4.46 PJ	8.20 PJ	15%	28%
C271	Iron & Steel Manufacturing	25.25 PJ	42.68 PJ	15%	26%
C272-273	Basic Non-Ferrous Metals	34.38 PJ	36.17 PJ	10%	11%
C27 (other)	Other Metal Products	1.41 PJ	1.97 PJ	12%	17%
C28-29	Machinery & Equipment	2.75 PJ	3.84 PJ	12%	17%
B & C	Mining & Manufacturing	148 PJ	202 PJ		



Methodology



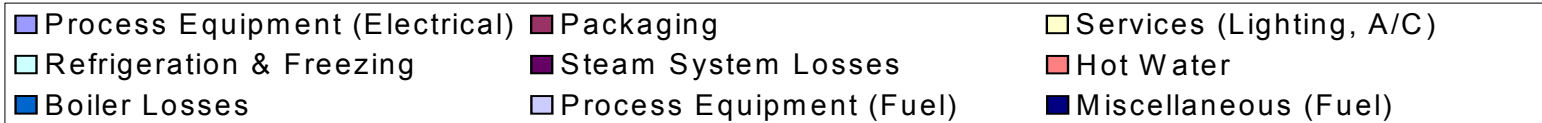
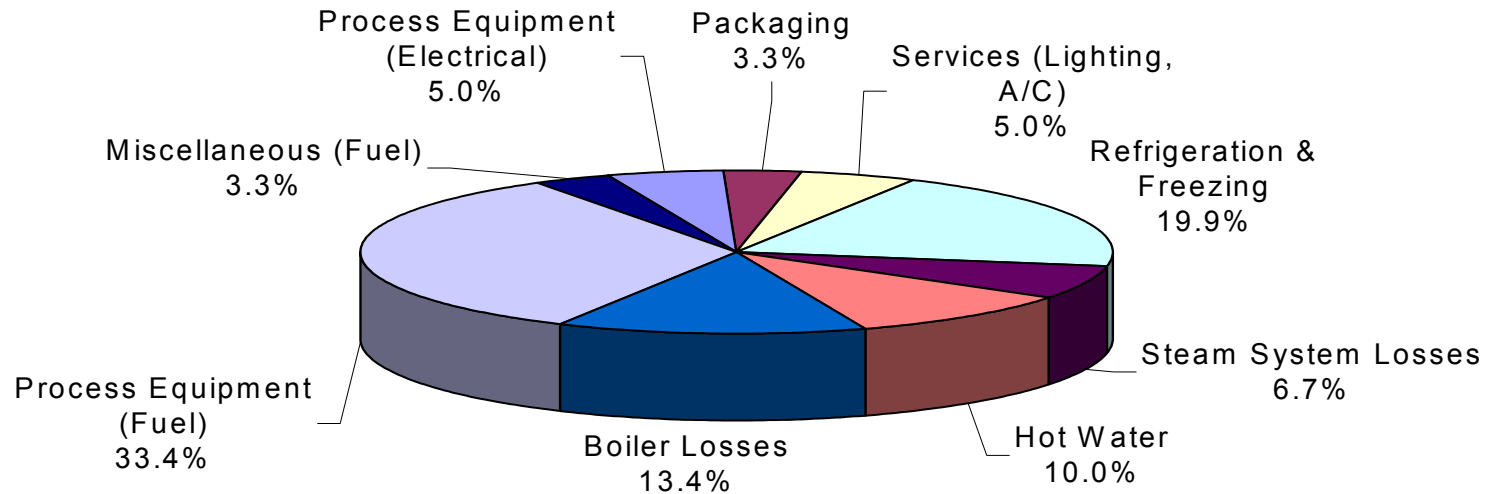
- Total Energy by sub-sector – NGGI, End Use Allocation of Emissions (GWA) – eg Meat



Legend: Black Coal, Wood, woodwaste, LPG, ADO, Fuel Oil, Natural Gas, Electricity



- Energy apportioned to end use applications from experience, literature – eg Meat



- Case study material is principally Energy Audits / Studies
- Typically 4-8 Audits per sub-sector
- Other literature also used (US, UK, EU)
- Opportunities generally expressed as a % saving by end use application and simple payback
- Hence EEI Potential can be referenced to baseline
- Typical % saving from audits extrapolated to estimate sub-sector EEI Potential for each opportunity



- Typical sub-sectoral energy prices used for each fuel
- Energy savings calculated in %, GJ and \$
- Paybacks used to convert energy savings into capital costs
- Opportunities organized by simple payback – lowest to highest in years – to develop cumulative data
- Markers at:
 - simple 1, 2, 3 & 4 year paybacks
 - cumulative 1, 2, 3 & 4 year paybacks



- Take-up rate for EEI opportunities < 100%
- Factors affecting take-up include:
 - Partial applicability – eg VSD/VVVF control suitable for some loads, not others, may already be part-implemented
 - EEI potential may be realized on replacement – eg HEM, new technology
 - Estimate made of % take-up over 12 year period



- EEI Cost Curve – Cumulative Savings vs Cumulative Cost
- EEI Potential Curve – Cumulative Energy Savings (% , PJ) vs Cumulative Payback
- Markers at Simple 1, 2, 3, 4-year paybacks and Cumulative 4-year payback



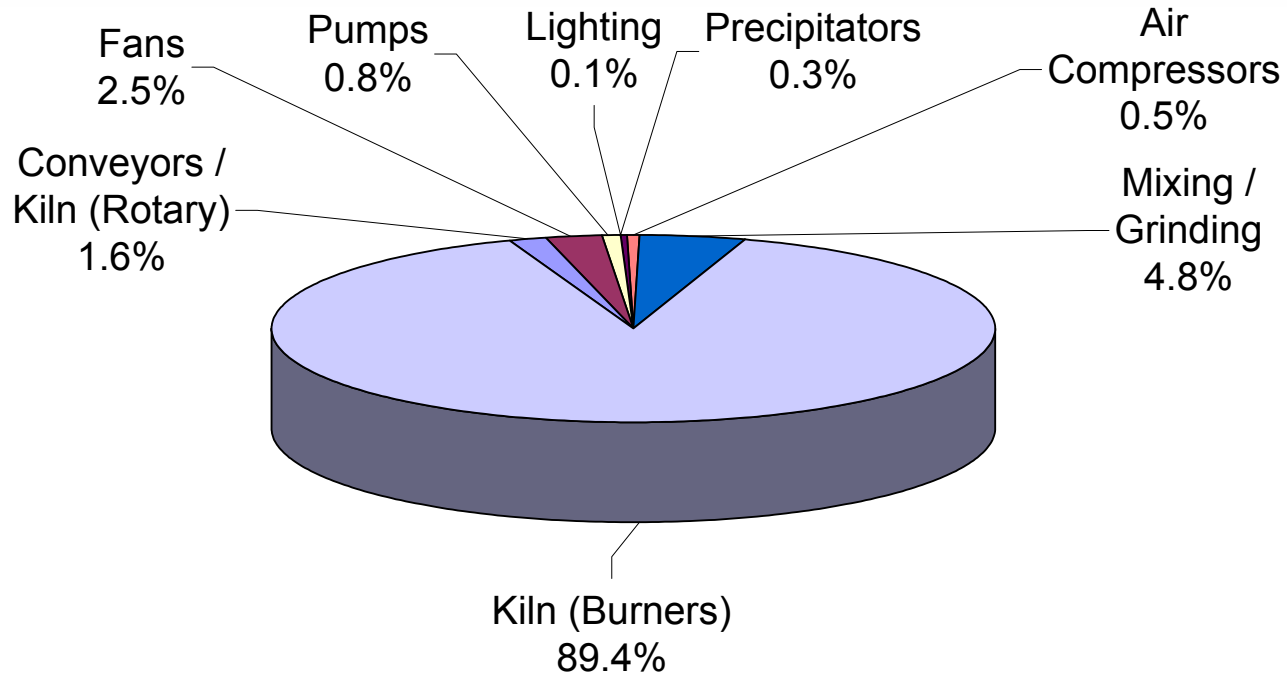
Results



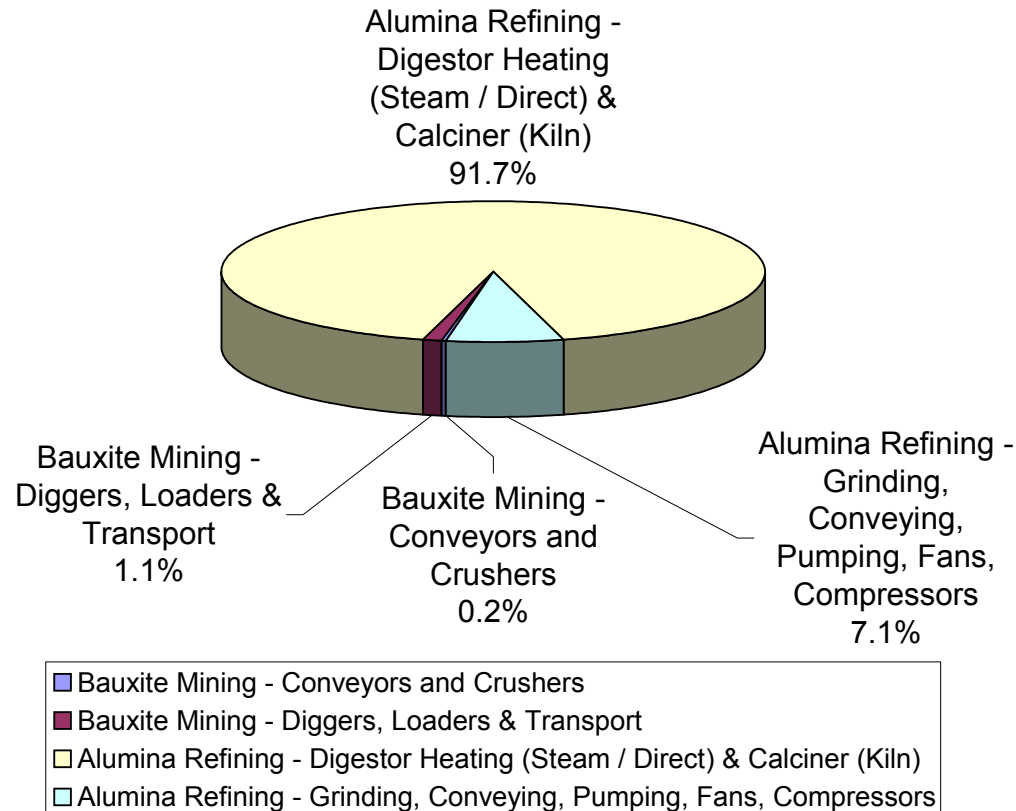
- Major Sectors include
 - Alumina and Aluminium
 - Iron and Steel
 - Cement
- Characterised by:
 - Small number of energy intensive equipment



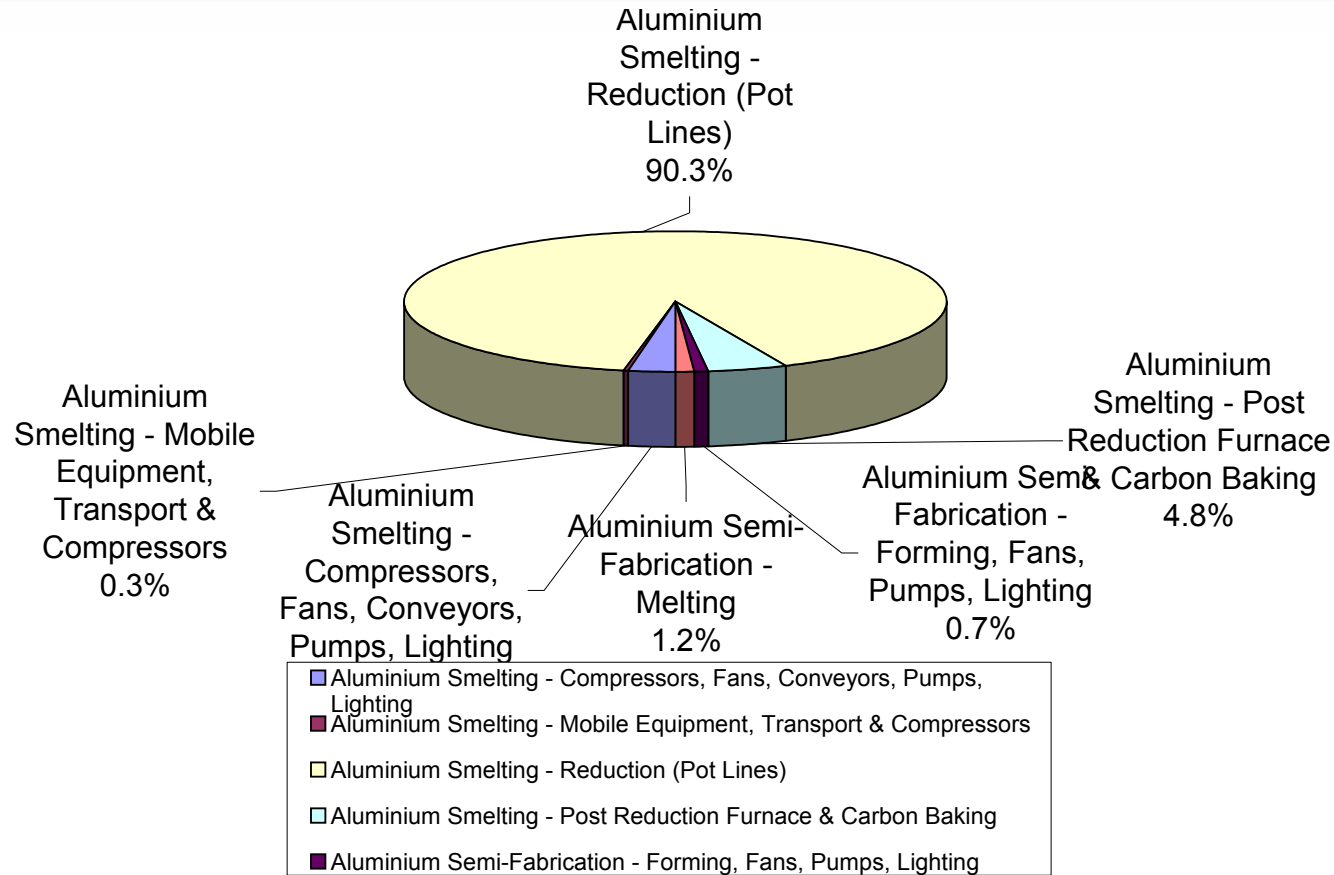
Cement – End Use Breakup



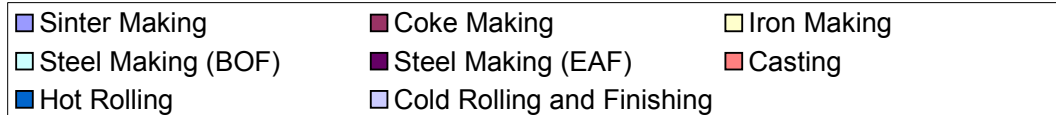
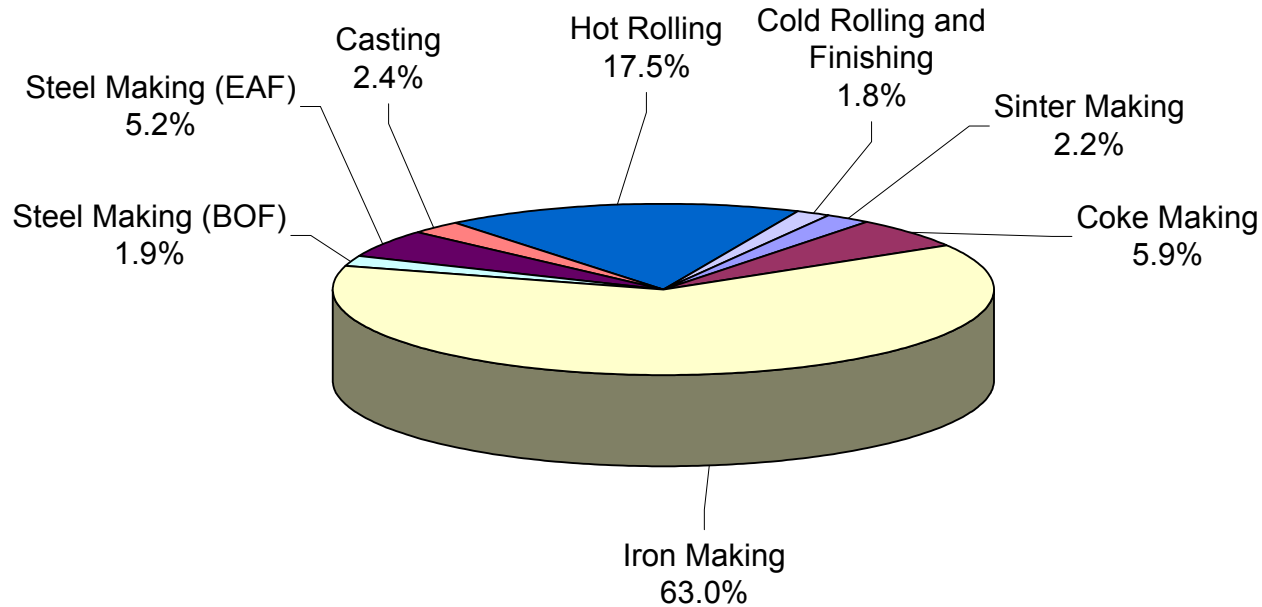
Alumina – End Use Breakup



Aluminium – End Use Breakup



Iron & Steel – End Use Breakup



- Audits generally up to 4-year simple payback
- New technology generally beyond 4-year payback
- Typical EEI opportunities
 - Combustion efficiency, process control, VSD, blending, HEM, insulation, heat recovery
- Technology
 - Pre-calcination / low pressure drop cyclones, multi-stage pre-heating – 4+ years
- Take-up rate 50% for many EEIs

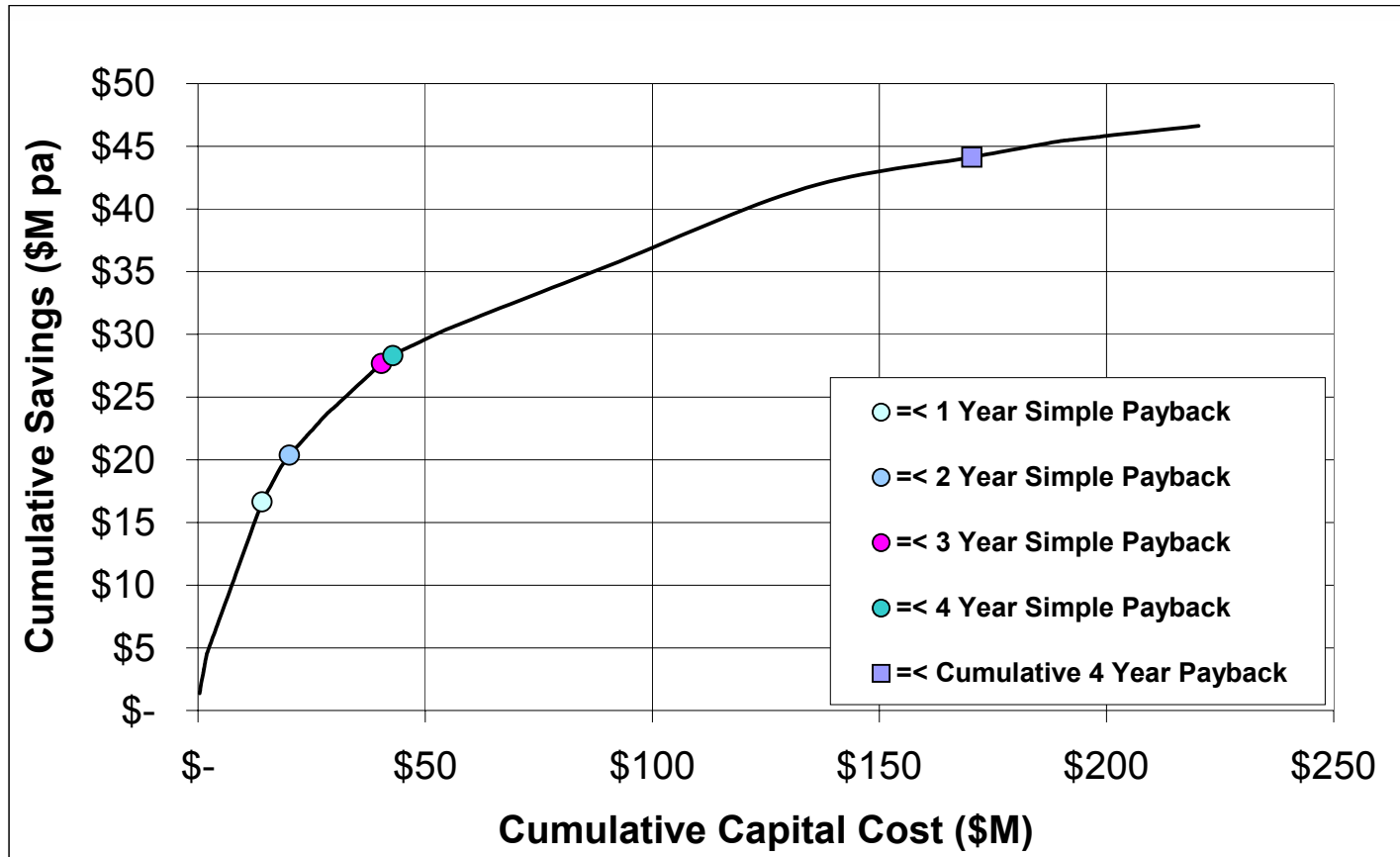


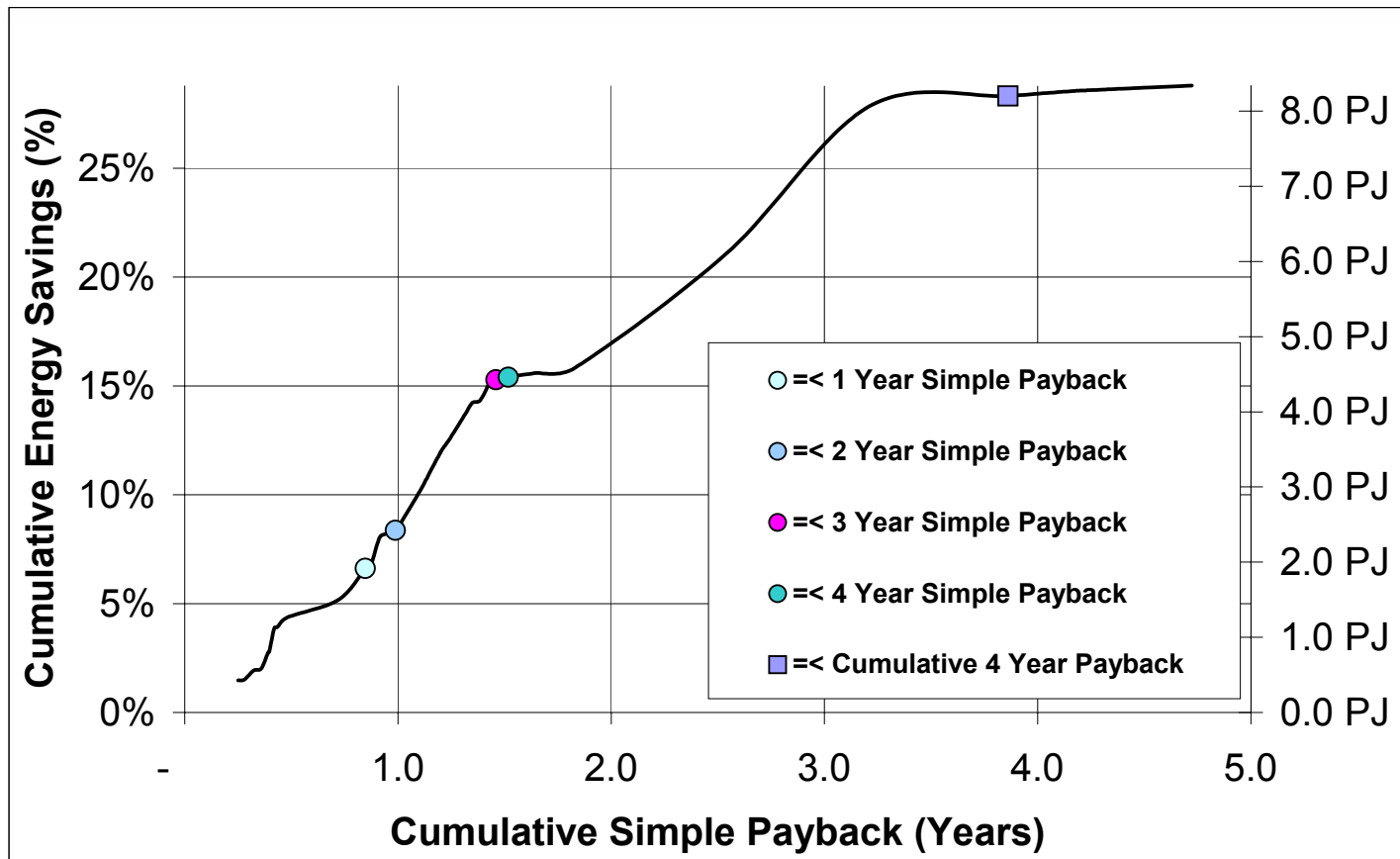
Raw Results – Cement

Simple Payback	Cumulative Capital Cost (\$M)	Total Savings (\$M pa)	Average Payback (Years)	Total Savings (PJ pa)	Savings (%)
=< 1 Year Payback	\$ 14.10	\$ 16.65	0.85 Years	1.92 PJ	6.6%
=< 2 Year Payback	\$ 20.12	\$ 20.36	0.99 Years	2.42 PJ	8.4%
=< 3 Year Payback	\$ 40.39	\$ 27.67	1.46 Years	4.43 PJ	15.3%
=< 4 Year Payback	\$ 42.93	\$ 28.30	1.52 Years	4.46 PJ	15.4%
> 4 Year Payback	\$ 220.29	\$ 46.64	4.72 Years	8.34 PJ	28.8%
Cumulative Payback	Cumulative Capital Cost (\$M)	Total Savings (\$M pa)	Average Payback (Years)	Total Savings (PJ pa)	Savings (%)
=< 1 Year Payback	\$ 20.12	\$ 20.36	0.99 Years	2.42 PJ	8.4%
=< 2 Year Payback	\$ 55.99	\$ 30.57	1.83 Years	4.59 PJ	15.8%
=< 3 Year Payback	\$ 90.31	\$ 35.48	2.55 Years	6.12 PJ	21.1%
=< 4 Year Payback	\$ 170.38	\$ 44.13	3.86 Years	8.20 PJ	28.3%
> 4 Year Payback	\$ 220.29	\$ 46.64	4.72 Years	8.34 PJ	28.8%
Beyond BAU EEI Potential by 2015		EEI Potential	BAU Potential	Net EEI Potential (PJ)	Net Savings
=< 4 Year Simple Payback EEI		4.46 PJ	1.69 PJ	2.77 PJ	9.6%
=< 4 Year Cumulative Payback EEI		8.20 PJ		6.51 PJ	22.5%



Raw Results – Cement





- Limited audit information – mainly auxiliaries
- Audit opportunities in air, steam boiler, furnace, process optimisation, controls, some heat reclaim / insulation, VSD
- Technology improvements – cell design, high efficiency calciners dominate EEI potential – hence timing of investment is critical
- Raw EEI potential 3-6% without new technology, 11-15% with new technology

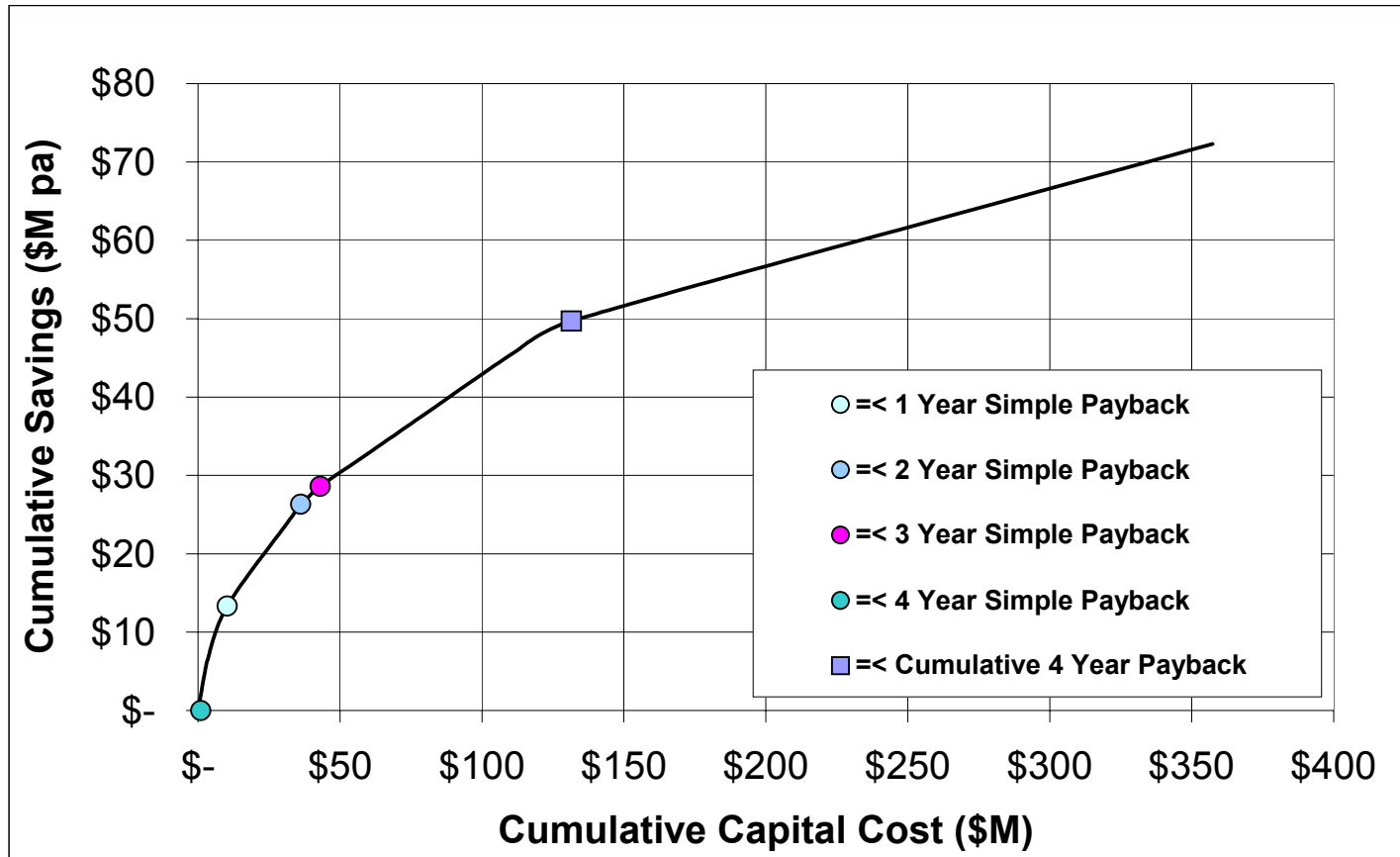


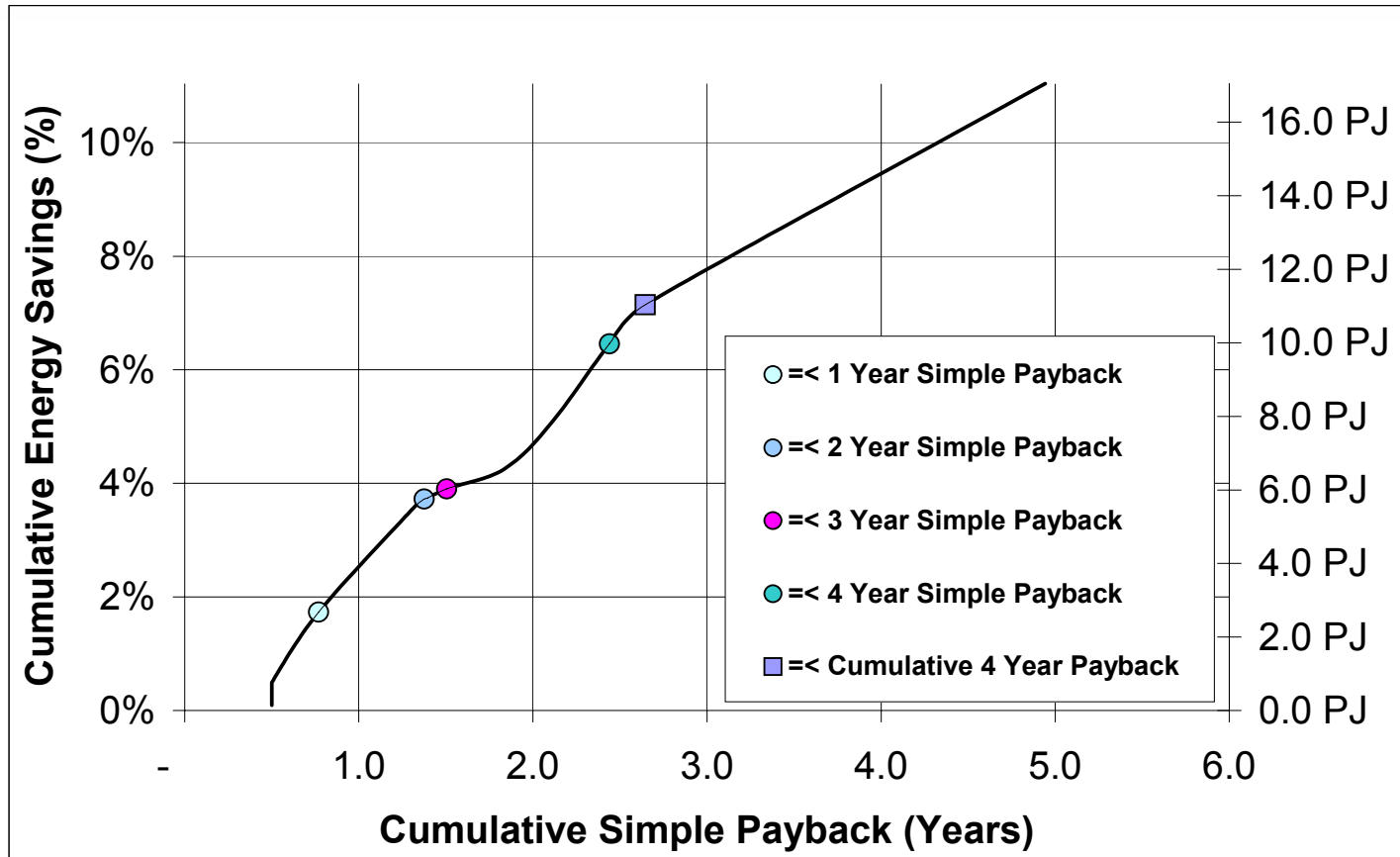
Raw Results - Alumina

Simple Payback	Cumulative Capital Cost (\$M)	Total Savings (\$M pa)	Average Payback (Years)	Total Savings (PJ pa)	Savings (%)
=< 1 Year Payback	\$ 10.26	\$ 13.34	0.77 Years	2.68 PJ	1.7%
=< 2 Year Payback	\$ 36.21	\$ 26.32	1.38 Years	5.75 PJ	3.7%
=< 3 Year Payback	\$ 43.05	\$ 28.60	1.51 Years	6.03 PJ	3.9%
=< 4 Year Payback	\$ 111.58	\$ 45.73	2.44 Years	9.97 PJ	6.5%
> 4 Year Payback	\$ 357.30	\$ 72.29	4.94 Years	17.05 PJ	11.0%
Cumulative Payback	Cumulative Capital Cost (\$M)	Total Savings (\$M pa)	Average Payback (Years)	Total Savings (PJ pa)	Savings (%)
=< 1 Year Payback	\$ 10.26	\$ 13.34	0.77 Years	2.68 PJ	1.7%
=< 2 Year Payback	\$ 60.57	\$ 32.98	1.84 Years	6.58 PJ	4.3%
=< 3 Year Payback	\$ 131.50	\$ 49.71	2.65 Years	11.04 PJ	7.1%
=< 4 Year Payback	\$ 131.50	\$ 49.71	2.65 Years	11.04 PJ	7.1%
> 4 Year Payback	\$ 357.30	\$ 72.29	4.94 Years	17.05 PJ	11.0%
Beyond BAU EEI Potential by 2015		EEI Potential	BAU Potential	Net EEI Potential (PJ)	Net Savings (%)
=< 4 Year Simple Payback EEI		9.97 PJ	9.02 PJ	0.96 PJ	0.6%
=< 4 Year Cumulative Payback EEI		11.04 PJ		2.02 PJ	1.3%



Raw Results – Alumina



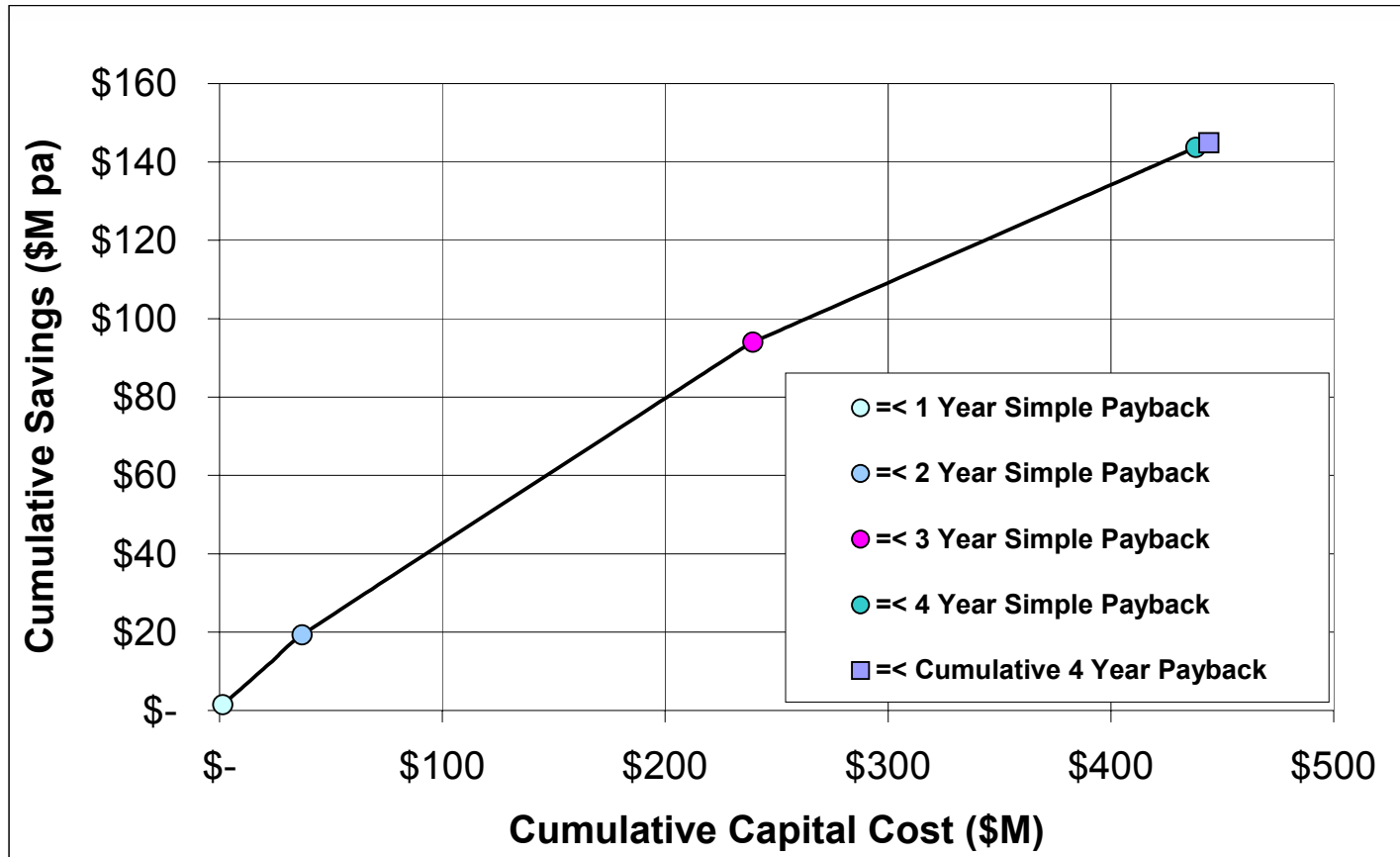


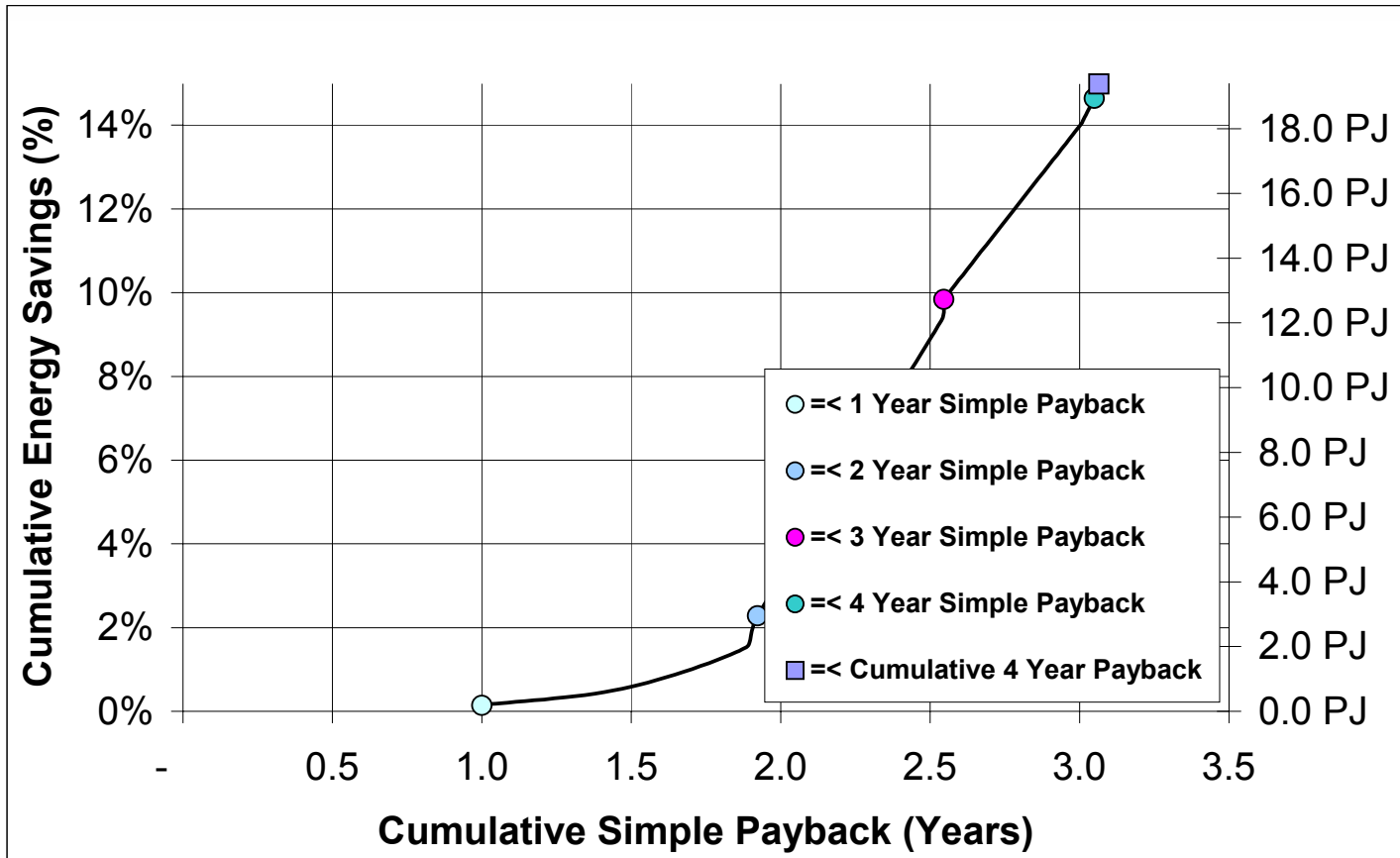
Raw Results – Aluminium

Simple Payback	Cumulative Capital Cost (\$M)	Total Savings (\$M pa)	Average Payback (Years)	Total Savings (PJ pa)	Savings (%)
=< 1 Year Payback	\$ 1.50	\$ 1.50	1.00 Years	0.19 PJ	0.1%
=< 2 Year Payback	\$ 37.11	\$ 19.31	1.92 Years	2.95 PJ	2.3%
=< 3 Year Payback	\$ 239.28	\$ 94.00	2.55 Years	12.73 PJ	9.8%
=< 4 Year Payback	\$ 438.18	\$ 143.72	3.05 Years	18.94 PJ	14.6%
> 4 Year Payback	\$ 443.97	\$ 144.88	3.06 Years	19.39 PJ	15.0%
Cumulative Payback	Cumulative Capital Cost (\$M)	Total Savings (\$M pa)	Average Payback (Years)	Total Savings (PJ pa)	Savings (%)
=< 1 Year Payback	\$ 1.50	\$ 1.50	1.00 Years	0.19 PJ	0.1%
=< 2 Year Payback	\$ 37.11	\$ 19.31	1.92 Years	2.95 PJ	2.3%
=< 3 Year Payback	\$ 239.28	\$ 94.00	2.55 Years	12.73 PJ	9.8%
=< 4 Year Payback	\$ 443.97	\$ 144.88	3.06 Years	19.39 PJ	15.0%
> 4 Year Payback	\$ 357.30	\$ 144.88	2.47 Years	19.39 PJ	15.0%
Beyond BAU EEI Potential by 2015		EEI Potential	BAU Potential	Net EEI Potential (PJ)	Net Savings (%)
=< 4 Year Simple Payback EEI		18.94 PJ	7.55 PJ	11.39 PJ	8.8%
=< 4 Year Cumulative Payback EEI		19.39 PJ		11.84 PJ	9.1%



Raw Results – Aluminium





- Audit information mainly excluding iron plant
- Audit data from Sinter, EAF, Coke, Hot Strip Mill mainly, also Cold Roll, Casting, BOF
- Audit opportunities in monitoring / process control, furnace optimisation, maintenance, gas/heat recovery, burner technology, VSD/HEM
- Other literature – pulverised coal, gas injection, BF gas recovery, ladle pre-heating, thin slab casting, burner technology, DC arc furnace
- Raw EEI potential 8-9% from audits at 4-year simple payback, 15% including other literature

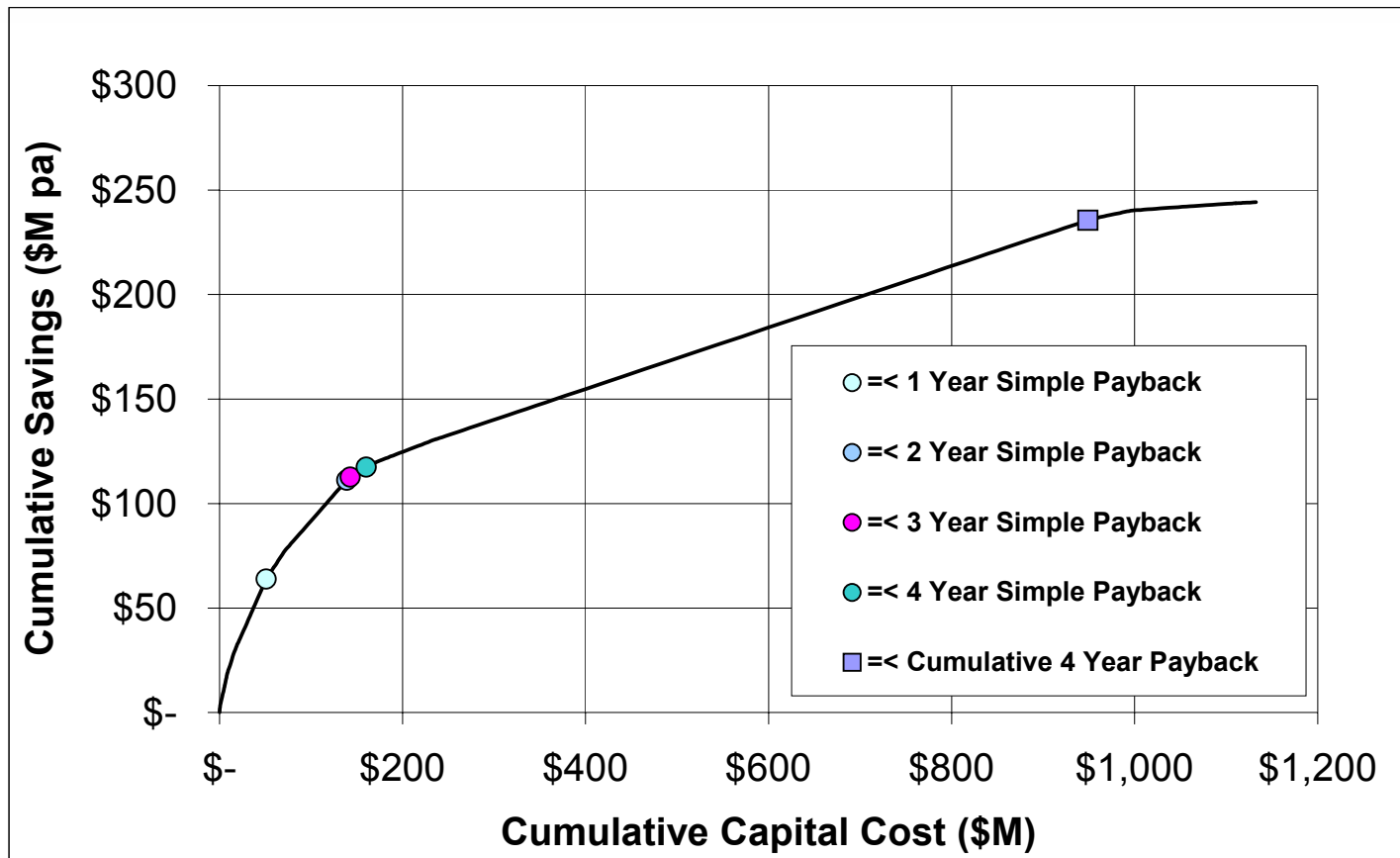


Raw Results – Iron & Steel

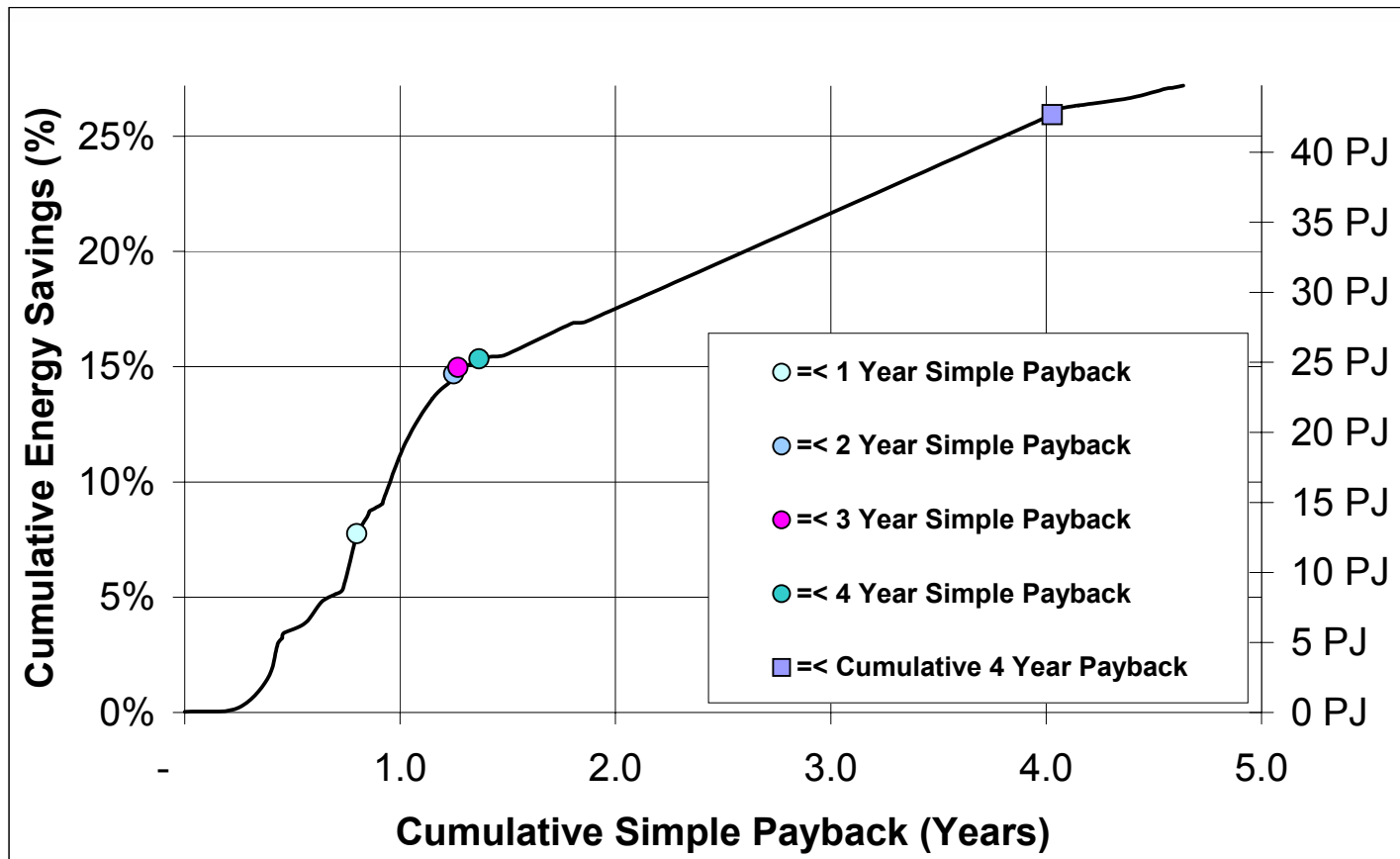
Simple Payback	Cumulative Capital Cost (\$M)	Total Savings (\$M pa)	Average Payback (Years)	Total Savings (PJ pa)	Savings (%)
=< 1 Year Payback	\$ 51	\$ 64	0.80 Years	12.78	8%
=< 2 Year Payback	\$ 139	\$ 111	1.25 Years	24.18	15%
=< 3 Year Payback	\$ 143	\$ 113	1.27 Years	24.63	15%
=< 4 Year Payback	\$ 160	\$ 117	1.37 Years	25.25	15%
> 4 Year Payback	\$ 1,133	\$ 244	4.64 Years	44.76	27%
Cumulative Payback	Cumulative Capital Cost (\$M)	Total Savings (\$M pa)	Average Payback (Years)	Total Savings (PJ pa)	Savings (%)
=< 1 Year Payback	\$ 71	\$ 77	0.92 Years	15.12	9%
=< 2 Year Payback	\$ 247	\$ 132	1.87 Years	27.94	17%
=< 3 Year Payback	\$ 247	\$ 132	1.87 Years	27.94	17%
=< 4 Year Payback	\$ 949	\$ 236	4.03 Years	42.68	26%
> 4 Year Payback	\$ 1,133	\$ 244	4.64 Years	44.76	27%
Beyond BAU EEI Potential by 2015		EEI Potential	BAU Potential	Net EEI Potential (PJ)	Net Savings (%)
=< 4 Year Simple Payback EEI		25.25 PJ	9.61 PJ	15.64 PJ	9.5%
=< 4 Year Cumulative Payback EEI		42.68 PJ		33.07 PJ	20.1%



Raw Results – Iron & Steel

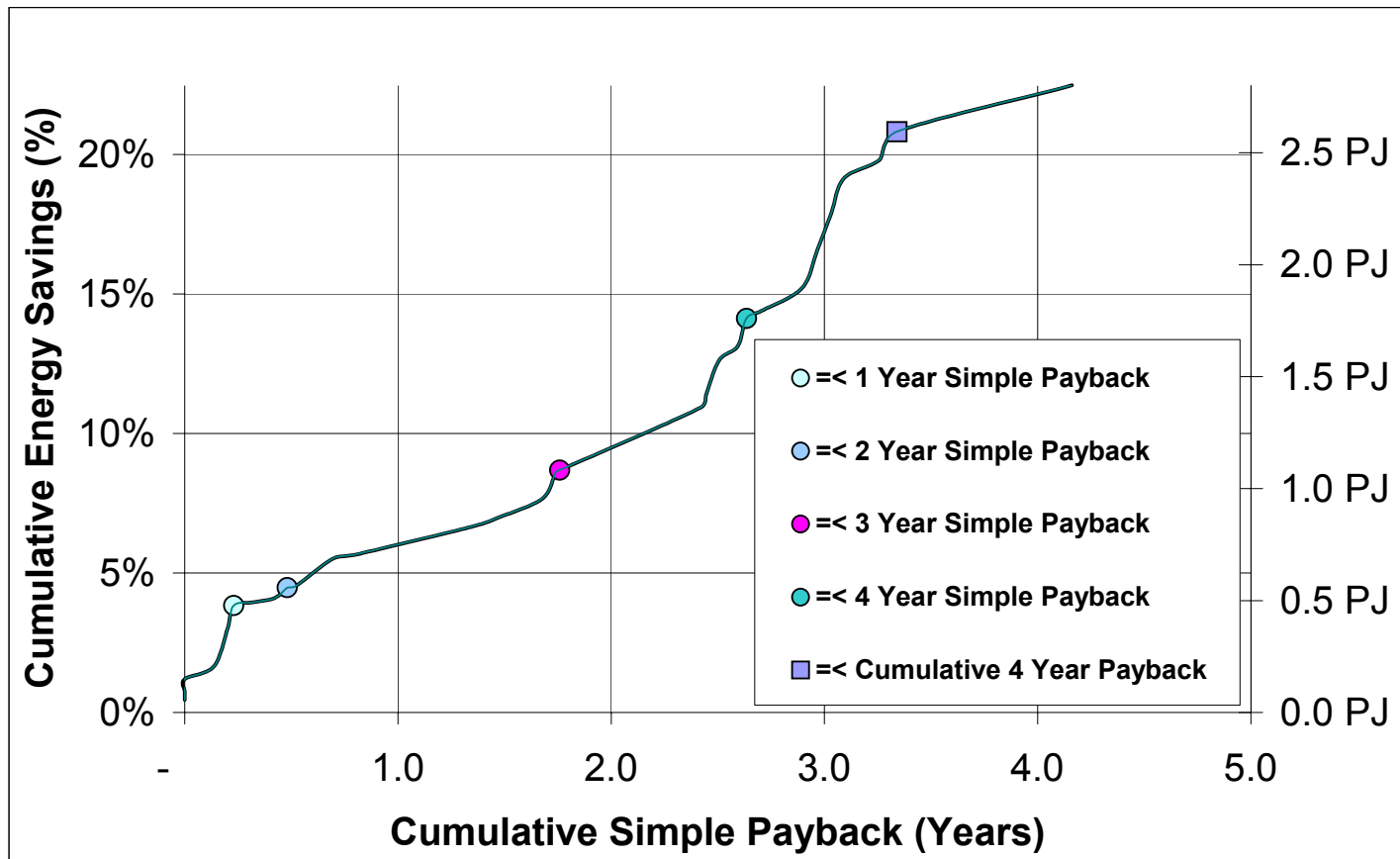


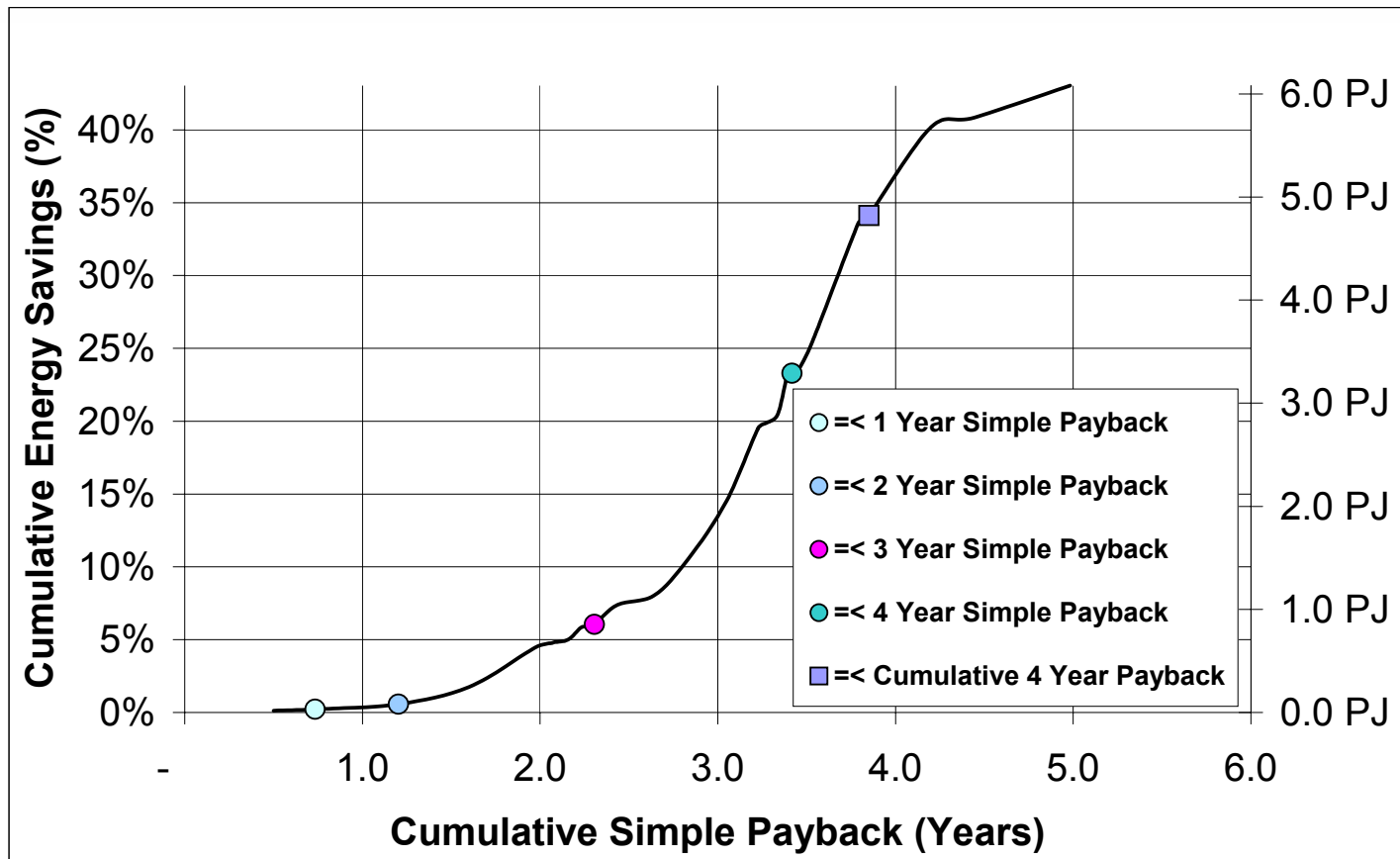
Raw Results – Iron & Steel



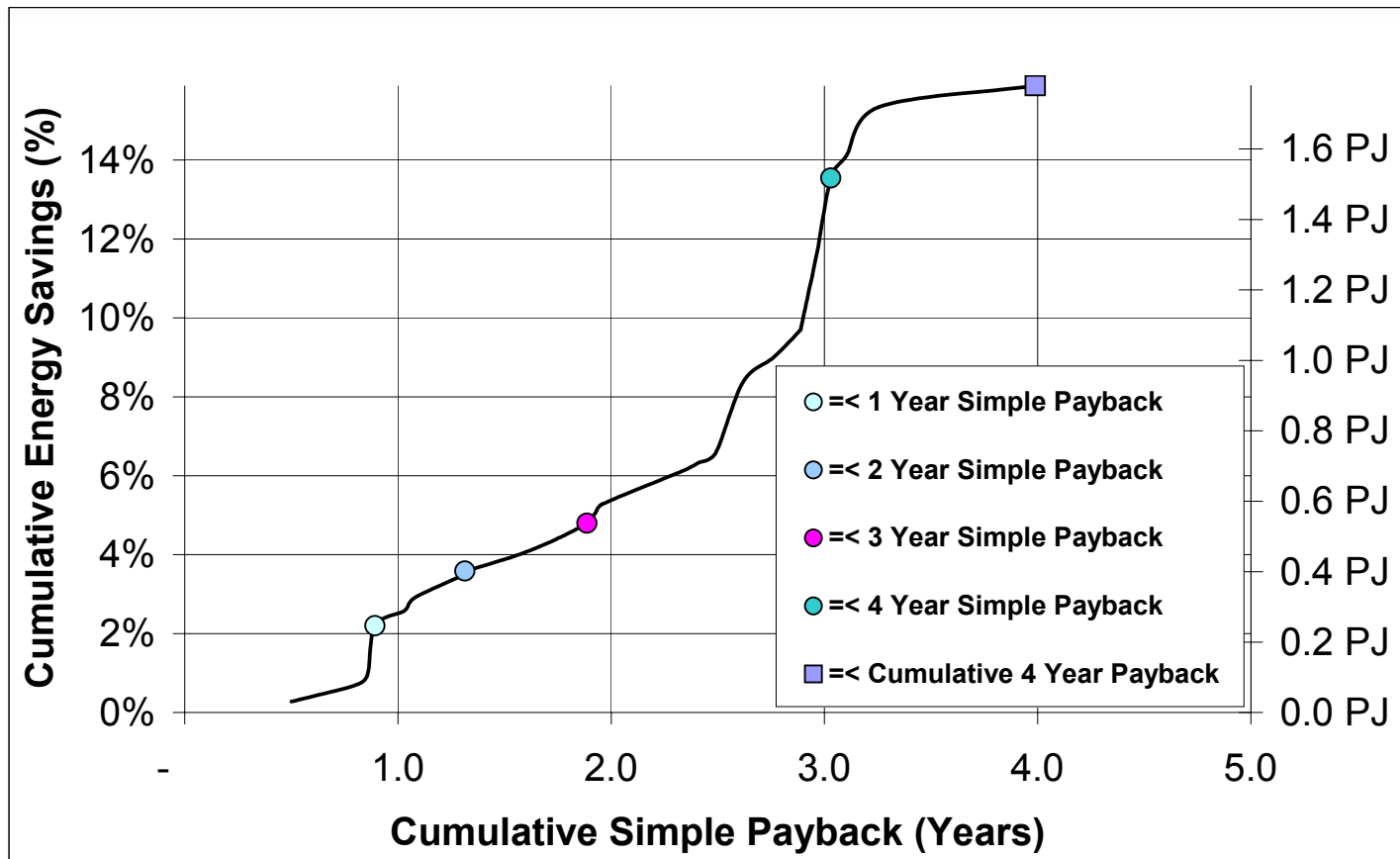
Other Sectors

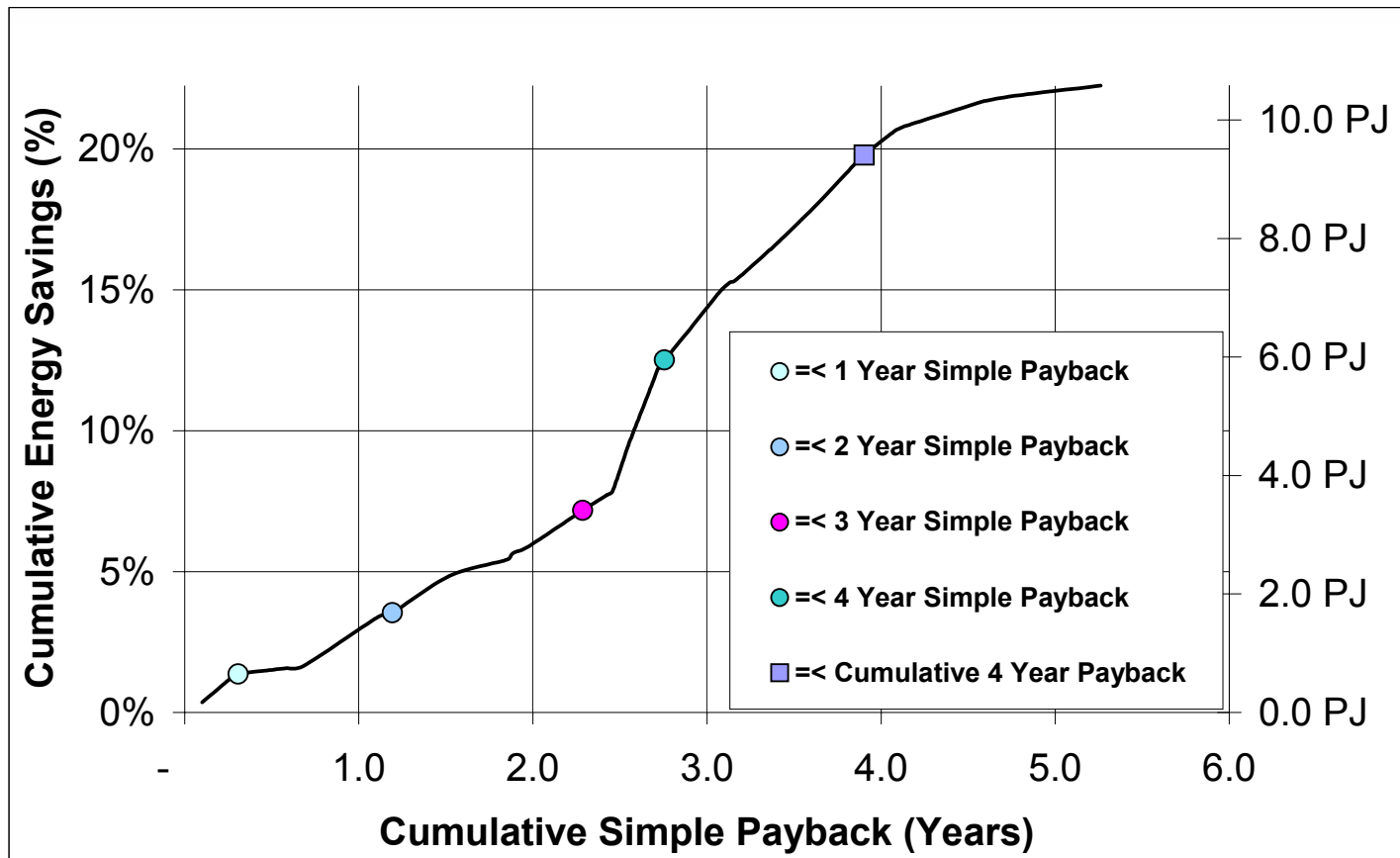


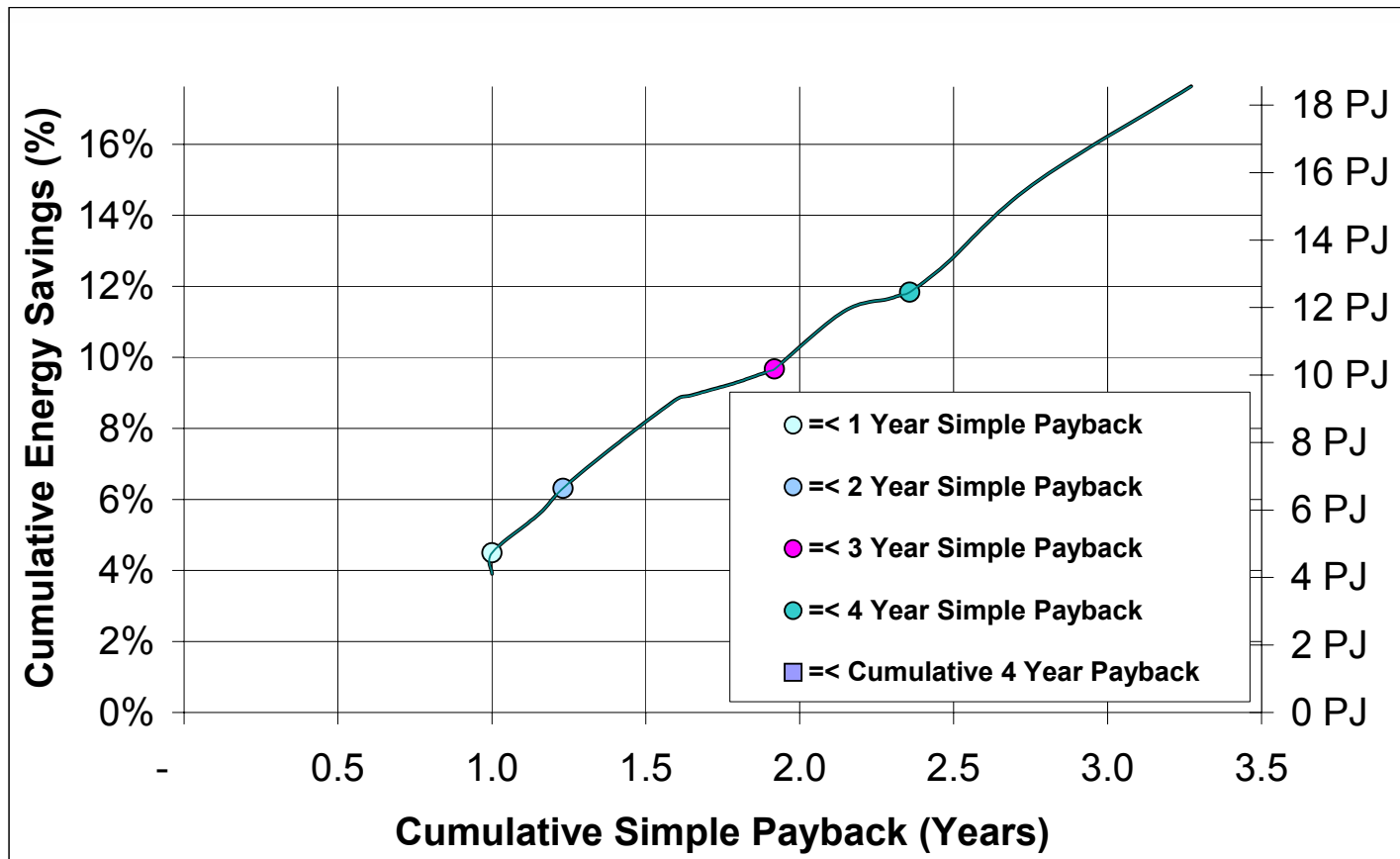


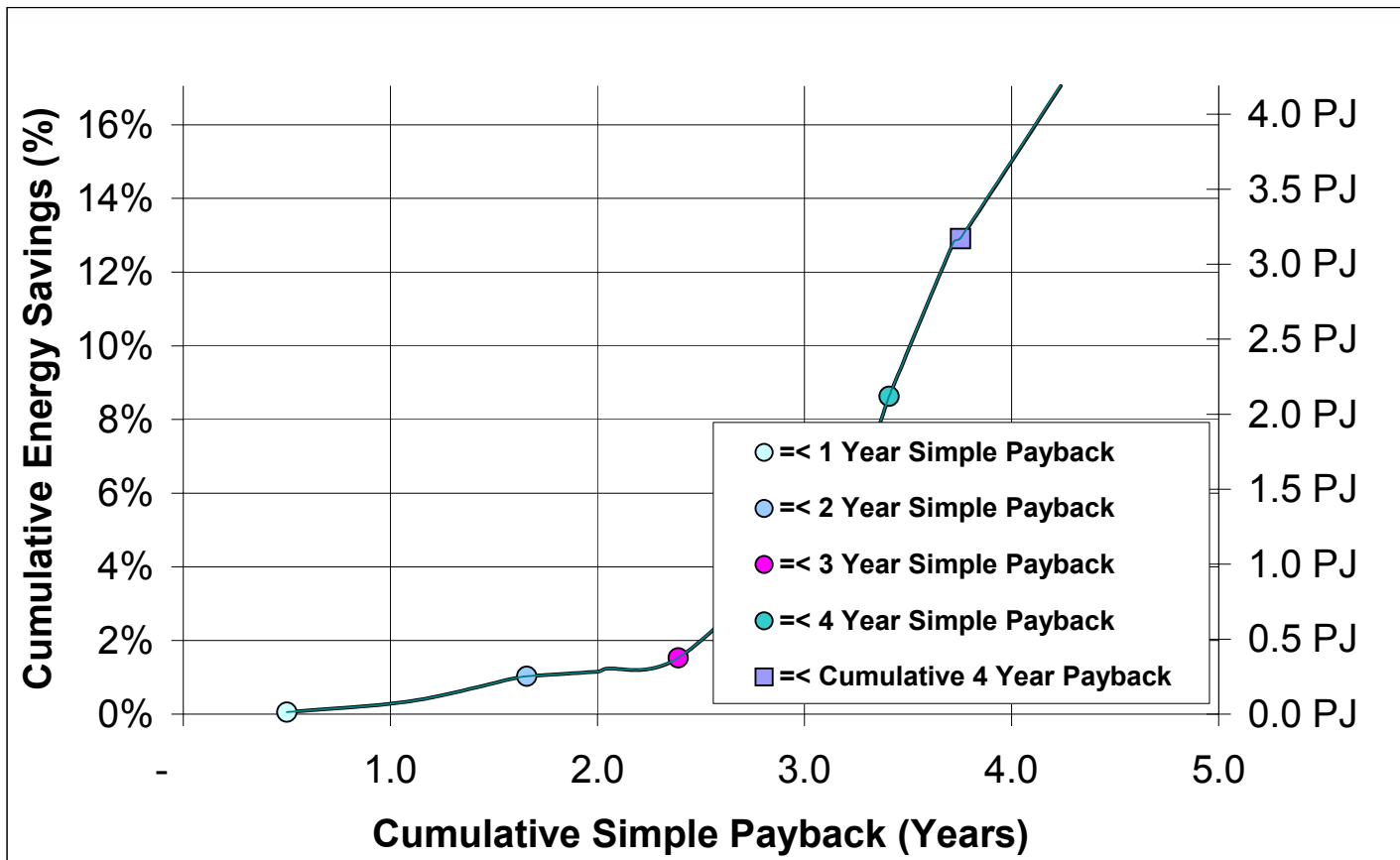


Raw Results – Milling & Baking

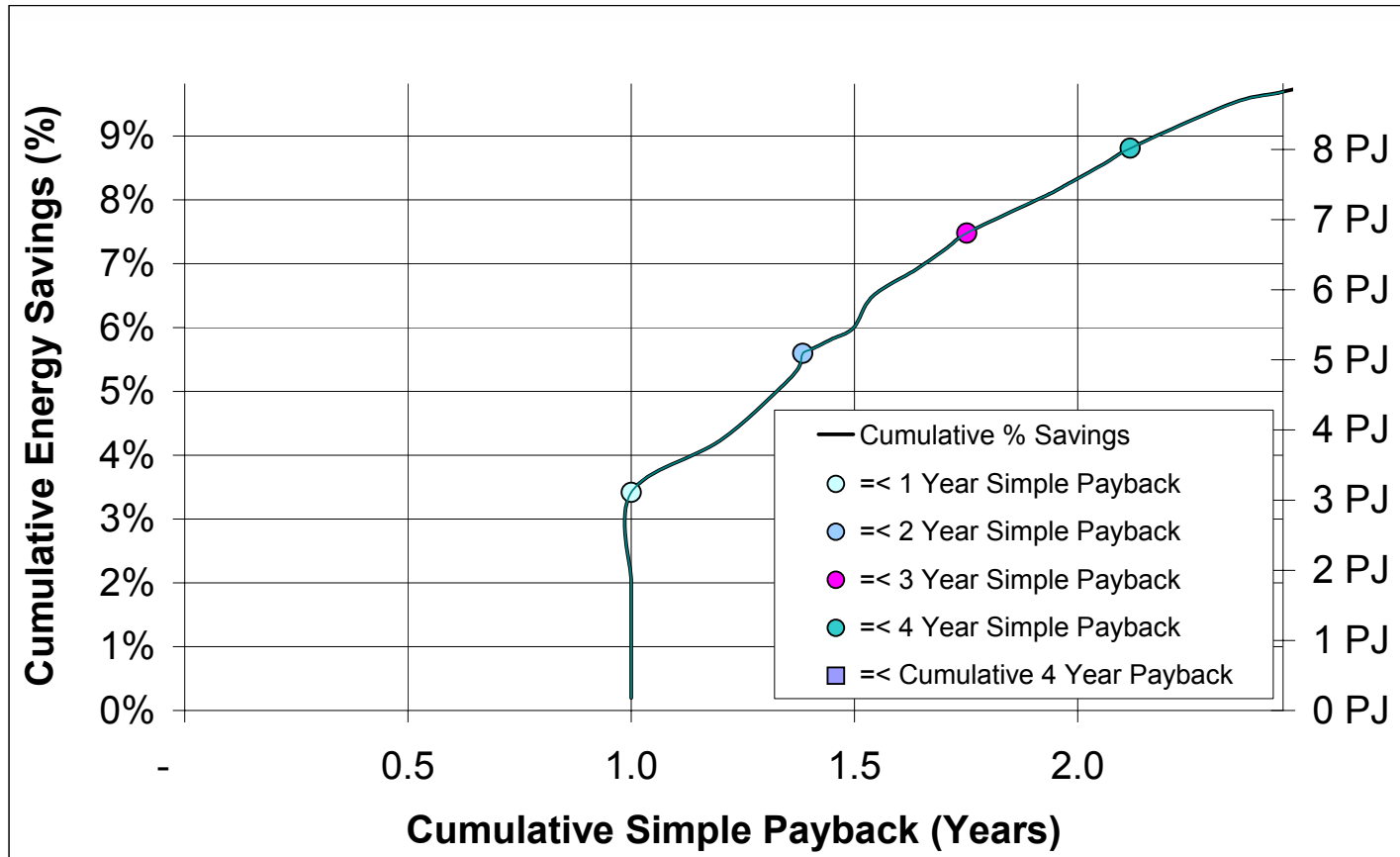




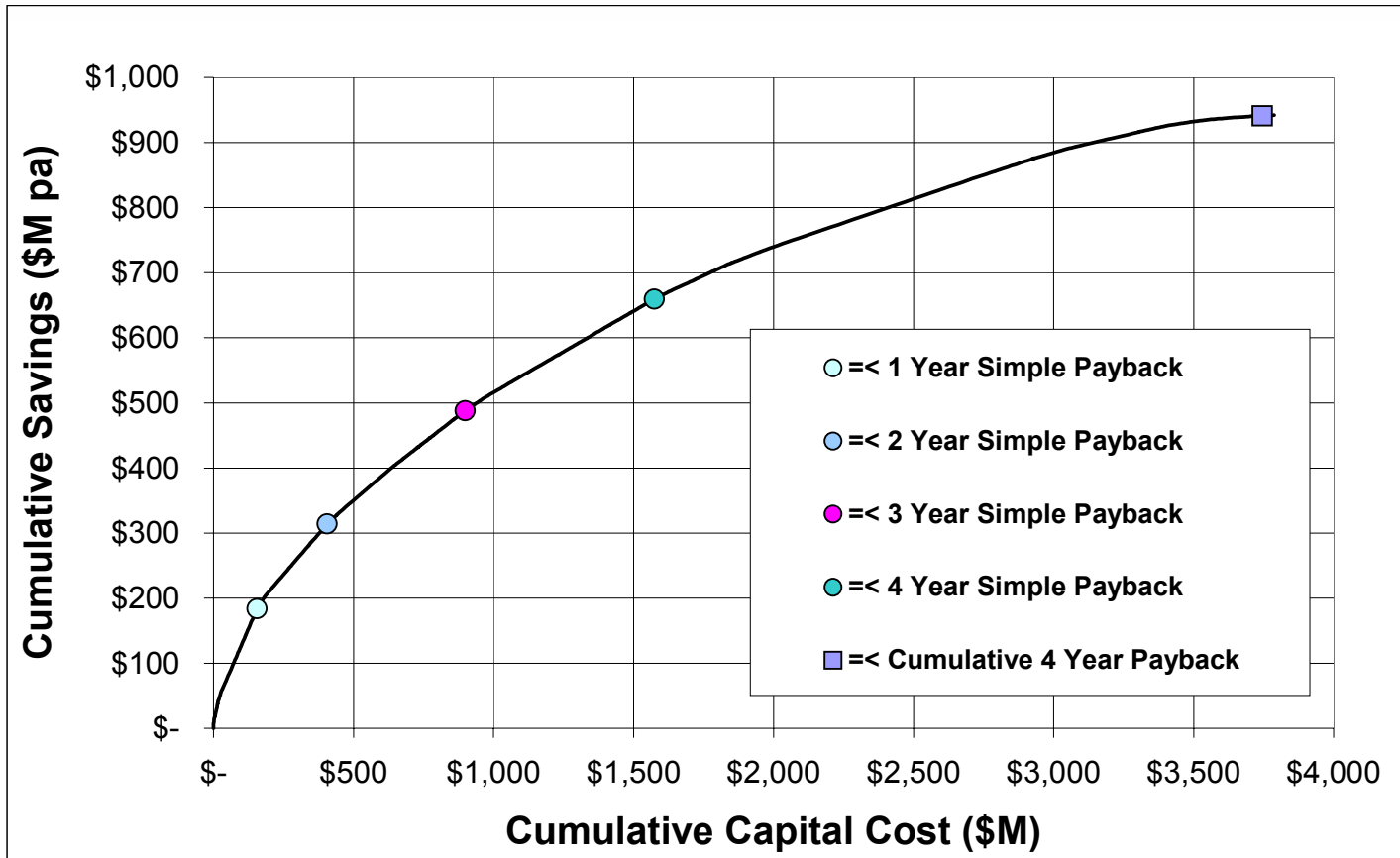




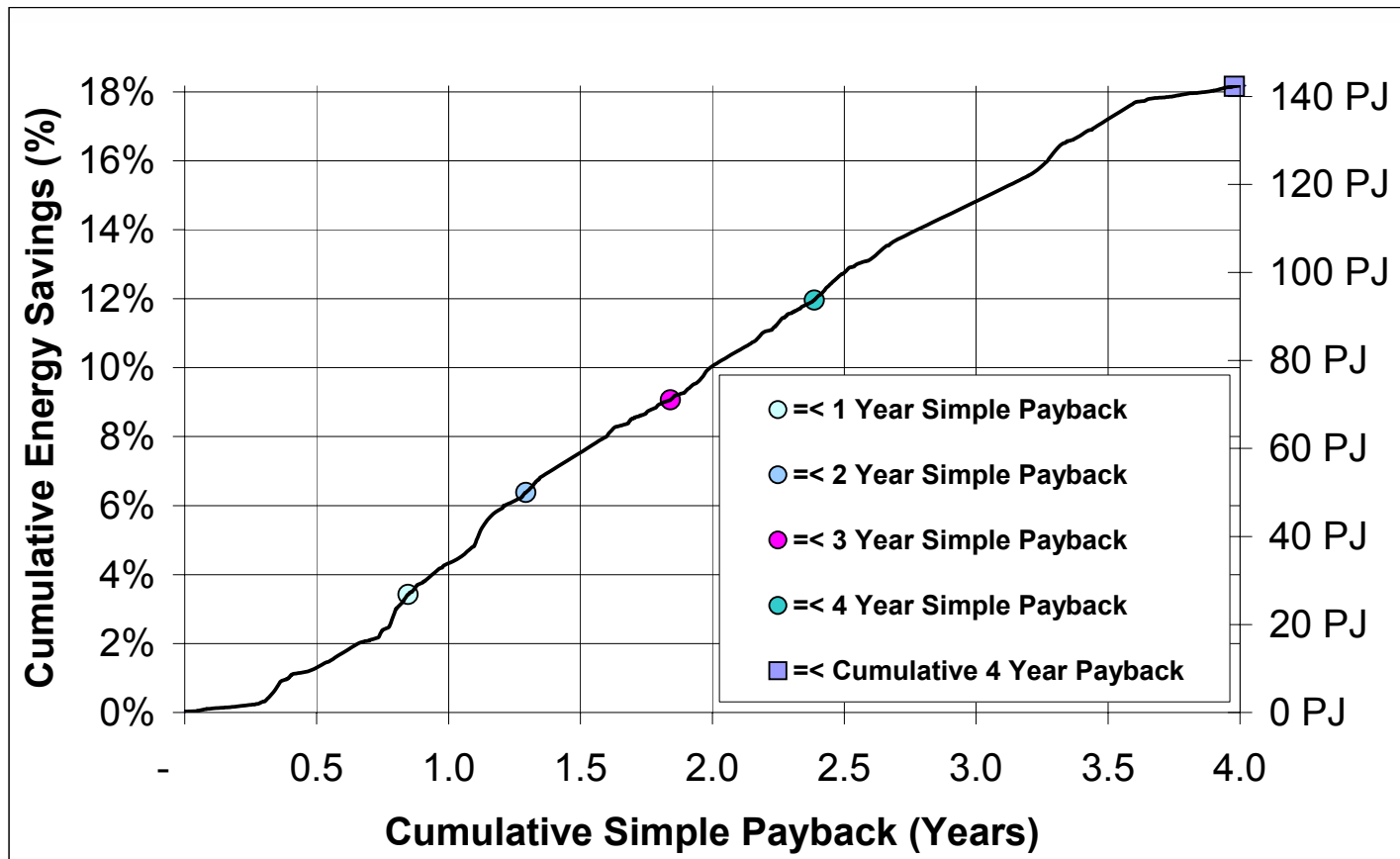
Raw Results – Mining (excl Transport, O&G)

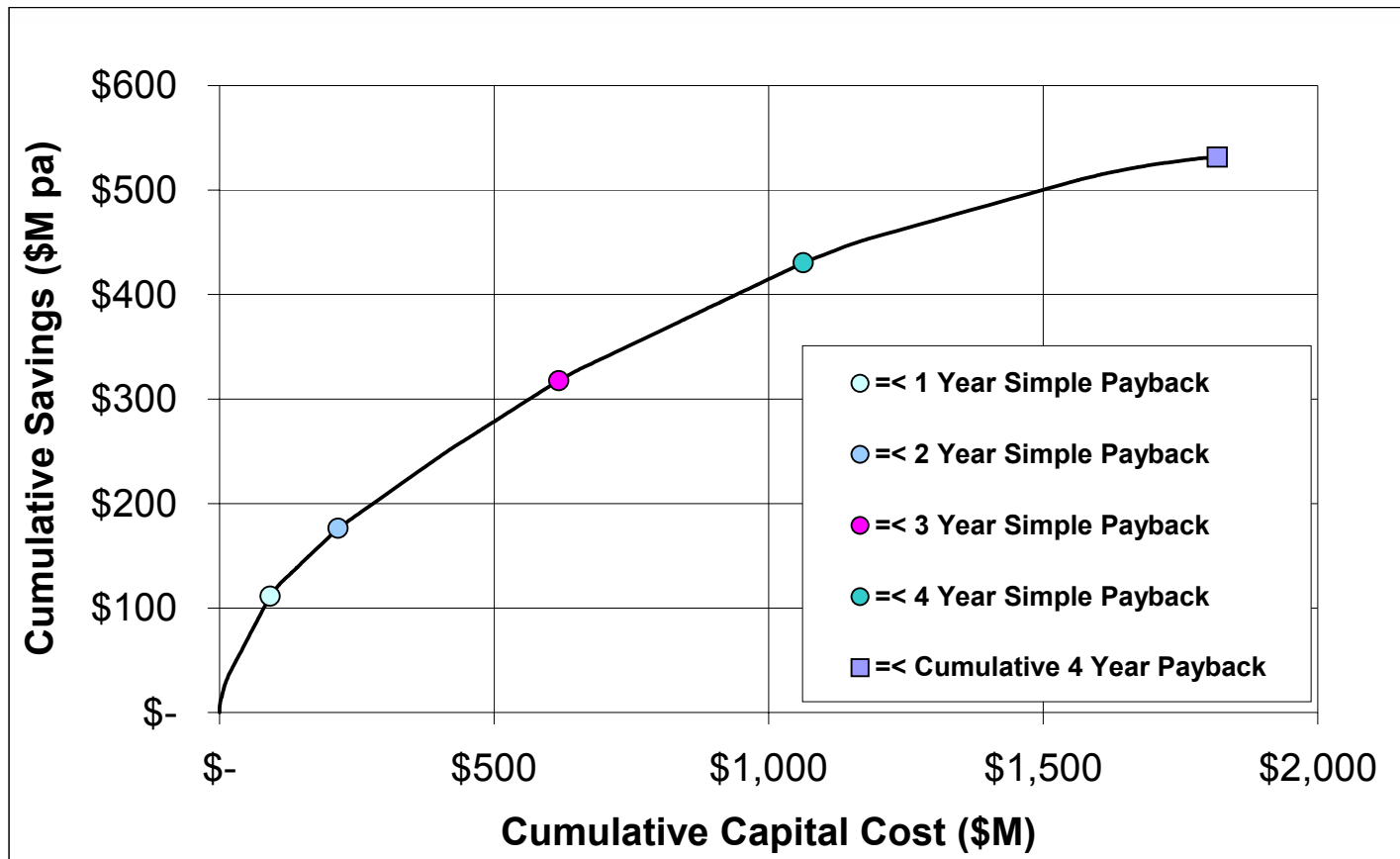


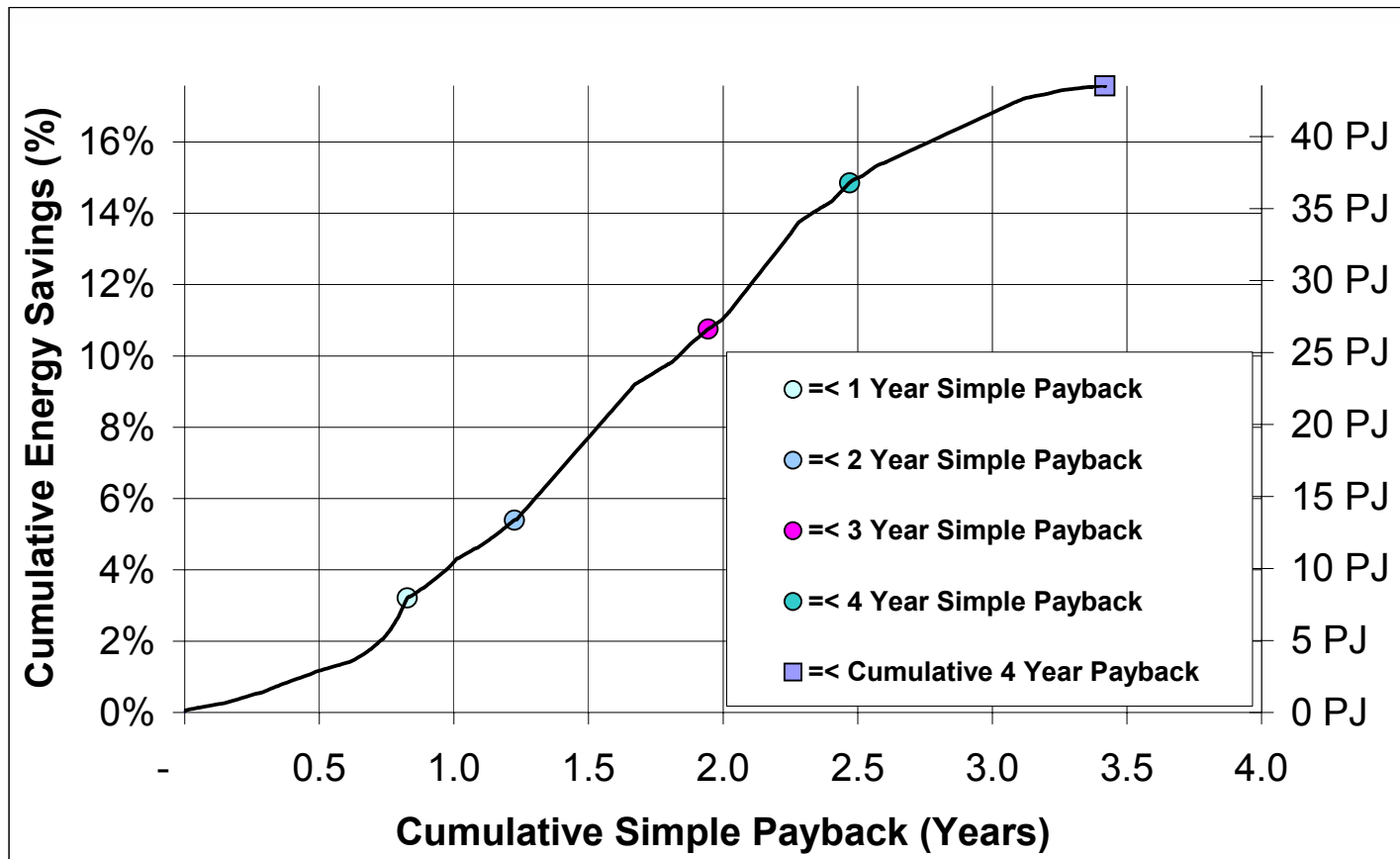
Raw Results – Overall Summary



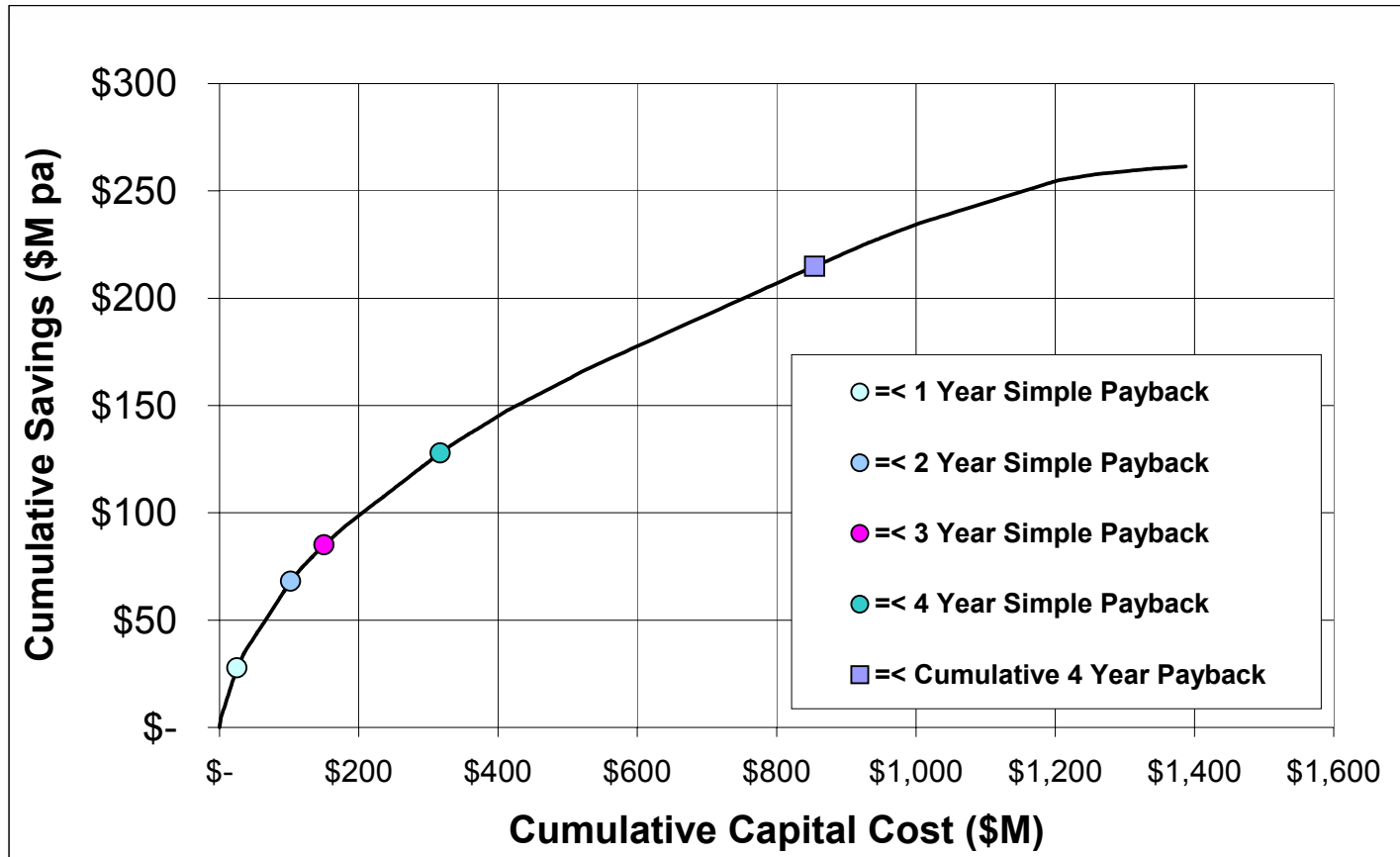
Raw Results – Overall Summary



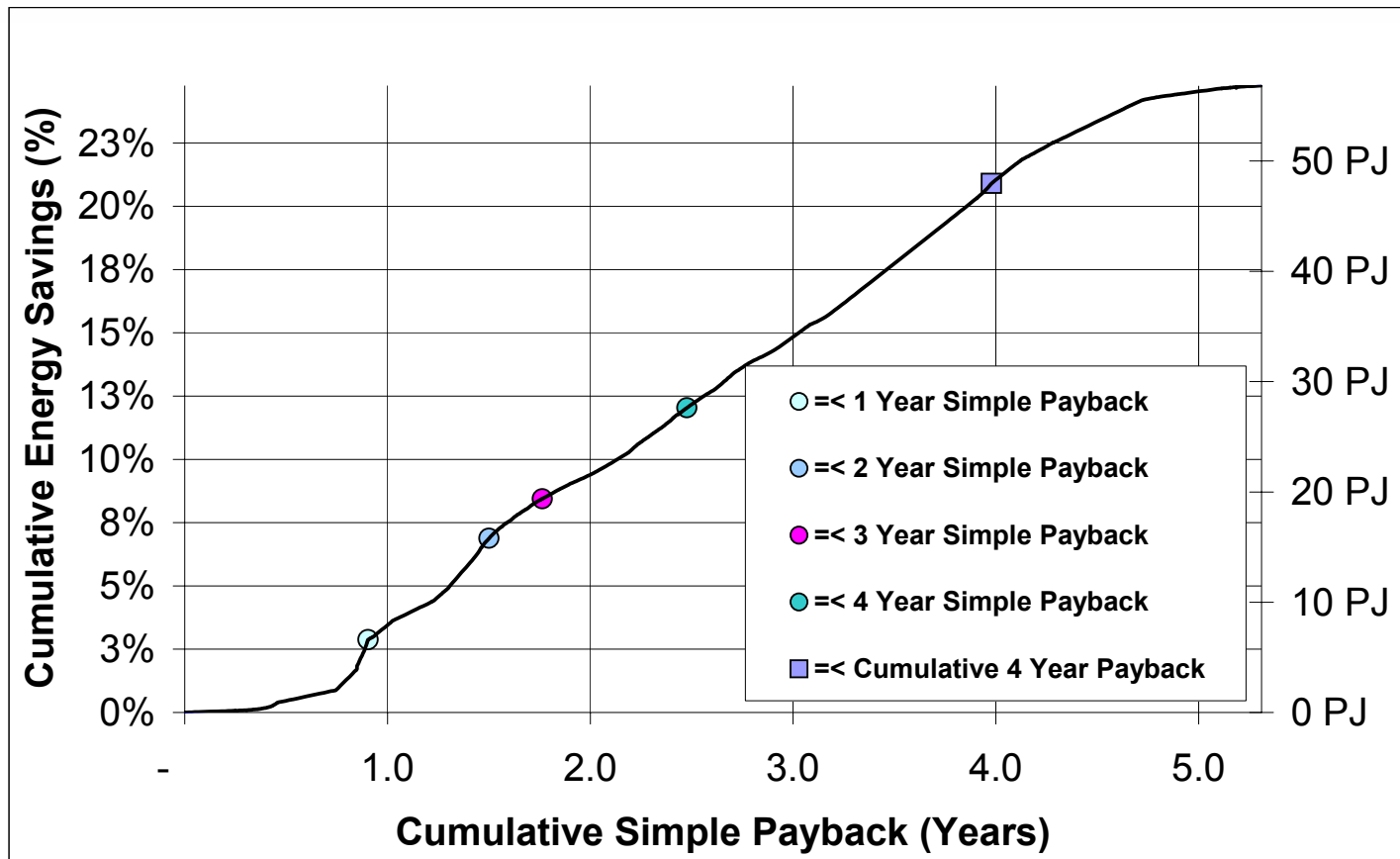




Raw Results – Natural Gas



Raw Results – Natural Gas



■ Coverage

- Includes energy efficiency within sample of existing facilities
- Excludes cogeneration, Greenfield developments, productivity gains or structural changes within industry sectors
- Likely impact – estimate understates total EEI Potential



- Non-energy savings
 - Payback based on energy savings only
 - O&M savings, productivity may be significant
 - Some actions entail new/ongoing maintenance (e.g. compressed air and steam leaks)
 - Other actions involve lower maintenance (e.g. efficient lighting, HEM, new technology)
 - Likely impact – non-inclusion of additional benefits presents a conservative view of potential paybacks



- **Additionality**
 - Excludes the potential effect of the additionality of individual actions
 - Excludes potential rebound effect (rebound effect is taken into account in the economic modeling)
 - Likely impact – estimate overstates the savings potential



- Applicability of EEI Potential Across Sub-Sectors
 - EEI from energy audits that Energetics has conducted, to a lesser extent from other literature and industry best-practice studies – assumes these are representative
 - Audits carried out where the need is greatest?
 - Lower potential savings in EE due to higher recent focus on EE (e.g. Greenhouse Challenge, EEBPP, SEPP AQM, SEDA ESB)?
 - Likely impact – estimate overstates savings potential



- Comprehensiveness of EEI Opportunities
 - In addition to the EEI opportunities identified from selected case studies, it can be expected that additional, cost-effective opportunities exist for improvement that have not been identified
 - Likely impact – higher EEI savings possible



- Other factors will have an impact on the quality of results:
 - Disaggregation of Energy Use
 - Level of 12-Year Energy Savings Achievable
 - Simple Payback
 - Implementation / take-up rate



- Experience suggests 10-20% EE savings is achievable at most sites
- Cogeneration, new developments, structural change may increase total EEI Potential, additionally an important factor
- Continuous improvement requires ongoing commitment, planning, resources, monitoring
- Sub-sectors where most energy is by one or a few items of equipment / processes – timing of replacement is critical



Questions?

