

## APPENDIX D: INPUT & OUTPUT ANALYSIS

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### *Introduction*

The economic input-output model used for this study was compiled by Skip Laitner, a Senior Economist of the US Environmental Protection Agency.

This work is indicative not authoritative, the aim is to stimulate debate around the issues of jobs and energy efficiency.

### *The Input-Output (I/O) model*

The I/O model is spreadsheet based. Essentially the model develops relationships between expenditure and savings (on an economy wide basis) resulting from electricity savings in industry due to an energy efficiency program. From this, 'multipliers' are calculated which establish income levels that derive from cash flow through the economy as transactions take place as a result of the energy efficiency intervention. The amount of money spent on salaries is deduced, and divided by an average wage.

The competing trends are between:

- money spent in the South African economy versus money spent on imports and
- reduced cash flows to the electricity sector (and therefore mining with further job implications) versus more money available to industry for spending in the local economy.

Important assumptions include:

- The percentage of local content in the measure being applied.
- The payback period of the outlay to achieve the energy saving.
- The fraction of the money spent to be taken as a loan.
- The number of years over which this money will be paid back.
- Other productivity gains resulting from the energy efficiency improvement, as a fraction of the energy savings.

In the case of this work the following assumptions were made:

- Generally two local/foreign content values were used for each measure: 20% and 80% to establish a range of impacts.
- A five year period was chosen for the loan repayments, with a real interest rate of 10%.
- A government program cost of 5% of the implementation cost was used over the period and added to the cost of the measure.
- The period considered was from 2003 to 2013 with savings initiating from 2004.

### ***Short description of the methodology***

The model follows the following steps:

- The model begins with a 'transaction table', of cash flow movements from to and from a set of sectors in the economy. The sectors considered are as follows:
  - Agriculture
  - Mining
  - Manufacturing
  - Electricity
  - Trade
  - Construction
  - Finance
  - Services
  - Wages
  - Other added value
- By dividing the individual transactions by the total for the sector, the percentage transaction from each sector to the other was established.
- By linear algebra manipulation a matrix was established which gave the change of income in that sector per unit of expenditure in that sector. This was termed the 'income matrix'.
- From the income matrix, it was possible to determine expenditure in each sector on wages, and from this derive an 'income multiplier'.
- The 'income multiplier' was derived for each sector.
- With the income multipliers, wages expenditure in each sector identified earlier, could be established for every rand added to that sector.
- The costs of the energy efficiency measure (or program) were unpacked into expenditure over the life of the project and into the relevant economic sector.
- The expenditure into each sector was then multiplied by the income multiplier to establish the increase in wages resulting from expenditure in the sector over the economy.
- The wage increases were the divided by an assumed average salary of R30 000 pa.

### ***Shortcomings of the I/O model approach***

Some of the shortcomings of the approach used in the modelling are summarised as follows:

- The users are still inexperienced with the technique, which is fairly new.
- It is assumed that the shape of the economy does not change significantly, and is dependant on a relatively static transaction table.
- It is assumed that industrial electricity growth is not significant over the period.
- The model does not necessarily capture the effect of displacing a new power station by increased energy efficiency. This is in part due to the assumption that the shape of the transaction table for the country is static.
- The transaction table should be updated, current figures are for 1997 and have been taken from Statistics South Africa.
- A Large proportion of transactions, outside of the sectors considered, are not clearly defined.
- It is assumed that the R/\$ exchange rate is kept constant.

### ***Screen captures from the spreadsheet model***

Please see Figure 1 on Page 4.

**Figure 1: Determining the income multipliers**

**South Africa 1997 TRANSACTIONS Table (Rm)**

	AG	MINE	MFG	ELEC	TRD	CON	FIN	SVC	Intermediate Output	Final Demand	TGO
AG	1,147	25	17,343	11	12	4	0	487	19,029	21,037	40,066
MINE	1	170	4,697	3,300	1	6	0	345	8,520	61,314	69,834
MFG	6,590	5,280	68,097	738	8,784	12,425	1,129	18,509	121,552	225,501	347,053
<b>ELEC</b>	<b>307</b>	<b>4,778</b>	<b>8,417</b>	<b>7,283</b>	<b>1,340</b>	<b>249</b>	<b>217</b>	<b>4,379</b>	<b>26,970</b>	<b>8,641</b>	<b>35,611</b>
TRD	3,135	2,694	24,158	773	14,826	3,593	1,372	12,527	63,078	74,658	137,736
CON	169	541	0	986	1,952	9,509	150	2,053	15,360	37,116	52,476
FIN	293	0	5,581	595	3,799	738	9,099	7,572	27,677	9,744	37,421
SVC	1,373	5,854	37,438	1,528	20,167	6,545	5,705	28,211	106,821	103,380	210,201
<b>Other added value</b>	<b>13,015</b>										930398
WAGES	5,373	22,188	65,001	5,558	49,452	11,702	23,371	47,083	229728	13,31957073	
TGO	40,066	69,834	347,053	35,611	137,736	52,476	37,421	210,201	930398	9,323699513	
								131608	<b>Total Save</b>	<b>Household Save</b>	
dElecUse	11.7	181.9	320.4	0.0	51.0	9.5	8.3	166.7	1078.4	328.9	
Share of Save	0.00%	36.21%	63.79%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	
Fraction Save											

3.81% Not to sure where this comes from ?? Perhaps this is the total saving for the program at a time - I.e. this changes to get the answe out.

**DIRECT REQUIREMENTS**

This is the percentage of expenditure in each sector as a function of total in that sector

	AG	MINE	MFG	ELEC	TRD	CON	FIN	SVC	Income Direct	Income Total	ie one dollar into Agriculture = t
AG	0.0286	0.0004	0.0500	0.0003	0.0001	0.0001	0.0000	0.0023	0.134	0.272	2.028
MINE	0.0000	0.0024	0.0135	0.0927	0.0000	0.0001	0.0000	0.0016	0.318	0.428	1.346
MFG	0.1645	0.0756	0.1962	0.0207	0.0638	0.2368	0.0302	0.0881	0.187	0.385	2.054
ELEC	0.0077	0.0684	0.0243	0.2045	0.0097	0.0047	0.0058	0.0208	0.156	0.329	2.110
TRD	0.0782	0.0386	0.0696	0.0217	0.1076	0.0685	0.0367	0.0596	0.359	0.535	1.489
CON	0.0042	0.0077	0.0000	0.0277	0.0142	0.1812	0.0040	0.0098	0.223	0.506	2.269
FIN	0.0073	0.0000	0.0161	0.0167	0.0276	0.0141	0.2432	0.0360	0.625	0.950	1.521
SVC	0.0343	0.0838	0.1079	0.0429	0.1464	0.1247	0.1525	0.1342	0.224	0.389	1.738
WAGES	0.1341	0.3177	0.1873	0.1561	0.3590	0.2230	0.6245	0.2240			
TGO	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000			

Wages as a fraction of expenditure  
Money spent on wages due to :  
Ratio of saleri

**IDENTITY MATRIX**

Simple linair programming

	AG	MINE	MFG	ELEC	TRD	CON	FIN	SVC
AG	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MINE	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
MFG	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
ELEC	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
TRD	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
CON	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000
FIN	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
SVC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

**(I-A) MATRIX**

Identity matrix minus the direct requirements matrix

	AG	MINE	MFG	ELEC	TRD	CON	FIN	SVC
AG	0.9714	-0.0004	-0.0500	-0.0003	-0.0001	-0.0001	0.0000	-0.0023
MINE	0.0000	0.9976	-0.0135	-0.0927	0.0000	-0.0001	0.0000	-0.0016
MFG	-0.1645	-0.0756	0.8038	-0.0207	-0.0638	-0.2368	-0.0302	-0.0881
ELEC	-0.0077	-0.0684	-0.0243	0.7955	-0.0097	-0.0047	-0.0058	-0.0208
TRD	-0.0782	-0.0386	-0.0696	-0.0217	0.8924	-0.0685	-0.0367	-0.0596
CON	-0.0042	-0.0077	0.0000	-0.0277	-0.0142	0.8188	-0.0040	-0.0098
FIN	-0.0073	0.0000	-0.0161	-0.0167	-0.0276	-0.0141	0.7568	-0.0360
SVC	-0.0343	-0.0838	-0.1079	-0.0429	-0.1464	-0.1247	-0.1524	0.8658

**OUTPUT MULTIPLIERS**

Have no idea where these come from - must be an inverted multiplication

	AG	MINE	MFG	ELEC	TRD	CON	FIN	SVC
AG	1.0420	0.0071	0.0672	0.0046	0.0072	0.0219	0.0053	0.0107
MINE	0.0055	1.0132	0.0225	0.1195	0.0044	0.0089	0.0036	0.0077
MFG	0.2383	0.1245	1.2966	0.0763	0.1278	0.4108	0.0912	0.1518

**Figure 2: Determining the program spending**

Year	Invest	Program Spend	Down Payment	Loan Payment	Annual Save	Net Save	Interest Payments
2002	0	0	0.0	0.0	0.0	0.0	0.0
2003	0	11	0.0	0.0	0.0	(11.0)	0.0
2004	110	22	55.2	14.6	110.5	18.6	3.5
2005	221	11	110.5	43.7	331.5	166.2	10.6
2006	221	11	110.5	72.9	552.5	358.0	17.6
2007	221	11	110.5	102.0	773.4	549.9	24.7
2008	221	11	110.5	131.2	994.4	741.7	31.7
2009	221	11	110.5	145.7	1,215.4	948.1	35.2
2010	221	11	110.5	145.7	1,436.4	1,169.1	35.2
2011	221	0	110.5	145.7	1,657.4	1,401.1	35.2
2012	0	0	0.0	116.6	1,657.4	1,540.8	28.2
2013	0	0	0.0	87.4	1,657.4	1,569.9	21.1
2014	0	0	0.0	58.3	1,657.4	1,599.1	14.1
2015	0	0	0.0	29.1	1,657.4	1,628.2	7.0
2016	0	0	0.0	0.0	1,657.4	1,657.4	0.0
2017	0	0	0.0	0.0	1,657.4	1,657.4	0.0
2018	0	0	0.0	0.0	1,657.4	1,657.4	0.0
2019	0	0	0.0	0.0	1,657.4	1,657.4	0.0
2020	0	0	0.0	0.0	1,657.4	1,657.4	0.0
<b>Totals</b>	<b>1,657.4</b>	<b>99.4</b>	<b>828.7</b>	<b>1,093.0</b>	<b>21,988</b>	<b>19,966.4</b>	<b>264.3</b> <b>1,657.4</b>



### ***Measures modelled and results of the I/O model***

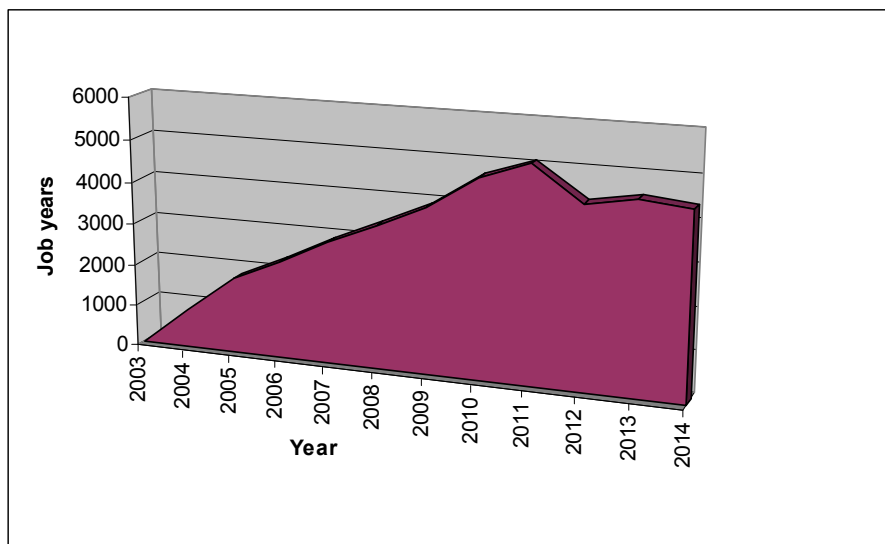
The following industrial electrical efficiency measures were modelled and reported below:

- ❖ All measures
- ❖ Compressed air
- ❖ Thermal
- ❖ HVAC
- ❖ Lighting
- ❖ Motors and
- ❖ VSD's

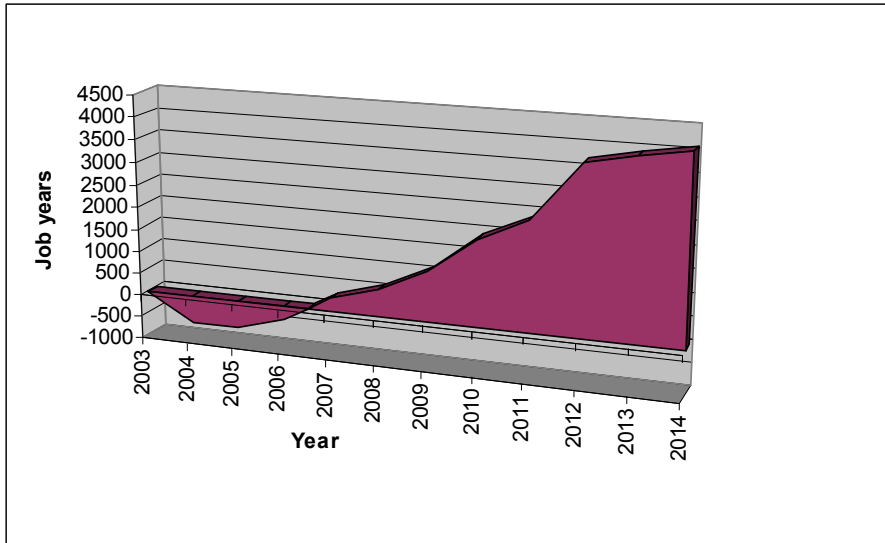
These are modelled with a local content of either 80% and 20%. In the case of compressed air an example of a 100% local content is shown.

### ***Results from implementing industrial energy efficiency options***

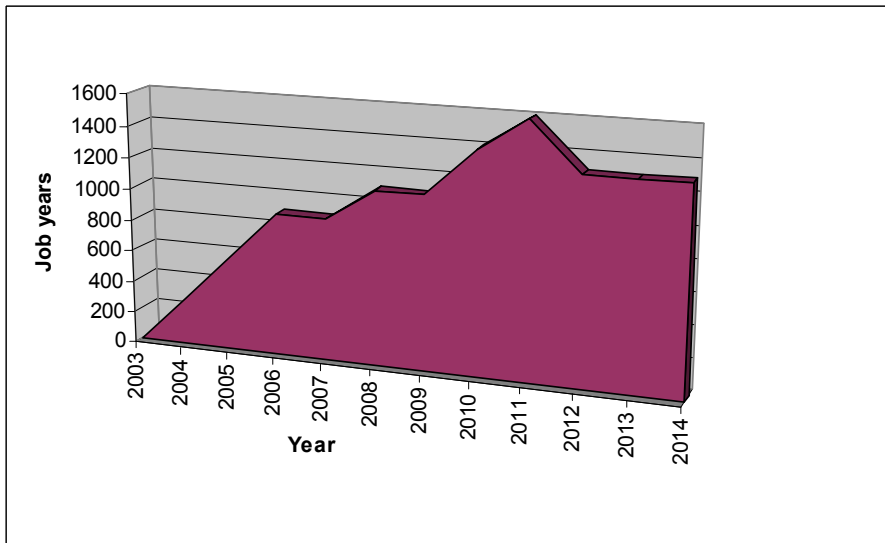
**Figure 4: Jobs created from applying all measures, assuming: 70% local content, 2 year payback and 15% electricity saving.**



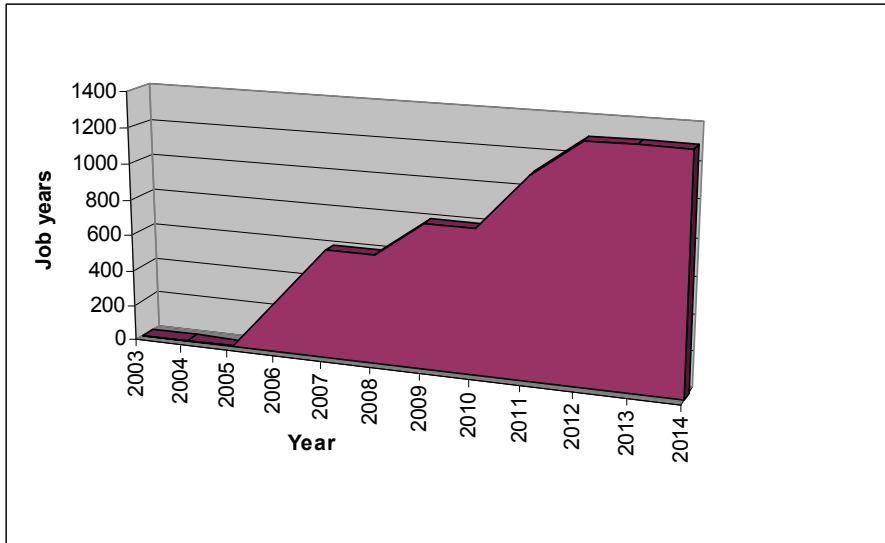
**Figure 5: Jobs created from applying all measures, assuming: 20% local content, two year payback and 15% electricity saving.**



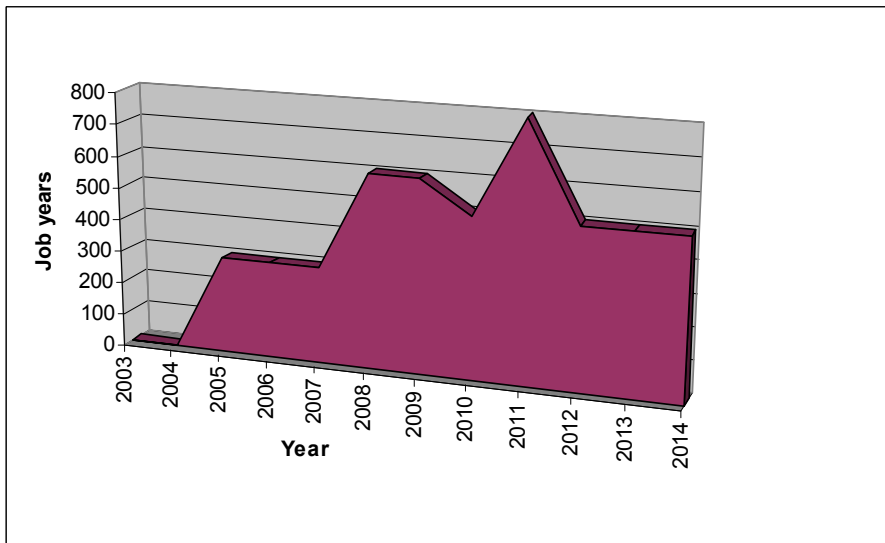
**Figure 6: Jobs created from applying compressed air leak fixing measures, assuming: 100% local content, 0.75 year payback and 4% electricity saving.**



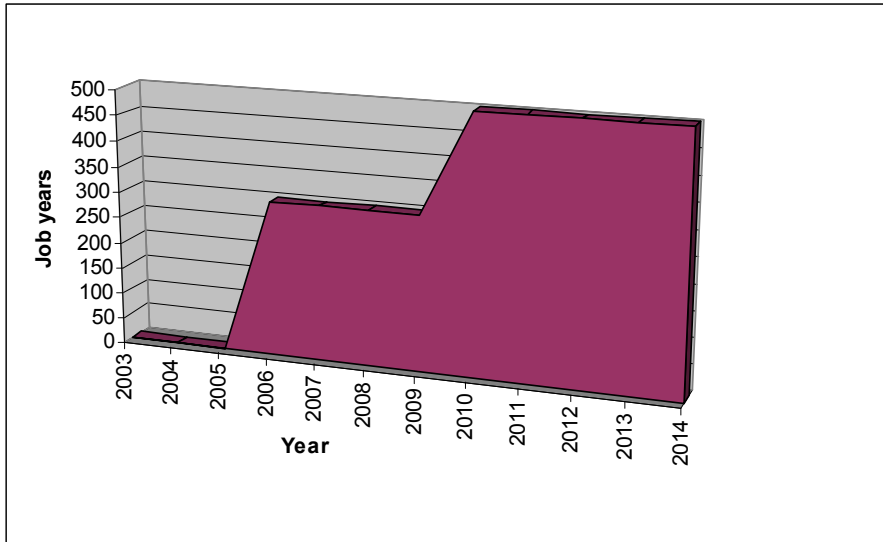
**Figure 7: Jobs created from applying compressed air leak fixing measures, assuming: 20% local content, 0.75 year payback and 4% electricity saving.**



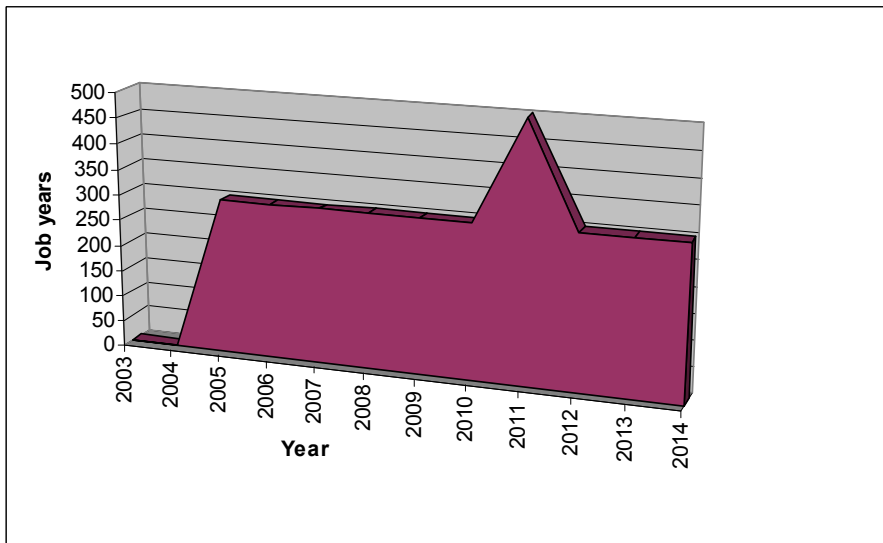
**Figure 8: Jobs created from applying steam management and thermal efficiency measures, assuming: 80% local content, 0.5 year payback and 2% electricity saving.**



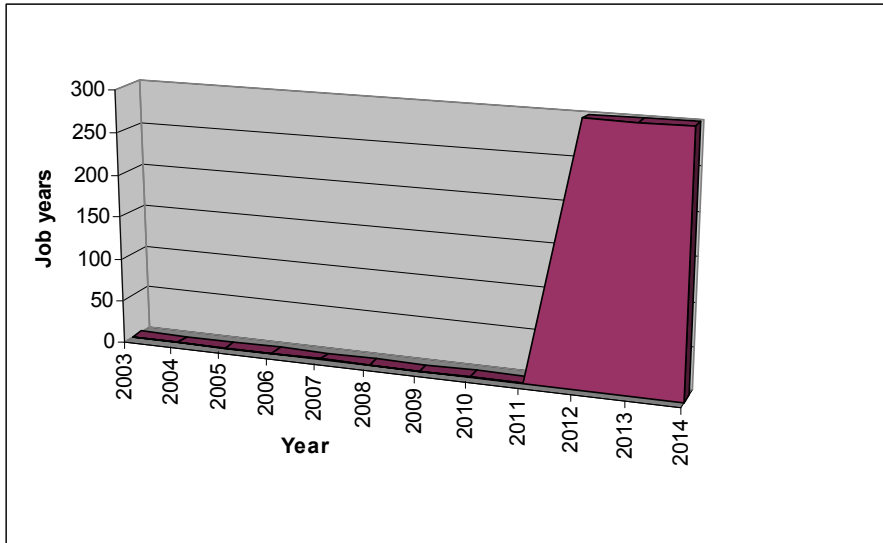
**Figure 9: Jobs created from applying steam management and thermal efficiency measures, assuming: 20% local content, 0.5 year payback and 2% electricity saving.**



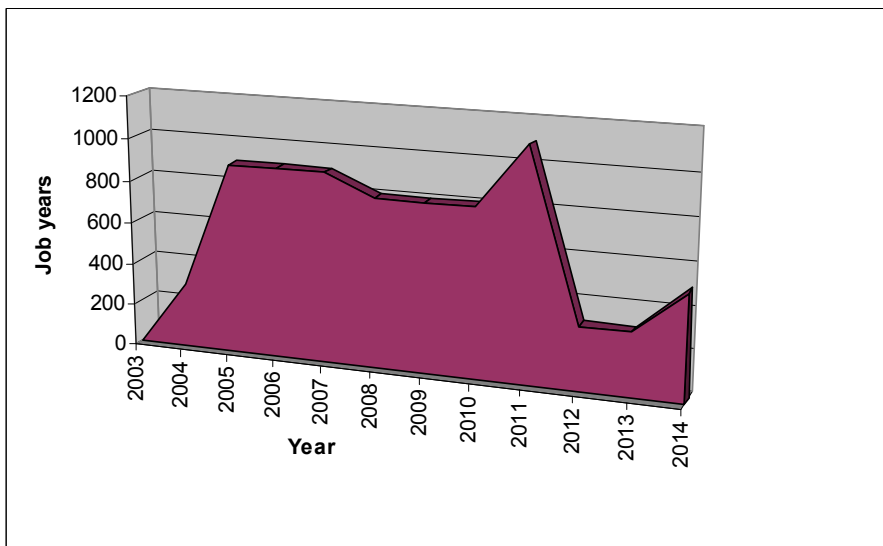
**Figure 10: Jobs created from applying HVAC efficiency measures, assuming: 80% local content, 0.5 year payback and 1% electricity saving.**



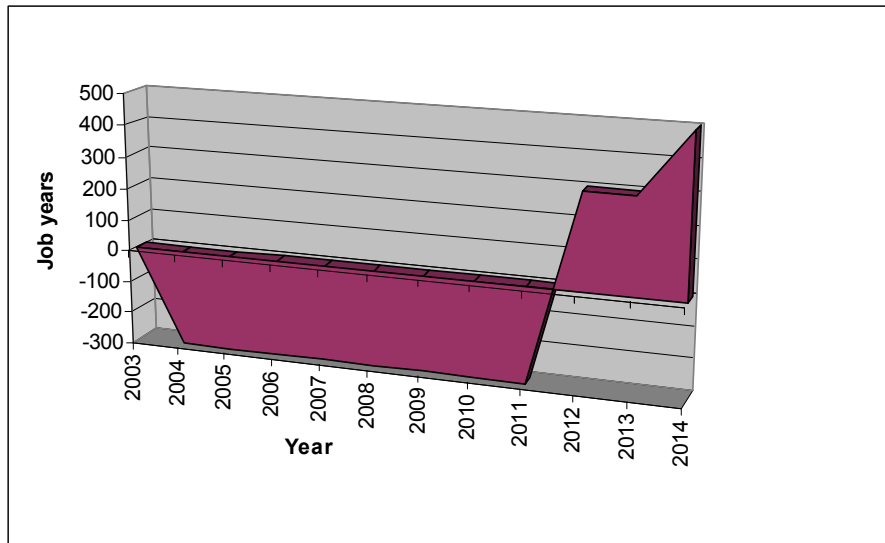
**Figure 11: Jobs created from applying HVAC efficiency measures, assuming: 20% local content, 0.5 year payback and 1% electricity saving.**



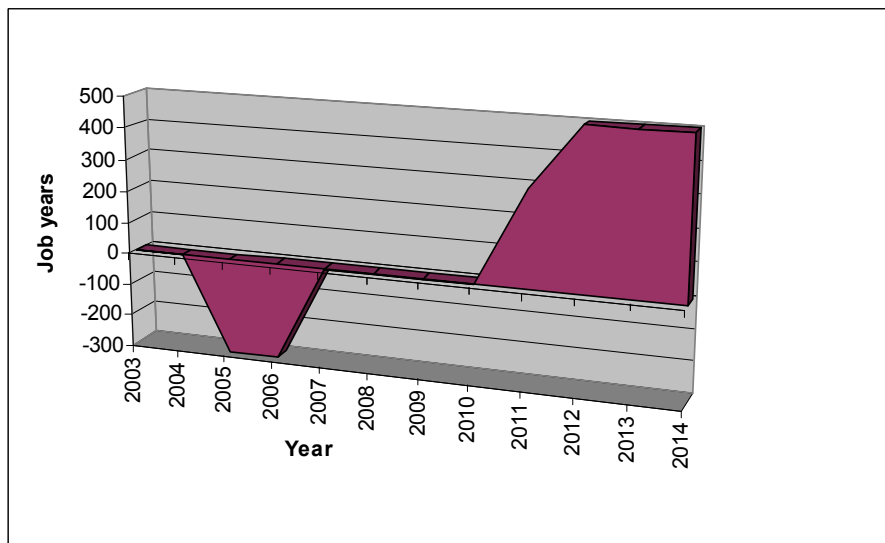
**Figure 12: Jobs created from applying energy efficient lighting measures, assuming: 80% local content, 5 year payback and 2% electricity saving.**



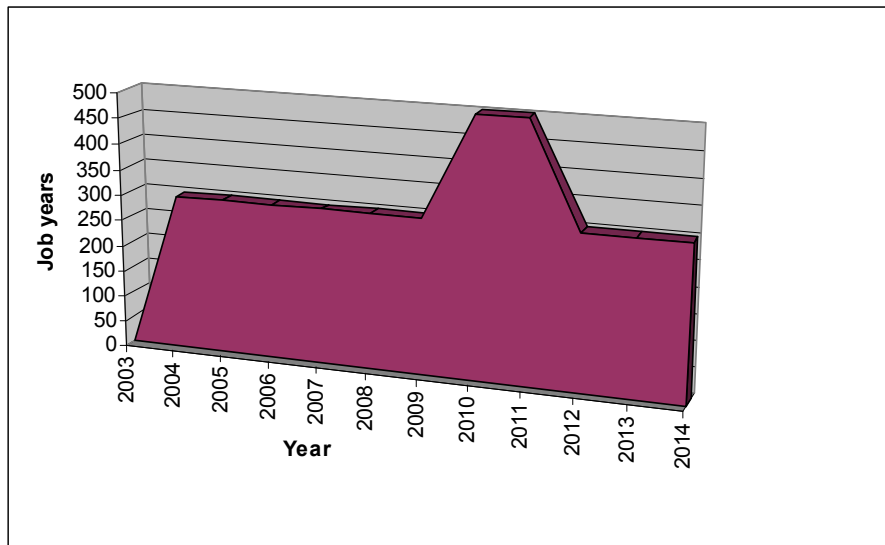
**Figure 13: Jobs created from applying energy efficient lighting measures, assuming: 20% local content, 5 year payback and 2% electricity saving.**



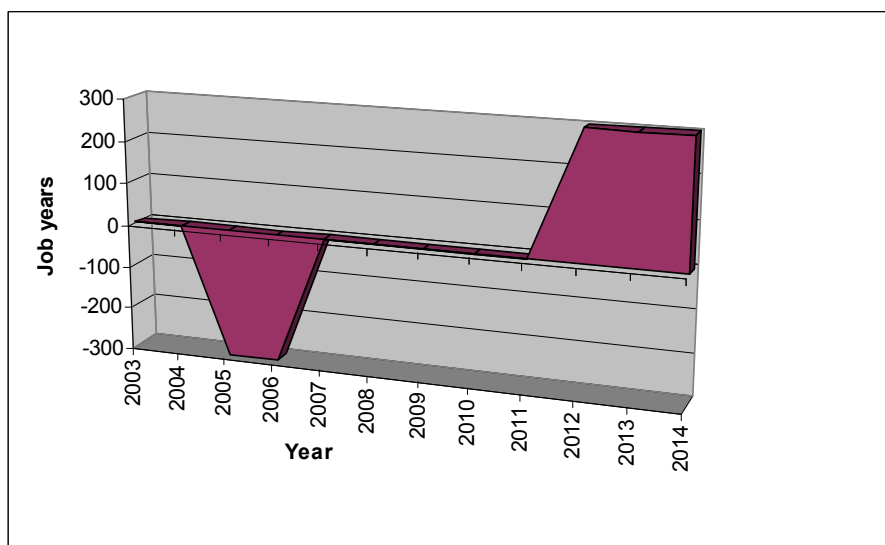
**Figure 14: Jobs created from applying energy efficient lighting measures, assuming: 20% local content, 3 year payback and 2% electricity saving (hypothetically assuming similar to CFL implementation in commerce.)**



**Figure 15: Jobs created from applying energy efficient motor measures, assuming: 80% local content, 4 year payback and 1% electricity saving. (A similar graph is generated for VSD's)**



**Figure 16: Jobs created from applying energy efficient motor measures, assuming: 80% local content, 4 year payback and 1% electricity saving. (A similar graph is generated for VSD's)**



## **Conclusion**

The results of the IO modelling are included to encourage debate concerning energy efficiency and job-creation. This work should be re-done in detail, and expanded to different sectors and measures. It is interesting that payback and local content are important considerations when developing energy efficiency strategies. Also noteworthy is the fact that after time, all energy efficiency seems to create sustainable jobs.

It should again be emphasised that this is only an indicative study, and critical comments in the early section of this appendix apply.