Chapter Five

Results and Recommendations

The results obtained from the AHP and the Decision Matrices ranking process use presented in this section, which is also concluded by a set of recommendations.

5.1 AHP Implementation and Results

To populate the AHP matrices, 20 interviews were carried out with a wide scope diversity of stakeholders. These range from government officials, members of the Parliament, directors of public departments, private consultants and academics. Interviews were made both individually and collectively and the results were combined and entered into a resulting global matrix using the geometric mean of the entries in all individual matrices. Below is a description of the final matrices that were entered into the AHP software.

Level 1: National objective of the analysis weight is '1'

Level 2: The decision criteria in this level have impact vertically on one factor, which is the national objective. Hence, one matrix 5x5 is constructed as follows:

	NEE	ULR	SE	MP	EQ
NEE	1	1.11	2.98	1.11	1.13
ULR	0.9	1	3.26	1.02	0.87
SE	0.34	0.31	1	0.43	0.38
MP	0.9	0.98	2.31	1	1.07
EQ	0.88	1.15	2.67	0.94	1

Level 3: We have five influencing factors so a matrix of 6x6 is needed to reflect the impact on each of the factors in level 2. The relative weights with respect to the factors in the upper level are as follows:

- Relative to National Economy Efficiency (NEE):

	PL	F	CC	T	R	PA
PL	1	1.8	3.09	4.63	3.78	1.5
F	0.56	1	1.71	2.65	2.33	0.54
CC	0.32	0.59	1	1.73	1.61	0.38
T	0.22	0.38	0.58	1	0.94	0.33
R	0.26	0.43	0.62	1.06	1	0.31
PA	0.67	1.85	2.66	3.07	3.27	1

- Relative to the Use of Local Resources (ULR):

	PL	F	CC	T	R	PA
PL	1	1.60	1.87	2.39	0.88	1.26
F	0.63	1	1.42	1.72	0.75	0.83
CC	0.54	0.71	1	1.55	0.61	0.59
T	0.42	0.58	0.65	1	0.38	0.61
R	1.13	1.34	1.64	2.63	1	1.04
PA	0.79	1.21	1.70	1.64	0.96	1

- Relative to Social Equity (SE):

	PL	F	CC	T	R	PA
PL	1	2.00	2.82	3.99	2.82	1.54
F	0.5	1	1.47	2.16	1.38	0.79
CC	0.35	0.68	1	1.59	1.02	0.33
T	0.25	0.46	0.63	1	0.61	0.30
R	0.35	0.73	0.98	1.63	1	0.39
PA	0.65	1.27	3.06	3.31	2.54	1

- Relative to Market Potential (MP):

	PL	F	CC	T	R	PA
PL	1	1.03	1.01	2.74	2.05	0.93
F	0.97	1	0.91	2.28	1.71	0.85
CC	0.99	1.10	1	2.00	2.01	0.88
T	0.36	0.44	0.50	1	0.82	0.38
R	0.49	0.59	0.50	1.21	1	0.38
PA	1.08	1.18	1.14	2.66	2.65	1

- Relative to Environmental Quality (EQ):

	PL	F	CC	T	R	PA
PL	1	2.40	3.06	2.91	2.27	1.44
F	0.42	1	1.12	0.99	0.78	0.51
CC	0.33	0.89	1	0.84	0.71	0.38
T	0.34	1.01	1.19	1	0.92	0.57
R	0.44	1.28	1.41	1.09	1	0.64
PA	0.70	1.96	2.60	1.77	1.57	1

Level 4: We have here six influencing factors from level three. Six matrices each of order four were considered.

- Relative to Adequacy of Regional Policies & Legislations (RPL):

	LR	PSP	MBP	DA
LR	1	1.31	0.78	3.89
PSP	0.76	1	0.54	3.56
MBP	1.28	1.86	1	4.61
DA	0.26	0.28	0.22	1

- Relative to availability of Funding (F):

	LR	PSP	MBP	DA
LR	1	0.72	0.65	2.48
PSP	1.39	1	0.88	3.19
1MBP	1.53	1.14	1	3.06
DA	0.4	0.31	0.33	1

- Relative to Commerciality and Competitiveness (CC):

	LR	PSP	MBP	DA
LR	1	0.52	0.61	2.97
PSP	1.91	1	1.17	4.63
MBP	1.63	0.85	1	4.20
DA	0.34	0.22	0.24	1

- Relative to immaturity of Technology (T):

	LR	PSP	MBP	DA
LR	1	0.56	0.53	2.13
PSP	1.79	1	0.94	3.56
MBP	1.90	1.06	1	3.48
DA	0.47	0.28	0.29	1

- Relative to adequacy of Resources (R):

	LR	PSP	MBP	DA
LR	1	1.04	1.04	3.65
PSP	0.96	1	0.90	3.51
MBP	0.96	1.11	1	3.36
DA	0.27	0.29	0.30	1

- Relative to Public Awareness (PA):

	LR	PSP	MBP	DA
LR	1	0.63	0.54	1.04
PSP	1.58	1	0.85	1.88
MBP	1.85	1.17	1	2.11
DA	0.96	0.53	0.47	1

Figure 7 shows the policy alternatives ranking obtained from the AHP. As can be seen the design and adoption of market-based programs (MBP) is considered the best policy option for accelerating the Technology Transfer Process. The second policy option, in order of importance, is the private sector active (PSP) participation, followed by the need to modify, update and enforce the relevant laws and regulations. The last policy option in the list is to keep on supporting the- and benefiting from the programs of international donors agencies.

Figure 7 provides the Eigen vectors of the decision matrix confirming the prioritization of policy options as described above.

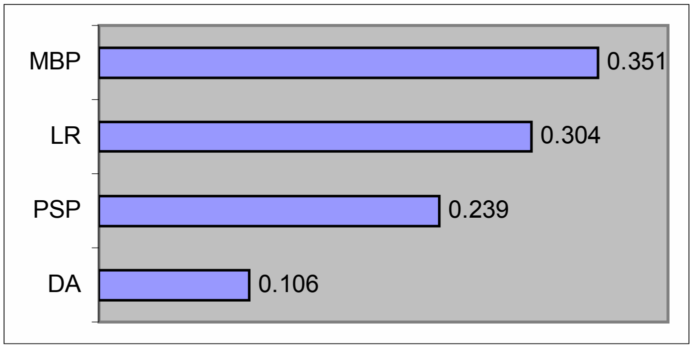

Figure 7: Policy option results/ranking

As to constraints/ factors facing technology transfer, the AHP analysis suggests that the application of existing laws and regulations as well as updating them when relevant, constitute the most important constraint. The second constraint in order of importance is the availability of financing, followed by public awareness. Whereas the Eigenvector of (PL) is 0.317, the Eigenvectors for (F) and (PA) are 0.194 and 0.185 respectively meaning that they are almost of equal importance. The other constraints in order of importance are the commercializing and competitiveness of proposed new technologies, the adequacy of supporting infrastructure and finally the immaturity of technology. Figure 8 provides the Eigenvectors of the decision matrix confirming the prioritization of constraints/factors as described above.

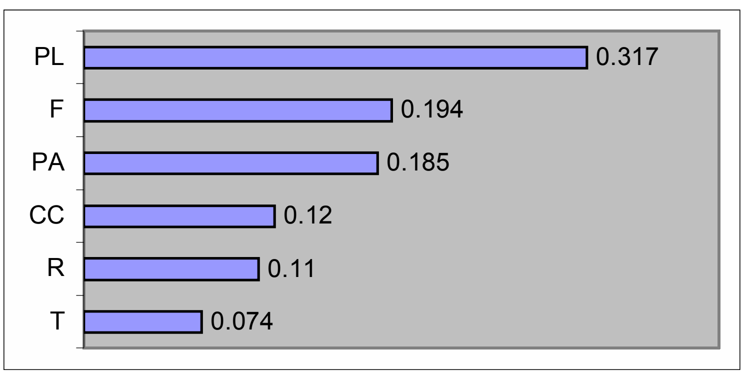

Figure 8: Ranking of constraints/factors

Finally, in terms of criteria selection for Technology Transfer, the AHP results indicate that caring for improvement of national economy efficiency is of highest priority (0.310) followed by the adequate use of available local resources followed by environmental quality (less pollution and less GHG emissions). Of less importance came the criteria of markets development and social equity.

Figure 9 provides information on eigenvector calculations for level 2 that supports the priority ranking of decision criteria mentioned above.

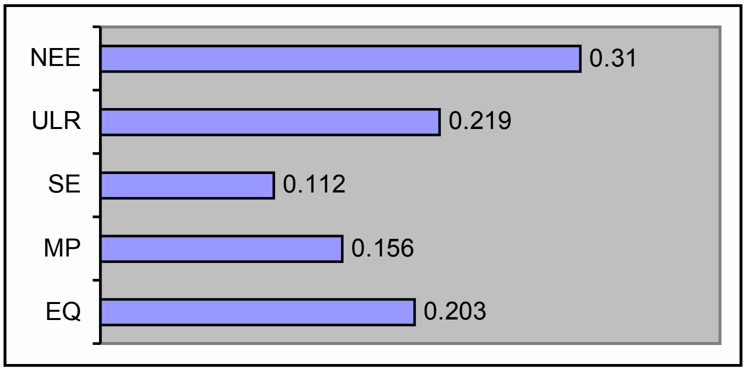

Figure 9: Ranking of decision criteria

The AHP analysis allows a kind of sensitivity analysis through which one can compare the relative importance of each element in, say, level 3 with each element of level 2. This would help better understand the logic behind the ranking of each element in each level according to their relative importance with respect to the national goal which was set as "Acceleration of Technology Transfer 'Process". For example, Figures ….. to…. show the relative importance of each element in level 3-constraints with respect to each element of level 2-decision criteria.

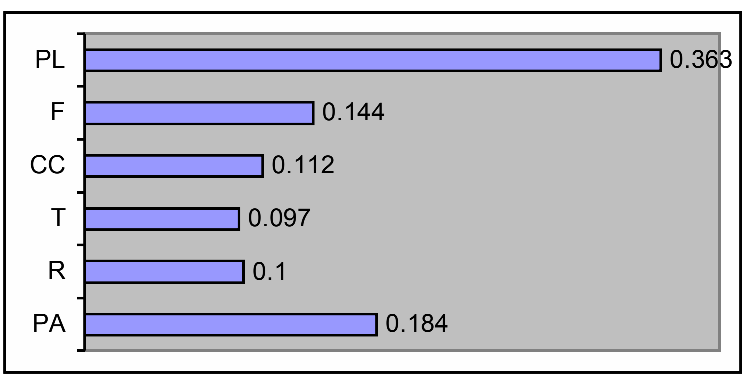

Figure 10: The relative importance of elements of level 3 with respect to EQ

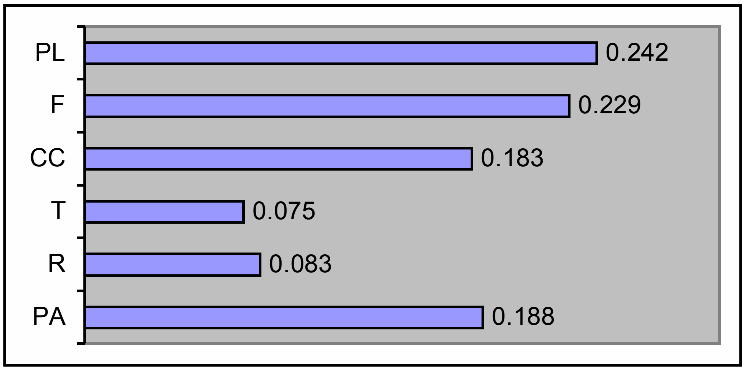

Figure 11: The relative importance of elements of level 3 with respect to MP

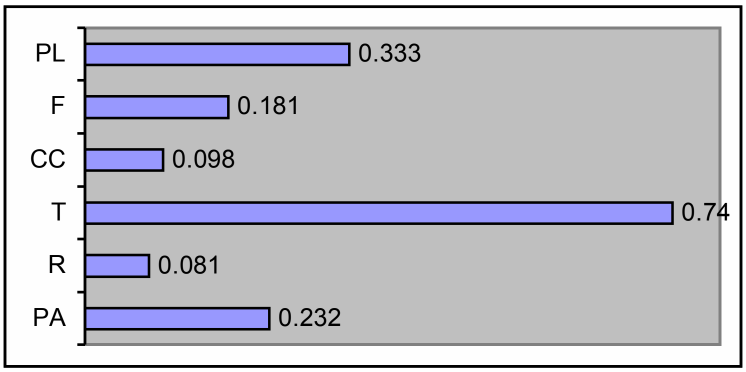

Figure 12: The relative importance of elements of level 3 with respect to SE

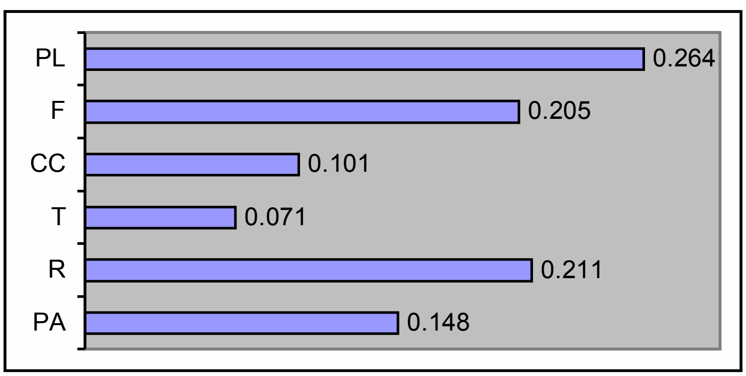

Figure13: The relative importance of elements of level 3 with respect to ULR

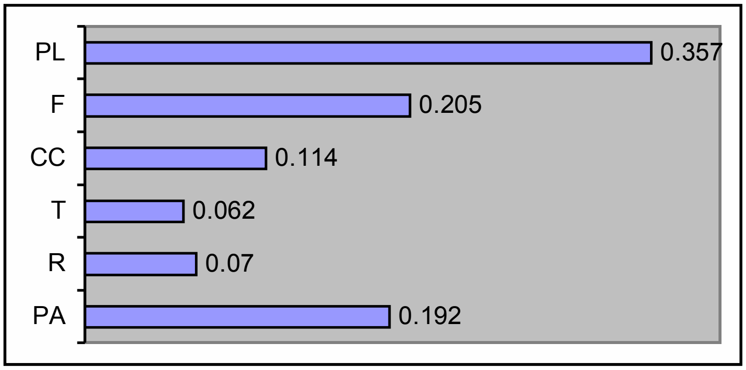

Figure 14: The relative importance of elements of level 3 with respect to NEE

5.2 Ranking of Technology Options

The ranking and evaluation of applicable technology options for each sector have been conducted by stakeholders through interviews and during the round-table meeting held during September 2002. The tables below provide the combined results of each technology option for all major economic sectors.

A. The Power Sector

Option 1: Switching to Natural Gas

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	90	Natural gas is very abundant and has low carbon content compared to fuel oil. Switching to NG in thermal power plants reduces CO_2 by about 30%.	31.5
2	Efficiency improvement and energy saving	25	82	Natural gas has combustion efficiency higher than that of equivalent oil by around 10% and resultant energy savings.	20.5
3	Investment Level	10	47	High capital investment is required initially for NG infrastructure including the construction of regional NG network.	4.7
4	Operation and maintenance cost	10	72	Operation and maintenance cost are comparable to those of liquid fuels	7.2
5	Option sustainability	10	71	Sustainability is secured by the availability of NG locally or through networking projects being constructed in the region.	7.1
6	Payback period	5	47	Average payback period could be relatively long due to the high capital investment. It also depends on the fuel availability and the cost of its transport/ storage infrastructure.	2.4
7	Societal and economic benefits	5	80	Establishment of infrastructure will create jobs and enhance NG penetration into other industries. It will also reduce imports of other fuels.	4
				Total	**77.4**

Option 2: Deployment of Combined Cycles

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	94	Combined cycles, conversion efficiencies almost double the conventional units (up to 70%), would therefore emit half the GHG	33
2	Efficiency improvement and energy saving	25	90	Combined cycles provide opportunities for energy and cost savings per kWh of generated electricity	22.5
3	Investment Level	10	51	High capital is required to deploy this option in refurbishing existing power plants.	5.1
4	Operation and maintenance cost	10	75	No substantial incremental cost will be required.	7.5
5	Option sustainability	10	72	This option is sustainable along the life span of the plant.	7.2
6	Payback period	5	55	Average payback period is between 4-5 years which is high compared to other technologies	2.75
7	Societal and economic benefits	5	45	Further increase in cooperation between neighboring countries in the field of natural gas.	2.25
				Total	**80.3**

Option 3: Technology Upgrading

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	60	Emissions reduction as a result of system upgrading could be up to 20%.	21
2	Efficiency improvement and energy saving	25	80	Modern technologies are associated with improved efficiencies and energy savings up to 35%.	20
3	Investment Level	10	68	Costs of purchasing and installing modern technologies will be relatively high.	6.8
4	Operation and maintenance cost	10	78	Operation and maintenance cost would drop with modern technologies.	7.8
5	Option sustainability	10	81	Option can be sustained throughout the plant lifetime.	8.1
6	Payback period	5	75	Payback period could be up to few of years.	3.75
7	Societal and economic benefits	5	62	Allows improving management commitment to energy saving and safety conditions in the plant.	3.1
				Total	**70.55**

Option 4: Electric Interconnection

No	Criteria element	Criteria weight (%)	Option Score (%)	Rational for scoring	Final score
1	GHG reduction	35	81	Potential GHG reduction in the range of 20-40% as a result of increased efficiencies, and the decrease of the reserve margin for individual systems without affecting system reliability.	28.35
2	Efficiency improvement and energy saving	25	87	Direct savings are expected from postponing the construction of new plants. Allows for units to operate at maximum- efficiency loads for most of the time.	21.75
3	Investment Level	10	69	Low to medium capital required for interconnection. This cost, however, will be shared by connected countries.	6.9
4	Operation and maintenance cost	10	81	O&M costs are in line with national grid requirements	8.1
5	Option sustainability	10	75	Technically, highly sustainable over the life span of over 25 years. Politically, it is prone to bilateral relations between nations.	7.5
6	Payback period	5	55	Estimated payback period of investment is relatively long.	5.5
7	Societal and economic benefits	5	80	Enhances the technical and economic cooperation between neighboring states. System reliability improves significantly. Economic benefits also result from the drop in fuel transport cost.	4
				Total	**82.1**

Option 5: Reduction of Network Losses

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	75	Reduces GHG emissions due to anticipated efficiency improvement.	26.25
2	Efficiency improvement and energy saving	25	69	Reducing the high transmission losses down to world average of around 7% will result in energy saving of the same level.	17.25
3	Investment Level	10	50	Medium–to-high capital cost investment may be required depending on the length of the line.	5
4	Operation and maintenance cost	10	85	No additional O&M costs are generally required.	8.5
5	Option sustainability	10	80	The long life span makes this option quite sustainable.	8
6	Payback period	5	70	Payback period, estimated at around 4-7 years, is short compared to the regular life span of 25 years	3.5
7	Societal and economic benefits	5	52	Improves utilities management commitment to energy savings and reduce electricity prices. It also increases the network reliability.	2.6
				Total	**71.1**

Option 6: Reducing/Phasing out Subsidies

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	77.5	Induces consumers to decrease consumption. Any reduction in fossil fuel generated electricity would result in reduced GHG emissions. Could result in a reduction of 7% of global GHG.	27.1
2	Efficiency improvement and energy saving	25	85	Consumers will tend to use electricity efficiently and modify their consumption patterns so as to make use of off-peak periods. This option also increases the competitiveness of renewable resources.	21.25
3	Investment Level	10	65	Financial burdens may affect large portion of the community. Investment in energy- efficient devices is expected on the demand side.	6.5
4	Operation and maintenance cost	10	90	No cost are associated with O&M.	9
5	Option sustainability	10	67.5	If enforced with appropriate legislation and in accordance with other reforms, the option sustainability can be maintained.	6.75
6	Payback period	5	64	Governments relieved of the financial burden of subsidies. On the demand side, payback period of energy- efficient appliances is short (up to 2 years).	3.2
7	Societal and economic benefits	5	30	Bearing the full cost of electricity may become a burden on consumers and this option may be faced with social resistance.	1.5
				Total	**75.3**

Option 7: Demand-Side Management

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	71	GHG reduction is dependent on the decrease in electricity demanded The saving achieved is however case specific.	24.85
2	Efficiency improvement and energy saving	25	75	DSM can have significant impact on reducing electricity consumption, which may avoid or delay the need to construct additional capacity with potential GHG reduction.	18.75
3	Investment Level	10	79	Many DSM programmes involve a combination of energy efficiency and conservation measures that result in low- and no cost mitigate options.	7.9
4	Operation and maintenance cost	10	77.5	Low costs will be needed for maintaining the DSM tools.	7.75
5	Option sustainability	10	56	Option sustainability requires long-term planning.	5.6
6	Payback period	5	52.5	Varies according to the specific DSM programme to be implemented and the targeted sector. Average period may vary between 1 to 3 years.	2.6
7	Societal and economic benefits	5	70	DSM programs have been consistent with the national developments in many countries. New job opportunities are created.	3.5
				Total	**70.95**

Option 8: Partially Switching to Renewable Energy (SRE)

No	Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
1	GHG reduction	35	95	GHG saving will vary according to the decrease in electricity demanded The saving achieved is however case specific.	33.25
2	Efficiency improvement and energy saving	25	75	SRE can have significant impact on reducing electricity consumption, which may avoid or delay the need to construct additional capacity with potential GHG reduction.	18.75
3	Investment Level	10	50	Many SRE programmes involve a combination of energy efficiency and conservation measures that result in low- and no cost mitigate options.	5
4	Operation and maintenance cost	10	70	Costs are equivalent to other conventional technologies.	7
5	Option sustainability	10	75	Option sustainability can be maintained throughout the technology life time.	7.5
6	Payback period	5	50	Varies according to the specific SRE programme to be implemented and the targeted sector (industrial, residential, commercial). Average period may vary between 2 to 5 years.	2.5
7	Societal and economic benefits	5	60	SRE programs have been consistent with the national developments in many countries. New job opportunities are created.	3
				Total	**77**

A.1 Summary of technology options ranking in the power sector.

Option	**Overall Score**
Electric Interconnection	**82.1**
Deployment of Combined Cycles	**80.3**
Switching to Natural Gas	**77.4**
Partially Switching to Renewable Energy	**77**
Recycling/phasing out Subsidies	**75.3**
Reduction of Transmission losses	**71.1**
Demand-Side Management	**70.95**
Technology Upgrading	**70.55**