Chapter Four

Technology Needs Assessment and Technology Transfer for Lebanon

The proposed steps/ activities needed to implement TNA and TT can be initiated by forming institutional arrangements followed by TNA and TT. Implementation is as described below.

4.1. Forming Institution Arrangements

The formation of institutional arrangements to facilitate technology needs assessment and technology transfer may be done according to Figure 5. Detailed discussion on each block is presented below.
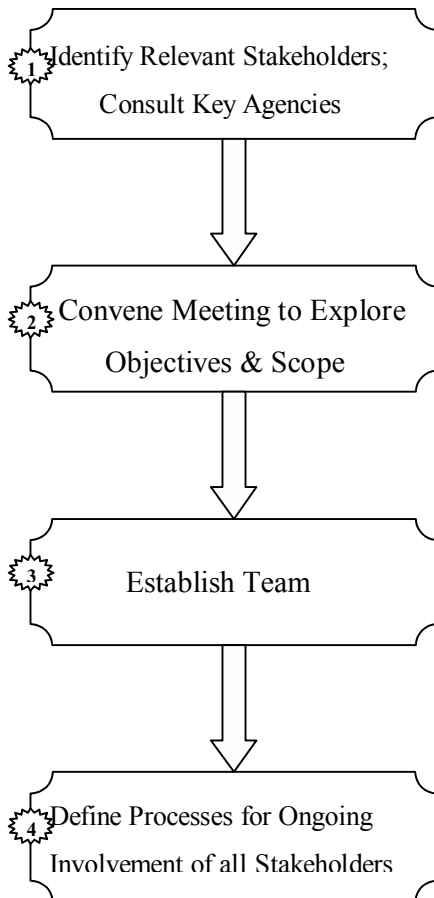

Figure 5: Forming institution arrangements

Block 1: Identify Relevant Stakeholders; Consult key Agencies

The technology transfer process must be country driven in order to identify and treat local concerns and to ensure commitment of relevant stakeholders. In this respect, and based on the findings of Lebanon's first national communication under the UNFCCC, several economic sectors have been identified as being significant in terms of GHG emissions and key elements in the national economy. These sectors are the electric power, transport, building, industry, and waste treatment sector. In order to get a feedback on technology needs in each sector as well as decision criteria, constraints and policy instruments needed to accelerate the transfer of technology to the country, each of the above sectors was represented by one or several experts such as government officials, directors, consultants, academics, active NGOs and relevant international agencies (See Appendix).

Block 2: Convene Meeting to Explore Objectives and Scope

Individual interviews/meetings have been carried out with the identified stakeholders with the purpose of exploring objectives and scope of the project as well as to get feedback on priority technology options in each sector and national policy to be adopted for the acceleration of the technology transfer process. The discussion also covered adaptation strategies.

Block 3: Establish the Core Team

After individual interviews/meetings with the various sectors representatives, a brain-storming meeting has been scheduled to expose sectors representatives to the technological options identified in all sectors and to unify the rather conflicting opinions regarding the establishment of the national policy on technology transfer. This leads to refining the opinions collected prior to starting the analysis using the Analytic Hierarchy Process (AHP) and performing technology ranking analysis (See section 4.3). The meeting should also lead to establishing a core team for project follow-up.

Block 4: Define Processes for Ongoing Involvement of all Stakeholders

During this meeting a framework for ensuring project sustainability should be recommended and ongoing involvement of all stakeholders is the corner stone in TNA and TT sustainability.

4.2. The Technology Need Assessment Process

The TNA process proposed for the country meets the guidelines established by UNFCCC, as described in chapter 1. Figure 6 presents a block diagram of the relevant steps.
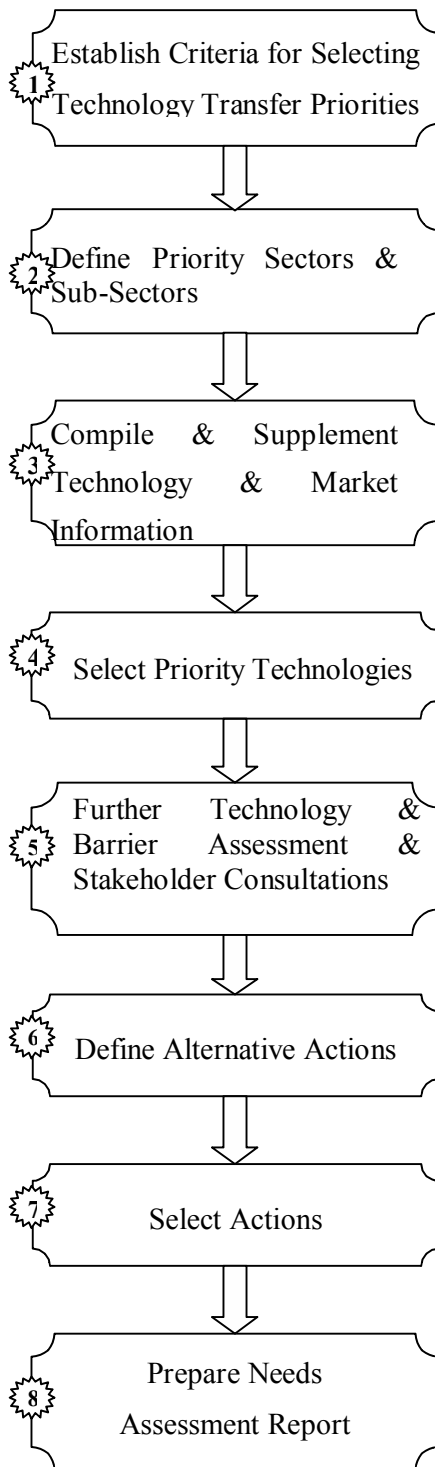
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        ┌─────────────────────────────────┐
        │ Establish Criteria for Selecting │
      (1)│ Technology Transfer Priorities  │
        └─────────────────────────────────┘
                        │
                        ▼
        ┌─────────────────────────────────┐
        │ Define  Priority  Sectors  &    │
      (2)│ Sub-Sectors                     │
        └─────────────────────────────────┘
                        │
                        ▼
        ┌─────────────────────────────────┐
        │ Compile  &   Supplement         │
      (3)│ Technology   &   Market         │
        │ Information                     │
        └─────────────────────────────────┘
                        │
                        ▼
        ┌─────────────────────────────────┐
      (4)│ Select Priority Technologies    │
        └─────────────────────────────────┘
                        │
                        ▼
        ┌─────────────────────────────────┐
        │ Further   Technology   &        │
      (5)│ Barrier   Assessment   &        │
        │ Stakeholder Consultations       │
        └─────────────────────────────────┘
                        │
                        ▼
        ┌─────────────────────────────────┐
      (6)│ Define Alternative Actions      │
        └─────────────────────────────────┘
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                        ▼
        ┌─────────────────────────────────┐
      (7)│ Select Actions                  │
        └─────────────────────────────────┘
                        │
                        ▼
        ┌─────────────────────────────────┐
        │ Prepare Needs                   │
      (8)│ Assessment Report               │
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Figure 6: The need assessment process

The Need Assessment process proposed for Lebanon falls into 8 levels or blocks as described below:

Block 1: Establishment of Criteria for Selecting Technology Transfer Priorities

Technology needs assessment is to be done under two systematic approaches. The first approach identifies criteria for technology inventory in every sector identified as priority sector, and the second approach uses a decision analysis technique in order to establish a national policy to help accelerate and smoothly achieve technology transfer in these sectors. In this work, the decision analysis tool used is the Analytic Hierarchy Process (AHP).

In the AHP model, the three decision criteria selected for justifying the support for technology transfer are development benefits, market potential and contribution to climate change response goals. With respect to development benefits national efficiency improvement and energy savings under the same category considering social equity and use of local resources. With respect to Implementation/Market Potential the criteria here is stimulate market growth, local and foreign investment and sustainability. While with respect to the contribution to climate change response goals, we observe the reduction potential of GHG as the main objective.

As to constraints, six categories have been considered. These are (1) the adequacy of local policies and legislation, and more importantly the enforcement of law, (2) the availability of funding whether from local/international investors, government money, and international donor agencies, (3) commerciality and competitiveness also is an important constraint as the inability to market and sell the proposed technology will eventually lead to its phase-out. (4) adequacy of local resources is another critical constraint as Lebanon must have developed supportive institutions including appropriate industrial bases for provision of technical support, suitable human expertise, etc. (5) immaturity of technology as a successful technology transfer must promote proven and well established technologies. The promotion of technologies with failing characteristics and/or non attracting economic return will negatively affect the transfer of other technologies. Finally, (6) public awareness is a very important constraints and needs to be increased on the level of all stakeholders including ordinary citizens, government officials, manufacturers, etc….

The last step in the national policy for accelerating the technology transfer process is the adoption of one or more policy instruments that lead to an effective technology transfer. The policy instruments recommended are (1) setting of appropriate laws and regulations, (2) establishment of market based programs that mainly entail introduction of taxes or provision of incentives, (3) effective engagement of the private sector, and (4) effectively benefiting from the work programs of NGOs and international donor agencies.

Block 2: Definition of Priority Sectors & Sub-Sectors

Based on Lebanon's first national communications under the UNFCCC, the following sectors are identified: The transport sector, the electric power sector, the industry sector, the buildings sector and the waste sector. As for adaptation on climate change the water and forestry sectors were also considered in the priority list.

Block 3: Compile & Supplement Technology & Market Information, and
Block 4: Select Priority Technologies

The considerations that fall under these blocks include provision of summary of alternative climate change response technologies, development benefits, implementation and investment potential, contribution to climate change response goals, information on technology performance & costs, identification of implementation barriers, existing and planning programs designed, and recommendation on how to facilitate the widespread of the recommended technologies. All of this information can be found Lebanon's first national communications under the United Nations Framework Convention on Climate Change, some ESCWA and GEF studies. A brief about the status of each of the considered sectors together with the issues raised above has been compiled for the purpose of this project.

Block 5: Further Technology, Barrier Assessment & Stakeholder Consultations, and
Block 6: Define Alternative Actions

Four points are considered: (1) Identification and analysis of specific barriers to achieve the full implementation of technology transfer, (2) Evaluation of effectiveness of Lebanon's and donor programs and their anticipated impact on technology transfer, (3) identification of specific opportunities to accelerate implementation such as private and public investments, market based programs, etc. and (4) the identifications of potential actions to facilitate implementation. All of these activities have been entertained in the AHP analysis mentioned above and are in the agenda of the meetings scheduled with stakeholders.

Block 7: Select Actions
At this level, the selection of the highest priority actions is to be considered. This can now be achieved because of the good knowledge of country priorities and needs, variety of options and actions that can be used to achieve effective technology transfer and sectoral information available from existing documents and interaction with stakeholders. A good synthesis is now needed to prioritize options and actions.

Block 8: Technology Needs Assessment Report
The assessment report must include (1) an overview of TNA and TT in other countries as well as summaries of methodologies recommended by the United Nations, (2) a description of the status of the various sectors of interest, (3) Lebanon's approach to TNA and TT, (4) results and recommendations of undertaken studies for technology transfer. This should provide the priority technologies and proposed implementation actions, key implementation Barriers, integration with the existing development programs, and key recommendations for implementation on national level.

4.3. Preparing and Implementing Technology Transfer Actions and Plans

The plan proposed for preparing and implementing TT actions and plans, shown in Figure 7, constitutes six major steps (blocks).
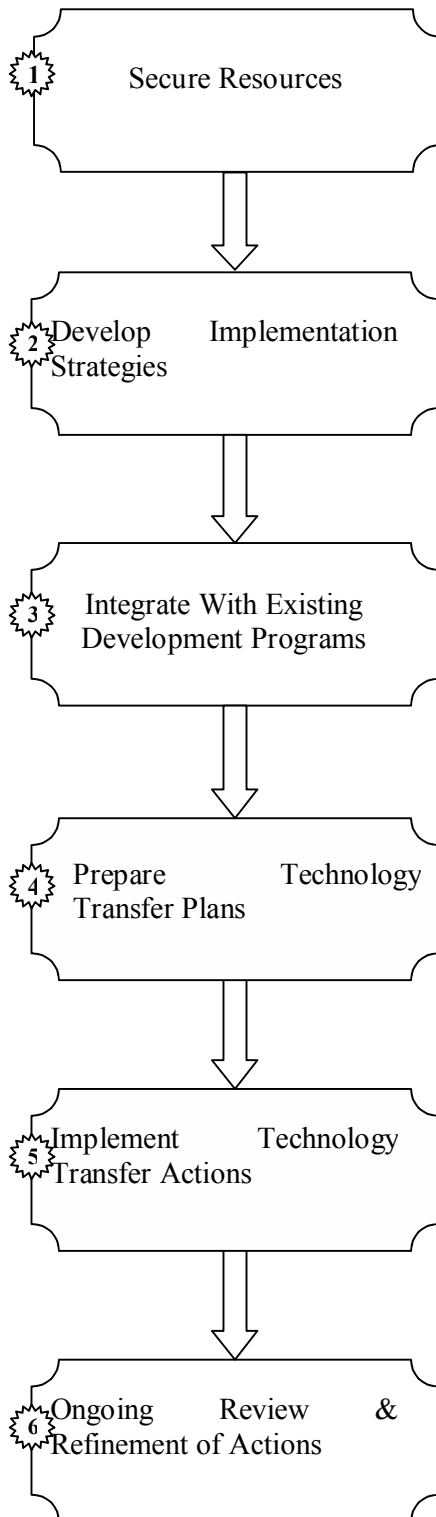
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┌─────────────────────────────────────┐
│ ✦1        Secure Resources          │
└─────────────────────────────────────┘
                    ⇓
┌─────────────────────────────────────┐
│ ✦2 Develop        Implementation    │
│    Strategies                       │
└─────────────────────────────────────┘
                    ⇓
┌─────────────────────────────────────┐
│ ✦3  Integrate With Existing         │
│     Development Programs             │
└─────────────────────────────────────┘
                    ⇓
┌─────────────────────────────────────┐
│ ✦4  Prepare           Technology    │
│     Transfer Plans                  │
└─────────────────────────────────────┘
                    ⇓
┌─────────────────────────────────────┐
│ ✦5 Implement        Technology      │
│    Transfer Actions                 │
└─────────────────────────────────────┘
                    ⇓
┌─────────────────────────────────────┐
│ ✦6 Ongoing       Review       &     │
│    Refinement of Actions            │
└─────────────────────────────────────┘
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Figure 7: Preparing and implementing technology transfer actions and plans

Block 1: Secure Resources

Securing resources requires working with donor organizations and domestic agencies, and leveraging new resources with existing country, donor and stakeholder programs. For this specific purpose, short meeting sessions have been planned with local financing agencies, mainly banks, and relevant international donor/lending agencies including the World Bank, UNDP, EU, USAID, etc. Such meeting sessions are expected in the final workshop scheduled end of October 2002.

Block 2: Develop Implementation Strategies

The implementation strategy recognizes three levels of intervention. The first level entails identification and prioritization of decision criteria that justify and support actions to facilitate technology transfer. The second level sets the constraints and barriers that must be analyzed and overcome to enable technology transfer to the various sectors. Finally, the third level recommends a set of policy options which must be adopted individually or collectively to ensure short and long term transfer of technologies.

The finalization of such a strategy requires interaction with stakeholders first individually in the form of interviews and second in the form of a brain storming sessions to be organized at a later stage.

Block 3: Integrate With existing Development programs and **Block 4:** Prepare Technology Transfer plans

Effectively integrate implementation regarding technology transfer with other national, and/or international development programs. It is anticipated that integration will be mainly with UNDP, IPP projects, technology related projects controlled by the CDR and anticipated plans on privatization.

Block 5: Implement Technology Transfer Actions, and **Block 6:** Ongoing Review and Refinement of Actions

Blocks 5 and 6 consist of implementation of the technology transfer plan, ongoing assessment and refinement of climate change technology transfer, implementing refinements, and developing new actions. A follow-up committee from all stakeholders will be formed to ensure implementation and project sustainability.

4.4. The Analytic Hierarchy Process (AHP)

The AHP was first developed by Professor Thomas L Saaty in the 1970s [Saaty, 1980] and since that time it has been widely applied in a variety of areas. Among these areas are the complex decisions in arms control, transport systems, and conflict analysis. The AHP has been accepted by the international scientific community as a very useful tool for dealing with complex decision problems. In addition many corporations and governments routinely use the AHP for major policy decisions.

4.4.1. The Philosophy of AHP

The AHP is an intuitive and relatively easy method for formulating and analyzing decisions. The three major concepts behind the AHP are: analytic, hierarchy, and process.

- Analytic

The AHP uses numbers. In holistic decision making no numbers are needed in order to reach a decision; simply the alternative that is most desired is chosen. However there are good reasons for using mathematics to understand and/or describe this choice. In this sense, all methods, which seek to describe it decision, are analytic, since they must use mathematical/logical reasoning.

- Hierarchy

It is a particular type of system, which is based on the assumption that the entities, which we have identified, can be grouped into disjoint sets, with the entities of one group influencing the entities of only one other group, and being influenced by the entities of only one other group. The elements in each group (level) of the hierarchy are assumed to be independent.

Hierarchies were not invented in corporation and governments to take care of their affairs. They are basic to the human way of breaking reality into clusters and sub clusters. To illustrate this we take again the case at hand: we are trying to find "a most appropriate" solution, among many others, to the technology transfer process for

Lebanon, in order to achieve a smooth and effective transfer, taking into consideration the various factors and constraints that are encountered while implementing such task.

The problem is structured into a hierarchy by decomposing it into levels; starting from the overall objective (acceleration of technology transfer process), down to sub objectives that we call decision criteria (like enhancing the development benefits, strengthening the market potential and improving environmental quality), down to the constraints that affect these sub objectives (legislations, funding, status of technology, etc) and finally down to the strategies that could be implemented (updating laws and regulations, increasing the participation of private sector, …etc). The though hierarchy will then look as shown in Fig.3.
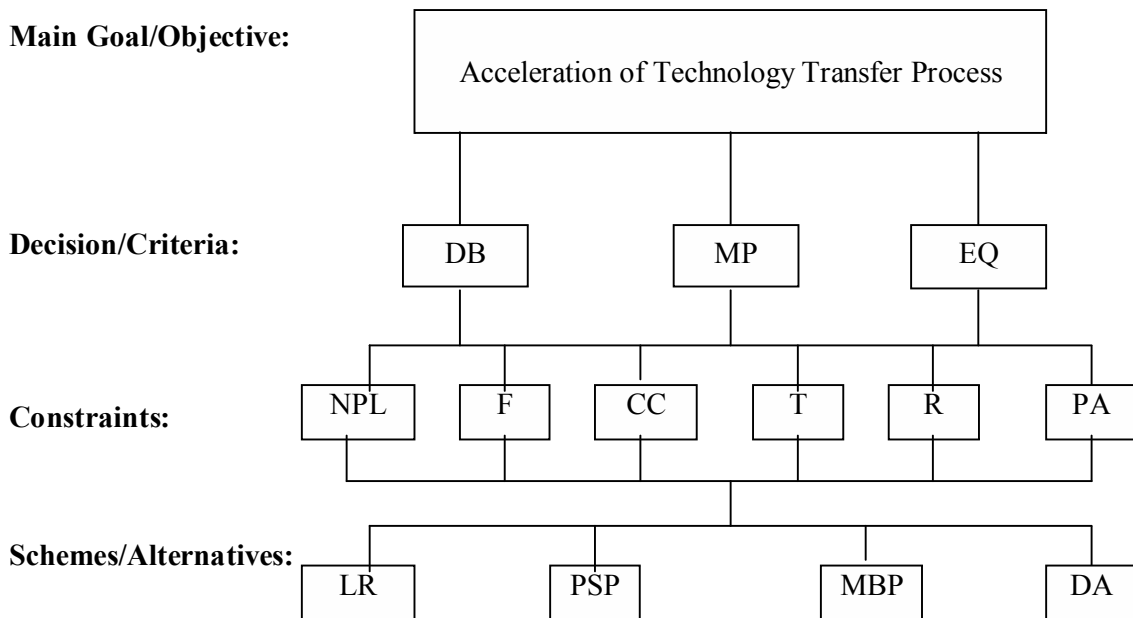
Figure 8: AHP block diagram

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In the above hierarchy, in level 2: DB is Development Benefits,
MP is Market Potential, and
EQ is Environmental Quality.

In level 3, NLR is Adequacy of National Policies and Legislation,
F denotes Availability of Funding,
CC is Commerciality and Competitiveness,
T is Immaturity of Technology,
R A is adequacy of Resources and,
PA is Public Awareness.

In level 4, LR is used to denote Laws and Regulations,
PSP is Private Sector Participation,
MBP is Market Based Programs and,
 DA represents NGOs and International Donor Agencies.

It is evident that components of each level interact with components of the level above and below.

The established hierarchy is not by itself sufficient for us to make a decision; there is a need to know the intensity of the influence of the elements in one level on elements in the next higher level, so that the impact of the lowest level on the highest level (Objective) can be determined. This is done through pairwise comparisons.

4.4.2. Process

Any real decision problem involves a process of learning, debating and revising priorities. The AHP is meant to be a tool to aid and shorten this decision process through the insights, which this method can generate; it has never and will never replace the overall decision process. The AHP points to where more information is needed, where major points of disagreement lie etc. If the outcome of the process appears unsatisfactory i.e. not to represent feelings accurately a decision-maker may return to the hierarchy to see if any true feelings have been misrepresented, or it may be that intuitive feelings will change after considering the problem in detail. This process is unavoidable and is in fact quite healthy; the AHP is meant to aid and not destroy this natural process of decision-making.

Pair Wise Comparison

Elements of a certain level are compared in pairs with respect to their relative impact (weight) on a property they share in common, in this case an element of the next higher level. For example, in the proposed hierarchy, criteria of level 2 can be compared with respect to their influence on accomplishing the overall objective in level 1: the question to be asked is: "For accelerating the technology transfer process, how does the Environmental element compare with the social one? With the market element? And with the developmental factors? Then, how does Market Potential compare with Environmental, and with Social Element?" and so on, until every element is compared with other elements in the same level, which influence a common element of the upper level.

These pair wise comparisons are reduced to a matrix form, which is a square array in which numbers are arranged in rows and columns as shown below:

$$
\begin{array}{c}
\\
A_1 \\
A_2 \\
A_3 \\
. \\
. \\
. \\
A_n
\end{array}
\begin{array}{ccccc}
A_1 & A_2 & A_3 & & A_n \\
\left(\begin{array}{ccccc}
a_{11} & a_{12} & a_{13} & \ldots & a_{1n} \\
a_{21} & a_{22} & a_{23} & \ldots & a_{2n} \\
a_{31} & a_{32} & a_{33} & \ldots & a_{3n} \\
. & . & & & \\
. & . & & & \\
. & . & & & \\
a_{n1} & a_{n2} & a_{n3} & \ldots & a_{nn}
\end{array}\right)
\end{array}
$$

where

$A_1 \ldots A_n$ is a set of n elements that are compared to each other, and a_{ij} is the relative importance or weight w of element i over element j with respect to the common criterion. ($a_{ij} = w_i/w_j$). It is important to note that $a_{ji} = 1/a_{ij}$ (reciprocal).

When problems are structured hierarchically, a matrix is arranged to compare the relative importance of criteria in the second level with respect to the overall objective of the first level. Similar matrices are constructed for pair wise comparisons of factors in the third level with respect to the criteria in the second level. The matrix is set up by providing the "comparison criterion" above and listing the elements to be compared on the left and top of the matrix. For example in the hierarchy presented above, the pair wise comparison matrix for level 2 with respect to level 1 is achieved by:

	NEE	ULR	SE	MP	EQ
NEE	1				
ULR		1			
SE			1		
MP				1	
EQ					1

Similarly, comparing elements in level 3 with respect to level 2, we get pairwise comparison matrices for level 3 with respect to each element of level 2. Namely:

- Relative to development benefits:

	NPL	F	CC	T	R	PA
NPL	1					
F		1				
CC			1			
T				1		
R					1	
PA						1

- Relative to market potential:

	NPL	F	CC		R	PA
NPL	1					
F		1				
CC			1			
T				1		
R					1	
PA						1

-   Relative to environmental quality:

	NPL	F	CC		R	PA
NPL	1					
F		1				
CC			1			
T				1		
R					1	
PA						1

In the same manner, matrices are constructed to compare elements of level 4 with respect to each element of level 3.

In the above matrices, we considered that every element of one level is influenced by all elements of the level below. In this case the hierarchy is called "complete". This is not always true though. Some factors could affect one element of the level above without having any influence on another element, in which case the hierarchy is "incomplete".

4.4.3. Need for a Scale of Comparison

Having formed these matrices, the next step is to fill them in with the appropriate weights or scales "W". The process begins with an element "A" on the left of the matrix and ask how much more important it is than an element listed on the top of the matrix "B". When an element is compared with itself, the ratio is obviously 1, hence the diagonal in the comparison matrix has all values as 1. As mentioned previously, the values in the lower triangle of the matrix (lower side of the diagonal) are the reciprocals (W_B/W_A) of those in the upper triangle (W_A/W_B). Hence it is enough to find the weights of the upper triangle and deduct the values in the lower triangle. Therefore the total number of comparisons needed to fill a matrix of size n is n(n-1)/2.

Now, how do we deal with non-measurable entities like social, political, emotional factors, where no units like dollars, miles or kilograms exist?

Taking again the example of A and B above, what can be done (when we do not know their weights such as in Kg) is take each one in one hand and try to "feel" their relative weights. Or we might pick them up sequentially with the same hand to avoid bias in our judgment. On such basis, we cannot state that A is so and so Kg heavier than B for example, but we would be able to say that A is "slightly heavier", "much heavier" or "absolutely heavier" than B. Similarly, when we compare the relative importance of intangible factors, we could legitimately state that one is more important or much more important…etc depending on our preferences and feelings. [Analytical planning the organization of systems, T. Saaty and K. Kearns p. 26]

4.4.4. Recommended Scale of Relative Importance

A scale that has been validated for effectiveness in many applications through a number of people, and also through theoretical comparisons with a large number of other scales, is illustrated in Table 14.

Table 14: Scale of relative importance

Intensity of relative importance	Definition	Explanation
1	Equal importance	2 activities contribute equally to the objective
3	Moderate importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance of one over another	Experience and judgment strongly favor one activity over another.
7	Demonstrated importance of one over another	An activity is strongly favored and its dominance is demonstrated in practice
9	Extreme importance of one over another	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the 2 adjacent judgments	When compromise is needed
Reciprocals	if importance of A over B (A/B) is 3 then B/A is 1/3	

The justification of using the 1 to 9 values is outside the scope of this report but can be found in [Saaty, 1980]

The AHP method can be described as follows:

Given the elements of one level, say the 3rd, of a hierarchy, and one element "e" of the next higher level (2nd). Compare the elements of level 3 pairwise in their strength of influence on "e". Insert the agreed upon numbers, reflecting the comparison, in a matrix and find the eigenvector with the largest eigenvalue. The eigenvector provides the priority ordering, and the eigenvalue is a measure of the consistency of the judgment. The following steps illustrate the method:

1. Define the problem and determine what you want to know.

2. Structure the hierarchy from the top (the objectives) through the intermediate levels (criteria on which subsequent levels depend) to the lowest level (usually a list of the alternatives).

3. Construct a set of pairwise comparison matrices for each of the lower levels-one matrix for each element in the level immediately above. An element in the higher level is said to be a governing element for those in the lower level that contribute to it or affect it. The elements in the lower level are then compared to each other based on their effect on the governing element above. This yields a square matrix of judgments expressed as integers from 1 to 9. If element A dominates element B, then the whole number is entered in row A, column B, and the reciprocal (fraction) is entered in row B, column A. if A and B are judged to be equal, a "1" is assigned to both positions.

4. There are n(n-1)/2 judgments required to develop each matrix in step 3. (Reciprocals are automatically assigned)

5. Having made all the pairwise comparisons and entered the data, the consistency is determined using the eigenvalue. The consistency index is tested then using the departure of λ_{max} from n compared with corresponding average values for random entries yielding the consistency ratio C.R.

6. Steps 3, 4, and 5 are performed for all levels in the hierarchy.

7. Hierarchical synthesis is now used to weight the eigenvectors by the weights of the criteria and the sum is taken over all weighted eigenvector entries corresponding to those in the next lower level of the hierarchy.

8. The consistency of the entire hierarchy is found by multiplying each consistency index by the priority of the corresponding criterion and adding them together. The result is then divided by the same type of expression using the random consistency index corresponding to the dimensions of each matrix weighted by the priorities as before. The consistency ratio (C.R.) should be about 10% or less to be acceptable. If not, the quality of the judgments should be improved.

4.4.5. Building our AHP Model: The Hierarchy

Having explored all the variables that affect the technology transfer process and introduced the AHP method, we now formulate our problem through a hierarchy, in the way explained earlier.

Level 1: Main Objective

Our main objective is to accelerate the technology transfer process on a national scale. This will be the top level of our hierarchy: "Acceleration of Technology Transfer".

Next, we have to address the criteria that affect this main objective by trying to solve the problems rendering it poor, and to capitalize on the issues that improve it.

Level 2: Decision Criteria

We have identified three main elements that directly affect the transfer of technology. We put them in the next level after breaking each element into its various components. These are development benefits (DB), market potential (MP) and environmental quality (EQ).

Development Benefits: As exposed earlier, the identification of priority technologies requires a view of the contribution that new technologies in different sectors might bring to social, environmental and development goals. It also requires that the cost effectiveness in terms of the possible high investments on new and alternative technologies be considered.

Looking closely into this issue, we find that national development is realized through (1) national economy efficiency (NEE), (2) use of local resources (ULR) and (3) social equity (SE).

- *NEE* are benefits that can be realized by utilizing high efficiency technologies in the various sectors of economy including residential, industrial, electricity generation and transport sectors.

- *ULR.* An important aspect for national development is the transfer of appropriate technologies that harness local national resources such as wind

and solar , and provide job opportunities for the qualified human resources as to enhance capacity buildings in technological upgrades.

- ***SE*** is at the heart of government policies. Equity can be a decisive element in technology transfer such as in transport where a cheap and reliable transport should be available to all citizens even in the most remote and rural areas. Also, the provision of electricity, health services, improvement of women work conditions are all important aspects of equity that technology transfer should address.

Market potential Any new technology should offer the potential to answer several market concerns including justifications for any additional capital and operating costs relative to alternatives, commercial availability, social acceptability and sustainability for country conditions and replicability and potential scale of utilization.

Environmental quality is a major decision criteria, the following issues influence largely the decision concerning EQ:

    i.   GHG emissions reduction potential
   ii.   Adaptation potential
 iii.   Enhancement of CO_2 sinks

Level 3: Factors/Constraints

While trying to improve the performance by acting on the various criteria, some other factors (or attributes) are to be taken into consideration, as they affect our ability to act on some or all of the problems: these are the possibilities available for us to use, or the constraints that limit our actions. They are divided into Legislative, economic, social, technological, marketing and infrastructure.

Policies and Legislatives: These are the conditions that greatly affect our actions for they can be the real barriers, some are the following: Regulations and standards that preclude new technologies, distorting market interventions such as subsidies for polluting industries, regulated markets that create disincentives for new technologies,

planning system issues, etc. On the other hand, the practical application of existing laws is an important factor that must be enforced and respected.

Availability of Funding. New technologies are capital intensive, even if operating and lifetime costs are low, potential investors may lack the financial resources required to bear the upfront cost.

Commerciality and Competitiveness. CC is one of the main barriers of accelerating the technology transfer process. CC is influenced by the monopoly powers that reduce incentives to innovate and erect barriers to new entrants and dominant interests that erect barriers to new entrants and may discourage innovation.

Immaturity of technology also known as information barrier, this may take several forms; the simplest is where potential purchasers are ignorant of new technology possibilities. They may also be faced with multiple and conflicting information and have limited ability/time to absorb it, and choose a known option in preference to new alternative.

Adequacy of Resources The transfer of new technologies requires the existence of supporting infrastructure. For example, testing laboratories, skilled labor for regular maintenance, and availability of local manufacturing facilities to support minor modifications and spare parts are all important elements for a successful technology transfer process.

Public Awareness and appropriate educational system have made a major barriers hindering the widespread of cost-effective new technologies. Awareness about the benefits that new technologies offer as well as the provision of alternatives are very important for facilitating acceptance of new technological options. Cultural and societal barriers are also important and need to be addressed.

The above factors constitute the 3rd level of our hierarchy, while the 4th and lowest level lists the policy options or alternatives that could be adopted on a national scale to facilitate technology transfer. These options need to be studied and compared in order to set the best possible scenario for an effective transfer of technologies.

Level 4: Policy Alternatives

Laws and Regulations. The introduction of new laws and regulations might constitute a solution to technology transfer. Examples include alleviation of tax import on certain products, enforcing a ban on certain fuel (e.g. leaded fuel in 2002), restructuring of certain sectors and ministries (e.g. the merging of Ministry of hydro-electric resources and Ministry of petroleum into one ministry which is the Ministry of energy and water)

Private Sector participation. The private sector in Lebanon has been the driving force in national economy. Finding ways to ensure private sector participation in technology related projects would be crucial to ensure effective technology transfer process.

Market based Programs such as incentives to acquire new technologies and taxing polluters. (e.g. the tax of about 1000 Lebanese pounds on leaded fuel has led to phasing out this product completely from the market in less than one year !)

NGOs and International Donor Agencies The work of NGOs and international donor agencies has been very useful and important to the country. Several projects were executed by UNDP, EU, USAID, local NGOs and other regional and international organizations. A systematic approach to progress achieved by these organizations is needed in order to get the utmost benefits of their work.

The hierarchy to be used for examining technology transfer for Lebanon is now complete and is shown on the next page.

For convenience, we use some abbreviations of the various elements, as shown:

Level 1: National Objective

1. Accelerate the technology transfer process
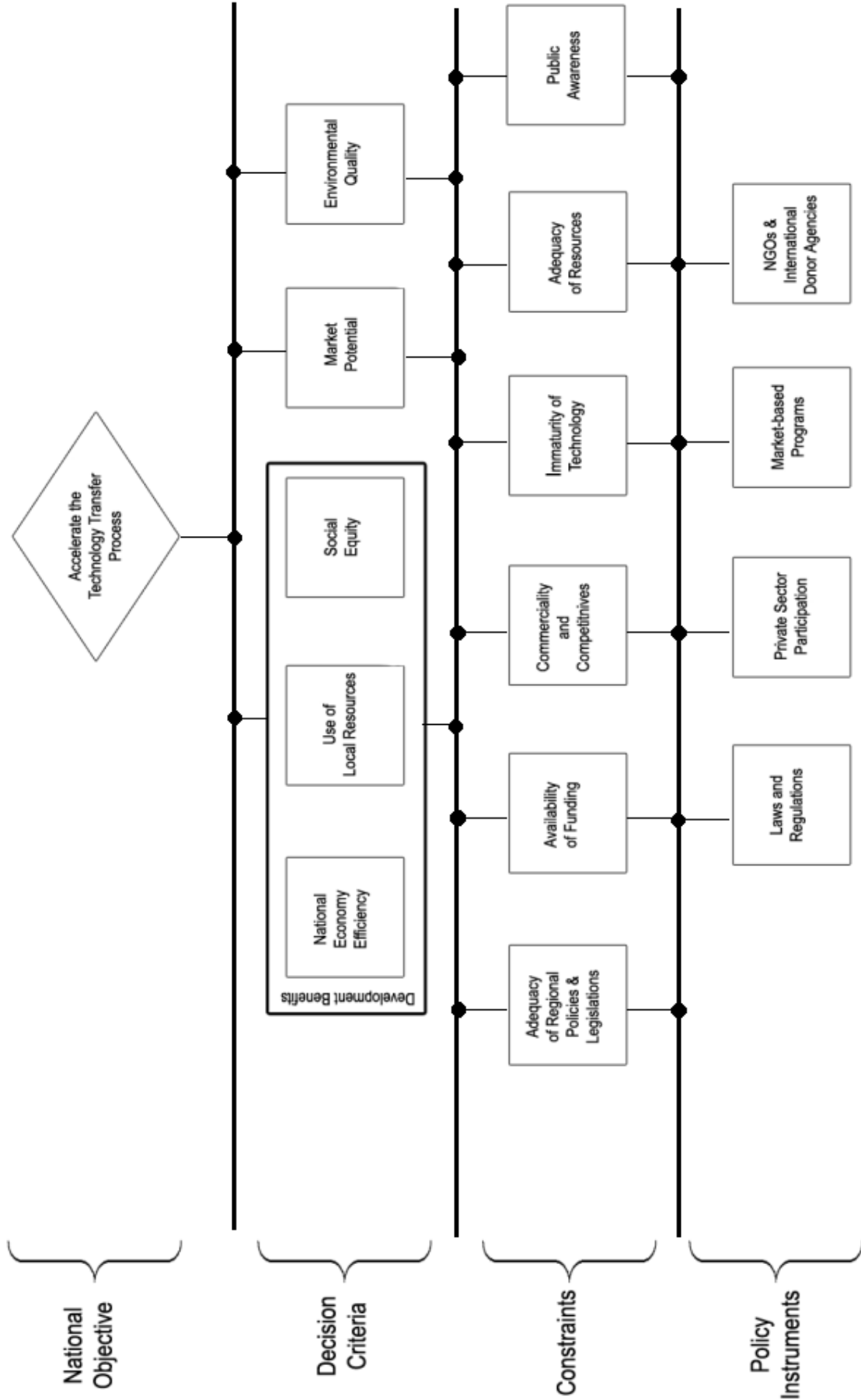
Level 2: Decision Criteria

1. Development Benefits		DB
	a. National Economy Efficiency	NEE
	b. Use of local Resources	ULR
	c. Social Equity	SE
2. Market Potential		MP
3. Environmental Quality		EQ

Level 3: Constraints

1. Adequacy of National Policies and Legislations	RPL
2. Availability of Funding	F
3. Commerciality and Competitiveness	CC
4. Immaturity of Technology	T
5. Adequacy of Resources	R
6. Public Awareness	PA

Level 4: Policy Instruments

1. Laws and Regulations	LR
2. Private Sector Participation	PSP
3. Market Based Programs	MBT

National Objective

Decision Criteria

Constraints

Policy Instruments

Accelerate the Technology Transfer Process

Environmental Quality

Market Potential

Development Benefits
- National Economy Efficiency
- Use of Local Resources
- Social Equity

Public Awareness

Adequacy of Resources

Immaturity of Technology

Commerciality and Competitinives

Availability of Funding

Adequacy of Regional Policies & Legislations

NGOs & International Donor Agencies

Market-based Programs

Private Sector Participation

Laws and Regulations

4.5. The Decision Matrices for Technology Needs Assessment and Technology Options Ranking

To conduct an evaluation/ranking process for various mitigation options in Lebanon a number of criteria has been adopted in a manner similar to that applied by recent ESCWA studies [ESCWA, 2001]. Based on the analysis conducted for the economic sectors, as described in Chapter 3, decision matrices have been designed based on seven selected criteria for evaluating and ranking mitigation options applicable for each of the sectors.

4.5.1. Criteria Elements

The selected criteria include the GHG reduction potential, impacts related to efficiency improvement and energy savings, capital and operation costs and the payback period, option sustainability, and other non- environmental impacts. In what follows is a listing of the criteria elements and the percentage weight assigned for each element with brief justification.

a) GHG reduction potential. Being the main objective of the TNA and TT tasks, this criterion is given the highest weight of 35%.

b) Efficiency improvement and energy saving. Energy saving and system efficiency improvement is also an important criterion since it leads to further benefits such as energy conservation and lower operation and maintenance costs. A weight of 25% is given for this criterion.

c) Capital investment. The cost of various technologies plays a significant role in its acceptance and wide spread especially in developing economies. Many of the options will require substantial investment for the purchase of equipment and equipments, establishment of infrastructure, introduction of new technologies, and training. This criterion has been assigned a weighting of 10%.

d) Operation and maintenance costs. These periodic costs are associated with running and sustaining emission-reduction measures after initial implementation. This criterion has been assigned a weighting of 10%.

e) Option sustainability. Options that can financially generate their own momentum tend to be self-sustaining. This criterion has been also assigned a 10% weighting.

f) Payback period. Profitable GHG mitigating options offer an attractive alternative for investments. Since it has been partially accounted for in the energy savings option, the weight assigned for this criterion is 5%.

g) Societal and economic benefits. Several options under consideration have the potential to deliver other non- environmental economic and social benefits in addition to reducing GHG emissions. Here also these benefits are partially accounted in the energy saving criterion, hence, a 5% weight has been assigned.

4.5.2. Mitigation Options

The evaluation process is performed by specifying a number of mitigation options for each sector such that:

In the Power sector: switching to natural gas, deployment of combined cycle, technology upgrading, electric interconnection, reduction of network losses, reducing/phasing out subsidies, demand side management, and partial switching to renewable energy.

In the Transport sector: improving the technical status of the fleet, improving traffic management, promoting mass transport, enforcing environmental standards and regulation, urban planning and land use, and switching to alternative fuels (natural gas).

In the Industry sector: switching to natural gas, energy- efficient systems, cogeneration, boiler improvement, and efficient motors.

In the Waste sector: wide- spread of composting, landfills, adopting anaerobic and aerobic digestion, and promoting the concept of reduce/reuse/recycle.

In the Building sector: building envelope, technology upgrading, solar heating water systems, and efficient lighting.

The criteria elements and the corresponding weights are unified for all sectors. Each criteria element is given a score which when multiplied by the criteria weight will give a final score for the element. A brief rationale for each score is also noted. The total score for each mitigation option is then obtained as the sum of the scores of all criteria elements. A sample of this evaluation process is shown in Table 15.

Table 15: A sample of the mitigation options ranking matrix.

Criteria element	Criteria weight (%)	Option score (%)	Rational for scoring	Final score
GHG reduction	35	86	Transport sector contributes to 20-25% of the CO_2 emissions from burnt fossil fuels. Other transport- related GHG include N_2O and CFC and HCFC from AC systems.	30
Efficiency improvement and energy saving	25	90	Improving vehicle maintenance and engine tuning greatly reduces emissions of GHGs and other pollutants by up to 30%. This leads to substantial energy and cost savings.	22.5
Capital Investment	10	65	Establish a vehicle I&M programme requires capital investment for the purchase and installation of testing units.	6.5
Operation and maintenance cost	10	50	To keep motor vehicles in proper operating conditions, and thereby maintaining returns in terms of lower GHG emissions, regular spending on labour, materials and spare parts will be required.	5
Option sustainability	10	60	Sustainability will depend on financial, technical and regulatory support. Vehicle maintenance requires annual investment by all stake holders	6
Payback period	5	50	Payback period is not easy to specify since I&M should be a continuous process	2.5
Societal and economic benefits	5	80	Proper maintenance and periodic inspection can reduce costs for items such as fuel and spare parts, and also increase the vehicle's resale value and extend its lifespan. Additionally, demand for vehicle servicing and for I&M centers will generate jobs.	4
			Total	**76.5**