TECHNOLOGY NEEDS ASSESSMENT GUIDANCE NOTE

EVALUATING MEASURES FOR INCLUSION IN A TECHNOLOGY ACTION PLAN

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Disclaimer:
This note is intended to support developing country governments, planners, and stakeholders who are carrying out technology needs assessment and technology action plans. The suggestions and examples presented in this publication are entirely those of the authors and do not necessarily represent the views of the institutions involved in the project or imply endorsement of any approach described.

1 Introduction

In the first step of a Technology Needs Assessment (TNA), countries' identify and prioritise technologies for adaptation and mitigation. The second step entails identification of barriers and elements of enabling framework. The enabling environment is the set of resources and conditions within which a technology and its target beneficiaries operate. The enabling framework, therefore, looks into resources and conditions that improve the quality and efficacy of transfer and diffusion of technologies.[1] In this process, a long list of measures is identified, which if implemented, have the potential to support transfer and diffusion of a prioritised technology. Not all measures from this long list can be implemented as actions and therefore included within the Technology Action Plan (TAP), primarily for three practical reasons as per TAP guidance. *First* reason is constraint in resources, as limited resources have to be optimised for achieving the ambition set for technologies within the TAP. *Second*, some measures can undermine other measures. *Third,* implementing all the measures is not politically feasible.

> ***Measures*** *are factors, financial or non-financial, that enable or motivate a specific course of action or behavioural change, or is a reason for preferring one choice to the other alternatives.*

> ***Actions*** are *those measures, which are taken into the TAP through a process of consultation and analysis*

> ***Technology Action Plan*** *is a concise plan for the uptake and diffusion of prioritised technologies. A TAP is usually made up of numerous and specific actions and is often technology specific.*

To sum up, a short list of implementable measures i.e., actions have to be identified that support technology transfer and diffusion. Various measures have to be evaluated to see their effectiveness in meeting the goal of technology diffusion by making efficient use of resources. In the TNA process, this task of analysing measures has to be performed by the consultants. Their information on comparative analysis of measures feeds into the stakeholder discussions for preparation of Technology Action Plans (TAPs) and enables stakeholders to identify the actions.

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[1] All definitions (unless specified) are as per: UNFCCC (2016). *Enhancing Implementation of Technology Needs Assessment: Guidance for preparing a Technology Action Plan.* Bonn & Copenhagen: The United Nations Framework Convention on Climate Change Secretariat & United Nations Environment Programme- Technical University of Denmark Partnership. Retrieved fromhttp://unfccc.int/ttclear/misc_/StaticFiles/gnwoerk_static/TEC_column_M/33933c6ccb7744bc8fd643feb0f8032a/82af010d04f14a84b9d24c5379514053.pdf OR
Nygaard, I. & Hansen, U. (2015). *Overcoming Barriers to the Transfer and Diffusion of Climate Technologies: Second edition*. Copenhagen: UNEP DTU Partnership. Retrieved from http://www.tech-action.org/Publications/TNA-Guidebooks

> *An action is usually composed of several* ***activities****, which are the specific tasks or 'sub-actions' needed to realise an action.*

The Barrier analysis guidebook provides guidance to analyse barriers to technology transfer and diffusion and identify measures that can address these barriers. The guidance on 'TAPs' provides an approach for developing a concise action plan for uptake and diffusion of prioritised technologies. This guidance on 'evaluation of measures' is focussed on analysing and comparing various measures identified in the barrier analysis to identify measures that go into the TAPs as actions. It is, therefore, a complement to guidance on 'TAPs' and the Barrier guidebook.

This guide note is written with simple examples to give consultants and practitioners a very simple overview of a way to assess and compare measures. There are three sections in this note i.e. the introduction in section 1; screening measures based on ambition in section 2; and steps for evaluating measure in section 3. Annex 1 and 2 give a hypothetical example for comparing different measures for a market technology[2] for adaptation and mitigation respectively.[3] Annex 3 provides a brief overview of sources of financing for these measures.

2 Ambition for Technology and Choice of Measures

The TAP preparation starts with setting an ambition for the technology[4]. The TAP guidance discusses this in the context of alignment with national priorities. The ambition level of the technology will have budgetary implications for the government due to two reasons. *First*, is that ambition affects the scale of measures. This implies that for large-scale implementation of technologies more resources are required and potentially for a long period of time. *Second* is that the type of measures is likely to be different for a limited ambition vis-à-vis bigger ambition. For example, if the ambition is limited to small-scale implementation of technology, then the measures could include procuring the equipment from foreign markets and providing them to the end users at a subsidised cost. These measures are directly linked to technology and are potentially one-time efforts. The budgetary allocation therefore is high upfront. However, if the ambition is a wide scale diffusion of the technology then the nature of measures will be different. This is because now the focus will be to facilitate players in market value chain to operate efficiently. Measures such as changing the policies structures to have right incentives for stakeholders or making more finance options available to users to invest in the technology are more expensive however will be spread over time.

[2] For definitions of Market and Non-Market Technologies, refer to the 'TNA Guide Note' at http://www.tech-action.org/Publications/TNA-Guidebooks

[3] Similar methods can be pursued for non-market technologies but this note limits the examples to market technologies

[4] 'Enhancing Implementation of Technology Needs Assessments' available at http://www.tech-action.org/Publications/TNA-Guidebooks

Larger ambitions also require coordination of measures with available finances and budgetary allocations in public finance. The budget for a technology implementation programme may not be available in one go and therefore the implementing agency may want to design the measures in a way that they correspond to availability of finance across the implementation period.

The ambition should also be linked to the status of technology in the country and the capacity within the country. Successful transfer and diffusion of technology can be a long term process of calibrating the policy (See Box 1 for example from Norway, which has supported its electric vehicle programme for over 40 years) though in some cases for developing countries the process may be a little shorter.

Box 1: Measures for Electric Vehicles in Norway

Norway has designed a very ambitious programme for dissemination of electric vehicles. The programme support continues in partnership government agencies, private organizations, general public and NGOs. The result is that in 2015, electric vehicles comprised 18% of total car sales. Following is a temporal overview of measures from the Norwegian government:

» 1970-90 - Research council of Norway provided financial incentives to the private sector for research and development
» 1990-99 - Incentives for EV offered such as exceptions from registration tax, toll road charges, annual licence fee
» Post 1999 - Incentive pool expanded

- 1999 - Free parking was provided in municipal parking lots
- 2001 - Battery eVs are exempt from 25 % VAT
- 2003 - Access to bus lanes in Oslo (In 2005 the access extended to entire Norway)
- 2008 - Launch of EV charging infrastructure programme
- 2009 - Free access to road ferries
- 2013 - EV incentives extended to 2017

3 Evaluating measures

In both market technologies and non-market technologies, the government has to play a significant role in their transfer and diffusion. The government, as the key stakeholder, can influence technology adoption by changing incentive structure for the users, implementers and providers of technologies. Therefore, for the government it is important to know how one measure is different from the other in changing the incentive structure for stakeholders and subsequently the budgetary implication of each measure. In this section, we discuss the process of evaluating measures. To evaluate measures, the government as a decision maker needs the following three levels of information.

- *First*, the level of additional incentive (or disincentive for the existing technology which is to be substituted) required to change the incentive structure in favour of the climate technology for the technology adopter to switch either from the state of absence of technology or from the state of conventional technology use.
- *Second,* budgetary implication for the measures. The government may want a large-scale implementation or may want to provide deep incentives for adoption, but these can be a huge fiscal burden or may be passed on as cross subsidies.
- *Third*, financial structuring and funding possibilities for the measures. Measures have to coordinated financial flows and potential sources of funding options.

Here, the evaluation process for measures is detailed through the perspective of a programme aimed at transfer and diffusion the climate technology. The steps in the evaluation process are demonstrated through two hypothetical examples for a climate technology in adaptation (Annex 1) and in mitigation (Annex 2). The measures will be evaluated based on incentives (or disincentives) needed for uptake of technology and the budgetary implications for the government.

For climate technologies in adaptation, there are no standard models. However, for climate technologies in mitigation, there are options of models such as RETSCREEN and HOMER. Evaluation of measures can be done using common financial ratios in a spreadsheet, which is demonstrated in examples in the annexes 1 and 2. Annex 1 uses a spreadsheet model FICAM, developed within the TNA project. Following are the general steps to evaluate measures:

1. *Determine the Base Case*
2. *The Assessment of Measures*
3. *Budgetary Implications*
4. *Choice of measure(s)* for inclusion in the TAP

3.1 Determine the Base Case

The base case involves enumeration of all revenues and expenses in the existing situation of conventional technology use vis-à-vis revenues and expenses for replacing the technology with a climate technology prioritised within the TNA. In some situations, there could be no technology currently in use. For example, in case of introducing drip irrigation, a state of no technology would be total reliance on rainfall for irrigation. By analysing the financial ratios, one can assess the financial barrier in adopting the technology. Box 2 gives an example using NPV to estimate the financial barriers. Other common financial ratios that can be used are IRR and discounted payback period.

Box 2: Understanding the financial barrier in base case

Solar powered pump sets are a clean and efficient alternative to conventional diesel or electric pump sets. Yet the technology is not well diffused even in places with frequent power disturbances. Suppose to adopt solar powered pump sets the farmer has to incur the following expenses assuming technology life span of 15 years.

1. Procuring a new pump (500 USD – one time at t_0)

2. Training to use and maintain the pump sets provided by private supplier (50 USD) – one time at t_0

3. Incremental maintenance costs of 20 USD p.a. from t_1 – t_{15}

4. Against these, there are additional savings of 60 USD p.a. from t_1 – t_{15}

Assuming a 5% discount rate, the NPV for the technology lifetime of 15 years is - 135 USD. This implies that the farmer cannot recover more than a quarter of the expenses incurred in switching to a more climate friendly technology. There is a “gap” in the revenues and expenses for the technology adopters, which is acting as barrier for transfer and diffusion of technologies. Let us term this as the ‘financial barrier’ and government has to tailor its measures in a way that they close this deficit of -135 USD, in order to promote the technology. This can be done by providing enough measures that increase incentives to adopt the climate technology or measures that target the conventional technologies making them a less viable alternative.

3.2 The Assessment of Measures

The next step is to see how each of the measures identified in the ‘barrier analysis and enabling framework’ overcomes the financial barrier identified in step 1. The analysis in this step is from the perspective of individual / entity that is going to invest into the technology. The base case analysis is helpful in understanding the financial barrier and therefore the quantum of change required in measures. For example, if the government decides to use capital subsidies so to facilitate the farmers to adopt solar pump sets, whether a 5% or 10% capital subsidy is enough will depend on the financial barrier identified in step 1. Measures can also be analysed individually or as a group of measures.

Financial analysis also requires due consideration for the discount rate to be used. The rate chosen should be reflective of either the opportunity cost of capital, social rates of time preference, or ethical values, as the case may be.

Box 3

Net Present Value (NPV)

A project's net contribution to wealth— present value of expected cash inflows minus initial investment. Present value of the expected cash flows is calculated by discounting them at the required rate of return.

$$NPV = \sum_{t=1}^{t} \frac{C_t}{(1+r)^t} - C_0$$

C_t = net cash inflow during the period t
C_0 = total initial investment costs
r = discount rate, and
t = number of time periods

Internal Rate of Return (IRR)

Discount rate at which investment has zero net present value

$$0 = \sum_{t=1}^{t} \frac{C_t}{(1+IRR)^t} - C_0$$

Discounted Payback Period

A project's payback period is found by counting the number of years it takes before the discounted cumulative cash flow equals the initial investment.

$$C_0 = \sum_{t=1}^{t} \frac{C_t}{(1+r)^{Paybackperiod}}$$

Source: Brealey, Myers & Allen (2011). Principles of Corporate Finance. New York: McGraw-Hill Irwin

3.3 Budgetary Implications

The next step is to calculate the cost of each of these measures and estimate the budget that the national /state government would need to implement them. Implementing any measure or a set of measures requires financial, technological and human resources. Designing policy frameworks, extending financial support, programme design, enhancing capacities, consultations all need resources. All the resources required come at a cost. In this step, we assess budgetary implication for the government of the resources required for each of the measures under evaluation.

While deciding the budget required for different measure a good perspective of sources and structuring of finance is important. The source and structure of finance influences the incentive structure for stakeholders in technology adoption process. It can also help in improving financial viability of the projects and reducing the risks. A short description on the sources and structuring of finance is provided in Annex 3.

3.4 Choice of Measure(s) for inclusion in TAP

In this last step, the most appropriate measures have to be chosen for inclusion in a TAP. The choice of measures to be included as actions within the TAP should overcome the financial barrier with least resources. We here assume that the measures that have been considered for the assessment process have been screened to take into account the softer aspects of peoples' preferences, cultural and social dynamics of the implementation area.

4 Annex 1: Adaptation Case Example

In the following hypothetical example, we evaluate some possible measures from the government. The example illustrates comparison of measures using simple financial ratios. As mentioned in the introduction, the measures for diffusion of climate technology are evaluated from a programme perspective, i.e. assuming that the measures identified were to be implemented as a part of a well-defined programme. The objective of the example is to walk through the steps of evaluation and not to delve into the preciseness of the numbers and correctness of technological aspects. The numbers used are hypothetical and actual numbers will be context specific. For most technologies, capital costs occur at the beginning, with returns and maintenance costs occurring over the technology lifespan. The temporal aggregation of asymmetrically spread returns and expenses requires discounting. There is an entire spectrum between an empirically based i.e. a finance-equivalent discount rate and a social discount rate, i.e. the social welfare-equivalent discount rate. Here we do not delve into a discussion on pros and cons of specific values of discount rates or the underlying fundamental basis of specific choice of discount rate as this is a country specific process. For ease of understanding, we use a single discount rate for the assessment period.

4.1 Problem Context

A provincial government wants to promote drip irrigation in a village of 50 equal sized farmlands in a region. The barriers identified to dissemination of technology are:

1. Drip irrigation is not economically competitive to non-irrigation or to sprinkler irrigation
2. Limited technical know-how among the farmers.

Given the above condition, let us understand the current situation in which there is no incentive to change from the current situation. Let us call this the base case. The assumed discount rate is 5% and the farmers (or institutions) can access finance at 5% interest rate. The life of technology is assumed as 10 years.

4.2 The Base Case

Though drip irrigation systems are efficient in terms of energy use and water consumption, yet they are not popular. Suppose a farmer intends to adopt this technology, he/she will have to buy the equipment from private suppliers, spend on the technical know-how and lose his labour hours when the system is being installed. The life span of the equipment is ten years after which the farmer will have to replace the equipment. Following are the costs and savings that the farmer has to bear to install drip irrigation system in farm. The operating costs stated are incremental to the current state.

	Per farm in USD	For 50 farms of region in USD
Capital Cost for equipment	1200	60,000
Variable maintenance costs p.a. (Incremental)	300	15,000
Access to technical know-how (one time)	500	25,000
Labour hours lost (one time)	300	15,000
Savings p.a. (Electricity)	300	15,000
Savings p.a. (Water)	200	10,000

Table 1: Costs and savings that farmer and the village of 50 farms has to bear to install drip irrigation system in USD

The cost matrix below shows the annual expenses the entire region under consideration of 50 farms will have to incur during the assessment period of 10 years.

COST MATRIX					
Unit	US$	US$	US$	US$	***Total Annual Costs (US$)***
Costs	Cost 1	Cost 2	Cost 3	Cost 4	
Variable Name	***Capital***	***Operating***	***Technical***	***Labour Hours Lost***	
Year 0	-60000		-25000	-15000	-100000.00
Year 1		-15000			-15000.00
Year 2		-15000			-15000.00
Year 3		-15000			-15000.00
Year 4		-15000			-15000.00
Year 5		-15000			-15000.00
Year 6		-15000			-15000.00
Year 7		-15000			-15000.00
Year 8		-15000			-15000.00
Year 9		-15000			-15000.00
Year 10		-15000			-15000.00

Table 2: Cost Matrix – Base Case

Similarly, there will savings every year for on account of less use of electricity and water. The following revenue matrix shows the annual savings accrued to the entire region under consideration of 50 farms during the assessment period of 10 years. Here benefits refers to the monetary gains or the revenue stream that occurs due to technology adoption.

REVENUE MATRIX			
Unit	US$	US$	***Total Annual Benefits (US$)***
Benefits/Profit	Benefit 1	Benefit 2	
	Electricity	***Water***	
Year 0	0		0.00
Year 1	15000	10000	25000.00
Year 2	15000	10000	25000.00
Year 3	15000	10000	25000.00
Year 4	15000	10000	25000.00
Year 5	15000	10000	25000.00
Year 6	15000	10000	25000.00
Year 7	15000	10000	25000.00
Year 8	15000	10000	25000.00
Year 9	15000	10000	25000.00
Year 10	15000	10000	25000.00

Table 3: Revenue Matrix – Base Case

A simple NPV assessment shows that there is not enough financial incentive for the farmer to switch, as the discounted cash flows are less than the discounted expenses. The following figure shows NPV at different interest rates. The gap also increases at higher discount rates because the capital investment in the initial years is much higher than the annual savings. The payback period of the technology is more than the life span of the technology.

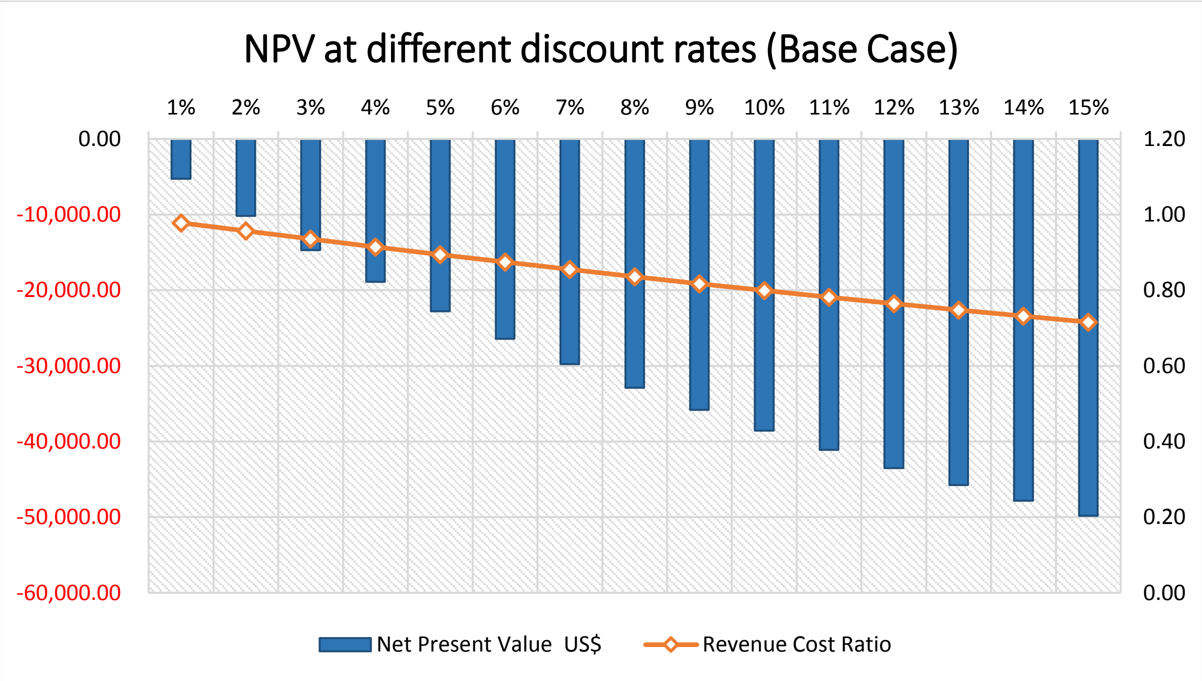

Figure 1: NPV at different discount rates

Discounted Revenue	193043.37
Discounted Costs	-215826.02
Discounted Net Benefits	-22782.65
Revenue/Cost	0.894
Discounted Payback Period	More than 10 years

Table 4: Summary Statistics

Given these calculations, provincial government concludes that there are three possible measures that the government can implement to enable the village to replace conventional flood irrigation with drip irrigation

Measure 1 (*Reform prices*): Increase price of water and electricity by 30%

Measure 2 (*Capital Subsidy*): Give a capital subsidy of 25% and provide technical know-how by charging nominal amount per farm.

Measure 3 (*Interest Subsidy*): Give a 100% interest subsidy and provide technical know-how by charging nominal amount per farm.

4.3 Assessment of Measures

Let us now assess how these measures affect the overall financial incentive of the farmers. Key statistics to look at while making the assessment are IRR, discounted payback period and ratio of revenues to costs.

4.3.1 Measure 1: Reform Prices

In this measure, the government takes an extreme measure of increasing the price of water and electricity by 30%. This would force the farmers to look for alternatives that are cheaper and one of which would be introducing drip irrigation systems because they use less electricity and less water. The entire system would have be purchased from private suppliers so the farmers would have to pay significantly. Let us assume that savings increase by the same amount as the increase in prices.

	Per farm in USD	**For 50 farms of region in USD**
Capital Cost for equipment	1200	60,000
Variable maintenance costs p.a. (Incremental)	300	15,000
Access to technical know-how (one time)	500	25,000
Labour hours lost (one time)	300	15,000
Savings p.a. (Electricity)	390	19,500
Savings p.a. (Water)	260	13,000

Table 5: Costs and savings that farmer and the village of 50 farms has to bear to install drip irrigation system in USD

COST MATRIX					
Unit	US$	US$	US$	US$	***Total Annual Costs (US$)***
Costs	Cost 1	Cost 2	Cost 3	Cost 4	
Variable Name	***Capital***	***Operating***	***Technical***	***Labour Hours Lost***	
Year 0	-60000		-25000	-15000	-100000.00
Year 1		-15000			-15000.00
Year 2		-15000			-15000.00
Year 3		-15000			-15000.00
Year 4		-15000			-15000.00
Year 5		-15000			-15000.00
Year 6		-15000			-15000.00
Year 7		-15000			-15000.00
Year 8		-15000			-15000.00
Year 9		-15000			-15000.00
Year 10		-15000			-15000.00

Table 6: Cost Matrix – Reform Prices (Measure 1)

The costs remain the same as base case, however, the revenue accrued from savings increases.

REVENUE MATRIX			
Unit	US$	US$	***Total Annual Benefits (US$)***
Benefits/Profit	Benefit 1	Benefit 2	
	Electricity	***Water***	
Year 0	0	0	0.00
Year 1	19500	13000	32500.00
Year 2	19500	13000	32500.00
Year 3	19500	13000	32500.00
Year 4	19500	13000	32500.00
Year 5	19500	13000	32500.00
Year 6	19500	13000	32500.00
Year 7	19500	13000	32500.00
Year 8	19500	13000	32500.00
Year 9	19500	13000	32500.00
Year 10	19500	13000	32500.00

Table 7: Revenue Matrix – Reform Prices (Measure 1)

NPV assessment across different discount rates shows that with lower discount rates, the incentive structure changes in favour of drip irrigation system. At a 5% discount rate, the technology becomes favourable to an individual adopter. The internal rate of return is higher than the discount rate, the payback period is less than the technology life span and the revenue cost ratio is greater than 1.

Discounted Revenue	250956.3852
Discounted Cost	-215826.0239
Discounted Net Benefits	35130.3613
Revenue/Cost Ratio	1.1628
IRR	11.73%
Payback Period	5.71
Discounted Payback Period	6.9

Table 8: Summary Statistics

For the specific measure, the provincial government may want to consider the effectiveness of the measure as increasing prices may have a regressive effect. Many farmers may resort to illegal connections if the prices are suddenly increased. Increasing prices is likely affect other essential services and can have an inflationary effect on other commodities.

4.3.2 Measure 2: Capital Subsidy

In this measure, the government bears 25% of the equipment price. This makes the price of the equipment cheaper for the individual farmers. In addition, the technical know-how can be provided through government's existing institutional set up. The farmer is expected to pay 100 USD dollars for accessing this. The government spends about 200 USD per farmer (over and above the amount paid by farmers) to provide relevant technical know-how. The following cost and revenue matrix show changes in the incentive structure for the individual farmers.

	Per farm in USD	**For 50 farms of region in USD**
Capital Cost for equipment (75%)	900	45,000
Variable maintenance costs p.a. (Incremental)	300	15,000
Access to technical know-how (one time)	100	5,000
Labour hours lost (one time)	300	15,000
Savings p.a. (Electricity)	300	15,000
Savings p.a. (Water)	200	10,000

Table 9: Costs and savings that farmer and the village of 50 farms has to bear to install drip irrigation system in USD

COST MATRIX					
Unit	US$	US$	US$	US$	***Total Annual Costs (US$)***
Costs	Cost 1	Cost 2	Cost 3	Cost 4	
Variable Name	***Capital***	***Operating***	***Technical***	***Labour Hours Lost***	
Year 0	-45000		-5000	-15000	-65000.00
Year 1		-15000			-15000.00
Year 2		-15000			-15000.00
Year 3		-15000			-15000.00
Year 4		-15000			-15000.00
Year 5		-15000			-15000.00
Year 6		-15000			-15000.00
Year 7		-15000			-15000.00
Year 8		-15000			-15000.00
Year 9		-15000			-15000.00
Year 10		-15000			-15000.00

Table 10: Cost Matrix – Capital Subsidy (Measure 2)

REVENUE MATRIX			
Unit	US$	US$	***Total Annual Benefits (US$)***
Benefits/Profit	Benefit 1	Benefit 2	
	Electricity	***Water***	
Year 0	0	0	0.00
Year 1	15000	10000	25000.00
Year 2	15000	10000	25000.00
Year 3	15000	10000	25000.00
Year 4	15000	10000	25000.00
Year 5	15000	10000	25000.00
Year 6	15000	10000	25000.00
Year 7	15000	10000	25000.00
Year 8	15000	10000	25000.00
Year 9	15000	10000	25000.00
Year 10	15000	10000	25000.00

Table 11: Revenue Matrix – Capital Subsidy (Measure 2)

Discounted Revenue	193043.37
Discounted Costs	-180826.02
Discounted Net Benefits	12217.35
Revenue/Cost	1.07
IRR	8.71%
Payback Period	6.50
Discounted Payback Period	8.06

Table 12: Summary Statistics

NPV assessment across different cost structures shows that the incentive structure remains favourable until close to 9%. The IRR of 8.71 % reflects this. The discounted payback period is less than the technology life span and the revenue cost ratio is greater than 1, indicating that through this measure the incentive structure has been changed favourably for the technology adopter. From the government's perspective, it should be kept in mind that by providing a capital subsidy, it will have to bear all the expenses in one go, as both capital subsidy and subsidy for technical know-how are one-time expenses occurring before there are savings generated from the equipment. The government thus has to bear 15,000 USD for providing capital subsidy and 10,000 USD for as an additional expense on their existing institutional structure to make technical know-how accessible.

4.3.3 Measure 3: Interest Subsidy

The third measure is in the form of 100% interest subsidy. The farmer has provide 200 USD and the remaining 1000 USD will be an interest free loan to be paid in 10 equal instalments. Suppose that the lending rate is 5% and therefore the equated annual instalments to be paid to the government and the famer is 6475.25 (for 50 farmers) of which the interest component is paid by the government and the principal is paid by the farmer. This is in addition to the support on technical know-how as in measure 2.

	Per farm in USD	For 50 farms of region in USD
Capital Cost for equipment	200	10,000
Variable maintenance costs p.a. (Incremental)	300	15,000
Access to technical know-how (one time)	100	5,000
Labour hours lost (one time)	300	15,000
Savings p.a. (Electricity)	300	15,000
Savings p.a. (Water)	200	10,000

Table 13: Costs and savings that farmer and the village of 50 farms has to bear to install drip irrigation system in USD

COST MATRIX					
Unit	US$	US$	US$	US$	***Total Annual Costs (US$)***
Costs	Cost 1	Cost 2	Cost 3	Cost 4	
Variable Name	***Capital***	***Operating***	***Technical***	***Labour Hours Lost***	
Year 0	-10000		-5000	-15000	-30000.00
Year 1		-18975.25			-18975.25
Year 2		-19174.01			-19174.01
Year 3		-19382.71			-19382.71
Year 4		-19601.85			-19601.85
Year 5		-19831.94			-19831.94
Year 6		-20073.54			-20073.54
Year 7		-20327.22			-20327.22
Year 8		-20593.58			-20593.58
Year 9		-20873.25			-20873.25
Year 10		-21166.92			-21166.92

Table 14: Cost Matrix – Interest Subsidy (Measure 3)

REVENUE MATRIX			
Unit	US$	US$	***Total Annual Benefits (US$)***
Benefits/Profit	Benefit 1	Benefit 2	
	Electricity	***Water***	
Year 0	0	0	0.00
Year 1	15000	10000	25000.00
Year 2	15000	10000	25000.00
Year 3	15000	10000	25000.00
Year 4	15000	10000	25000.00
Year 5	15000	10000	25000.00
Year 6	15000	10000	25000.00
Year 7	15000	10000	25000.00
Year 8	15000	10000	25000.00
Year 9	15000	10000	25000.00
Year 10	15000	10000	25000.00

Table 15: Revenue Matrix – Interest Subsidy (Measure 3)

Discounted Revenue	193043.37
Discounted Cost	-183685.55
Discounted Net Benefits	9357.83
Revenue/Cost	1.05
IRR	11.55%
Payback Period	5.23
Discounted Payback Period	5.91

Table 16: Summary Statistics

The IRR of this measure is very high which also means that the measure will yield positive NPV even at very high discount rates. The following table shows the principal and interest payments for every year over a period of 10 years. This measure has a very low payback period

Year	Principal	Interest	EMI	Remaining Principal
1	50000.00	2500.00	6475.25	3975.25
2	46024.75	2301.24	6475.25	4174.01
3	41850.74	2092.54	6475.25	4382.71
4	37468.02	1873.40	6475.25	4601.85
5	32866.18	1643.31	6475.25	4831.94
6	28034.23	1401.71	6475.25	5073.54
7	22960.70	1148.03	6475.25	5327.22
8	17633.48	881.67	6475.25	5593.58
9	12039.90	602.00	6475.25	5873.25
10	6166.65	308.33	6475.25	6166.92
		14752.23		

Table 17: EMI, Principal and Interest Payments

The burden on government other than the 10,000 USD on technical know-how is on the interest payment that totals 24752.23 over a period of 10 years, which at the discount rate of 5% is equal to 12140.64 USD. Besides the quantum of support being less, the burden on the government in this specific case is spread across a period of 10 years. There is a greater chance of adoption since the NPV is higher from a farmer's perspective over a wide range of discount rates.

4.4 Budgetary Implications

In all the three measures, the government has an important role to play. In the first measure of reforming price structure, we do not consider any direct subsidy expenses at the government's end. In practice, there may be many administrative expenses to ensure that the targeted group is paying the set price. However, in measures 2 and 3 the government has to bear the burden of providing subsidy during the ten year assessment period. The discounted budget requirements for the two measures is 25,000 USD and 22,140.64 USD respectively. Therefore, the budget requirement is less in measure 2.

Another aspect to take into consideration is the spread of expenses for the government. For the capital subsidy in measure 2, the government has to make an upfront expenditure. This is a one-time support and therefore the budgetary implication is only for the first year. For the interest subsidy in measure 3, the payment is spread across the technology lifespan/loan period. In this example of a small-scale implementation, the budget may not matter. If the project was a large-scale project say implementation in villages of an entire region, the amount of capital investment may be very high. The government in such a situation may not have the financial capacity to invest the entire amount in in one go. The broader message is that measures also have to be structured in accordance with finances available.

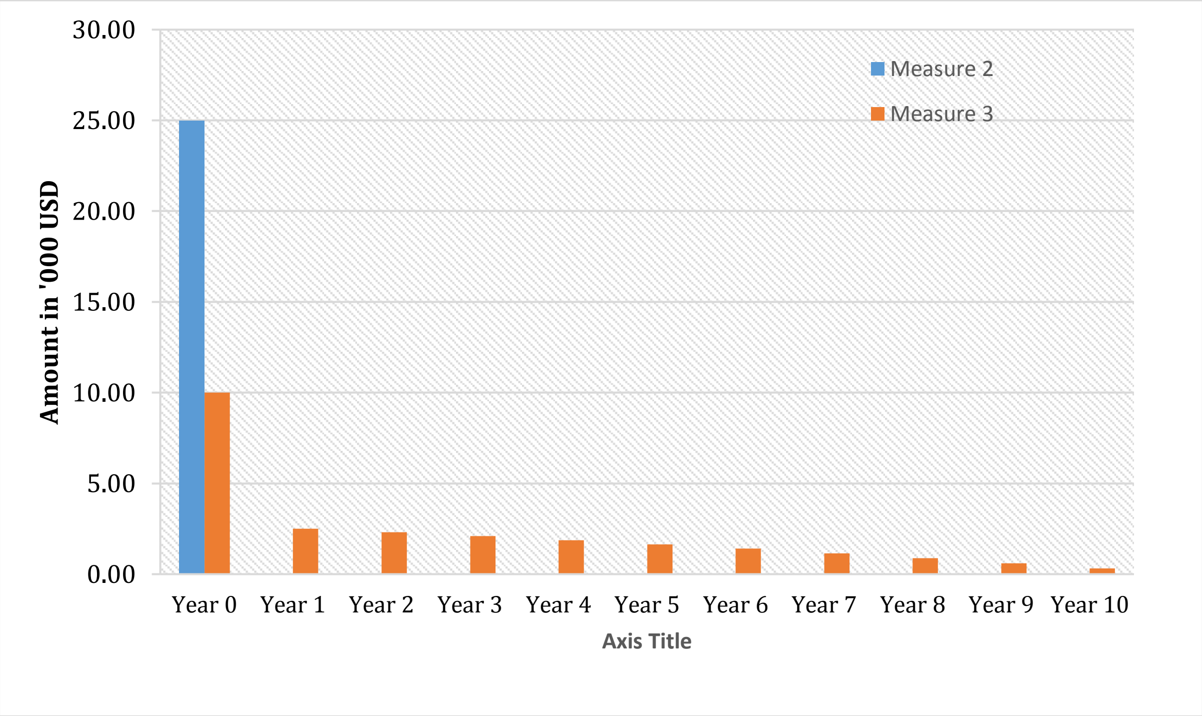

Figure 2: Subsidy burden on the government

4.5 Choice of Measure for inclusion in a TAP

In this specific case example, we have used hypothetical numbers that makes the choice of measure 3 very clear. Measure 3 of interest subsidy gives the highest IRR making it the option feasible also at high discount rates. The payback period is the lowest and the revenue cost ratio is the highest. The measure is doing well in changing the incentive structure for the technology adopter and has a relatively even spread (in comparison to measure 2) for budgetary implications. Measures 1 does not have budgetary burden for the government but has various social, political and economic repercussions. Measure 2 flairs poorly on all the financial ratios. However, in this measure also the incentive structure for an individual changes, and the measure can facilitate technology adoption though at a higher bud

4.6 Implications for Policy Decision Making

In this example, we do a level one assessment i.e. we are looking at immediate beneficiaries or the technology adopters. For technologies, there are many positive and negative spill over effects. Let us look into measures 1 of reforming price structures. This measure may have a very regressive effect on other water users like industries, cooperatives, households including the farmers. This measure will please the suppliers of drip irrigation or suppliers of water tankers financially. There will also be potential escalation effects on prices of commodities that use water. Such measures also are very reformative in nature trying to put a fair price to natural resources. In countries with significant differences between the rich and the poor, such reformative measures usually meet resistance. Therefore, implementation of measures should look into all stakeholders' perspectives. Usually, a well-represented stakeholder consultation in the TNA process identifies measures that take care of stakeholders' perspectives. Apart from this, the practical aspects like the administrative and infrastructure costs for implementing this action should be included. For example, it could be in metering and other forms of monitoring or if there is a differential pricing then the costs for ensuring different segments pay different prices have to be included.

The measures in their assessment may turn out to have a similar impact. Therefore, the decision-making should then include many other practical aspects like ease of implementation, convenience, monitoring requirements etc. Social barriers and a general inertia to change can be dealt with promotion and awareness. Sometimes these barriers can be quite strong and even if the monetary incentives change positively for the technology adopter, changes in actions of individuals / technology adoption.

Another aspect for important for decision-making is the extent of the measure. For e.g. whether the government should provide 100% interest subsidy or a 75% subsidy is needed. The idea to sufficiently incentivize and not over subsidize. A future view of making the technology self-sustaining should also be the goal of the bundle. Designing the measures in a way that the farmers will continue to adopt the technology even after the measures are withdrawn in future will ensure that the goal of technology dissemination continues to be met.

The method described in this case example uses simple spreadsheet functions for assessment. There are many more ways and softwares available that can be used for similar assessments. The key for a good analysis rests in robustness of assumptions and detailed understanding of problem context.

5 Annex 2: Mitigation Case Example

The mitigation case is analysed using the Financial and Cost Assessment Model (FICAM). FICAM supports comprehensive financial analysis for technologies and enables a user to come up with capital requirements, financial ratios (e.g., NPV, IRR, etc.). A user can evaluate contribution of alternative technology choices. This is relevant particularly when existing technologies have to be replaced and a comparison is needed with the baseline technology. The model is an open source excel based tool. In its existing state, the tool already lists some technologies and the user can define other technologies if they do not fall in this list.

5.1 Problem Context

The government wants to diffuse the Solar PV Roof Top Systems (Technology Assumptions in Table 18) through the market for households. The ambition is to have 30 MW of solar capacity by 2020. There are a few suppliers, however, it is largely believed that due to high costs of these systems, the suppliers have not been successful in technology penetration and some of them are planning to close down. The government is, therefore, keen to provide support for the solar systems through some measures but is not sure about the minimum level of support required for technology diffusion. The consultants / experts have to advise on the portfolio of financial measures that can be provided to ensure that these Solar PV Roof Top Systems become financially attractive.

Parameter	Unit	Value (USD)
Cost Model: General Parameters		
Technology Capacity	MW	30
Life of Technology	years	15
Cost Model: Capital and O&M		
Equipment and Construction Cost	USD Million/MW	4
Planning	USD Million/MW	0.1
Fixed O&M Cost	USD/ MW	0.1
Variable O&M Cost	USD/ MWh	5
Cost Fuel		
Capacity utilisation	%	35

Table 18 Technology Assumptions for Solar PV

5.2 The Base Case

The analysis of base case can be done using a financial model (we use FICAM model) and for this some basic information is required (See Table 19) beyond the technology costs, that is somehow related to the existing enabling environment. For example, if we want to substitute electricity from grid we should know the electricity prices. We also need to know if there are any incentives that are being provided (e.g., capital and operating subsidies).

Parameter	Unit	Value
COST & FINANCIAL MODEL: ADDITIONAL INPUTS		
Cost of Electricity	USD/MVh	100
FINANCIAL MODEL: OTHER PARAMETERS		
Gestation Period	years	1
Capital Grants per unit	USD per MW	100,000
Annual operating subsidies per unit	USD per MWh	20
GLOBAL PARAMETERS		
Discount Rate		10%
Base Year Price of CER	USD/tCO2	
Percentage if Debt	%	60%
Interest on Debt		10%
Tenure of Debt	years	10

Table 19: Additional Information for Financial Analysis

We analyse the financial viability of the technology with these basic conditions and we get the following key ratios from FICAM:

- Simple Project IRR - 12%
- Equity IRR - 7%
- Net Present Value -11 million USD
- Pay Back period - more than 15 years i.e., life of technology.

It is quite clear from the above ratios that the technology is not viable under the present conditions and would not be purchased by home buyers.

5.3 Assessment of Measures

During the barrier and enabling framework analysis, a number of measures are identified by the stakeholders for further examination. For this example, let us say these measures are as follows

1. Feed in Tariff
2. Capital and Operating Subsidy
3. Soft Support for Solar PV
4. Carbon Market

Now we will analyse these individually and collectively to see the impact on making this technology financially attractive for a home buyer. In order to simplify the decision we assume that an IRR of 20% should be good enough keeping in view that the discount rate is 10% and the risks for technology are high.

5.3.1 Feed in Tariffs

The Feed in tariff policy will enable home buyers to feed electricity from solar panels directly into the grid through enabling regulations for connection and smart metering. These feed in tariff policy implementation would require grid enhancements. However, it would do away with the need for large battery storage. The capital costs for home users are therefore expected to be 30% lower. In order to give further incentive for solar producers the government will provide a 10% higher price for electricity. The financial analysis provides us with the following results

- Simple Project IRR - 20%
- Equity IRR - 18%
- Net Present Value - 24 million USD
- Pay Back period - 14 years

It is quite clear if feed in tariffs are carried out the technology can be attractive for home buyers though a high pay back period can be a concern for the buyers since home buyers look for much shorter pay back period.

5.3.2 Capital and Operating Subsidy

The proposal for capital subsidy is to provide 40% of capital cost (provided unit cost does not exceed USD 4000 per Kw) and to provide 50% of variable O&M costs with the maximum value put as 5 USD per Mwh. The financial analysis provides us with the following results

- Simple Project IRR - 22%
- Equity IRR - 20%
- Net Present Value - 27 million USD
- Pay Back period - 13 years

It is quite clear if these subsidies are provided, the technology can be attractive for home buyers though a high payback period can concern them.

5.3.3 Soft Support for Solar PV

The market is very fragmented with no standards for solar panels, no testing facilities, no agency that can provide advice to buyers and shortage of trained people. This measure involves introduction of regulations that make it mandatory for suppliers to provide information on efficiency of panels and guarantee a minimum life of 15 years for the solar panels. It would also include starting a program to advice buyers and train technicians in installing solar panels. Due to this, the expected return is expected to reduce from 22% to only 18%. In addition, since a minimum life of 15 years has to be now guaranteed the life of panels was increased to 20 years. The financial analysis provides us with the following results

- Simple Project IRR - 14%
- Equity IRR - 11%
- Net Present Value - 4 million USD

- Pay Back period - 19 years

It is quite clear that improved standards alone won't make the technology attractive for home buyers. However, in combination with measure 1 or 2 it can reduce anxiety of buyers.

5.3.4 Carbon Markets

There was not much clarity whether the stakeholders were talking about an international or a domestic carbon market. In addition, there was not much clarity as to what the price for carbon should be and therefore it was not possible analyse this measure.

5.4 Budgetary Implications

We will now look at the budget implication for government to implement each of these measures. In this analysis we are not analysing the private costs that some of these measures may have. The private costs should however be discussed during stakeholder discussions for finalisation of TAP.

5.4.1 Feed in Tariffs

The government would need to make budget provision for this measure at three levels

i) A budget for drafting regulations at national / state and grid level

ii) A budget for improving grids

iii) A budget for providing incentive for electricity

The budget for item i) has been put as 100,000 USD however in practice this would require a discussion with the concerned ministry. The improvement to grids (ii) in terms of augmenting capacity, supplying smart meters, making changes to billing system, etc are estimated at 1% of the capital costs assuming minimal changes in grids[5] and therefore put at 1.2 million USD.

The last item is relatively straightforward and since 30 MW capacity is envisaged and at 35% capacity utilisation, the amount of electricity produced in a year would be 91728 MWh and with a USD 10 per MWh incentive for electricity produced from Solar PV the annual subsidy would be 917,280 USD.

5.4.2 Capital and Operating Subsidy

The capital subsidy envisaged is 40% of capital cost. In order to limit the subsidy burden the maximum unit price has been fixed as USD 4 million per MW. Therefore, subsidy per MW would not exceed 1.6 million. For a target of 30 MW, the subsidy that government should make a provision for would be 48 million USD.

[5] In case SMART grids also have to be created the costs may be much higher. The introduction of smart grids in US can increase electricity prices for consumers by 8.4 -12.98% according to EPRI, 2014 http://www.rmi.org/Content/Files/EstimatingCostsSmartGRid.pdf Accessed October 15, 2014

The operating subsidy proposed is 50% of variable O&M. The maximum variable costs are capped at 5 USD per MWh. Therefore, for an electricity output of 91728 MWh the subsidy would be USD 229,320 per year.

5.4.3 Soft Support for Solar PV

The overall program costs would involve setting up testing facilities, and creating a team of people that can train the people in the solar PV within the country. The program costs can be estimated on the basis of running similar programs e.g., a program for cogeneration. Accordingly, the program cost is being put as USD 3 million for a period of 3 years.

5.5 Choice of Measure for inclusion in a TAP

It is clear that the two measures related to feed in tariff and capital and operating subsidies can individually make solar financially viable though long pay back periods can result in uncertainty for the buyers. The Soft Support program is a relatively low cost option but can reduce anxiety of homebuyers due to long pack periods by guaranteeing the life for solar panels. Therefore, either of the first two measures can be combined with Soft Support for Solar PV. The financial analysis provides the following results.

Feed in Tariff + Soft Support	**Capital / Operating Subsidy + Soft Support**
Financial Ratios	
• Simple Project IRR - 21% • Equity IRR - 19% • Net Present Value - 40 million USD • Pay Back period - 13 years	• Simple Project IRR - 21% • Equity IRR - 19% • Net Present Value - 37 million USD • Pay Back period - 13 years
Budgetary Impact	
• Budget Feed in Tariff - 2.2 million USD • Budget Soft Support - 3 million • Total Budget (One time) - 5.2 million USD • Budget Annual - USD 917,280 USD	• Budget Cap/Op Subsidy - 40 million USD • Budget Soft Support - 3 million • Total Budget (One time) - 43 million USD • Budget Annual - USD 229,320 USD

Table 20: Comparison of Measures

It is clear that both the measures can deliver nearly identical financial outcomes for the solar home system buyer. The decision would therefore depend on the budget required for their implementation by the government and secondly on the political feasibility of the two measures which happen within the stakeholder discussion for approval of TAP. In terms of budgetary impacts Feed in Tariff + Soft Support looks more attractive since the level of upfront costs is much lower than providing a capital /operating subsidy. The annual payments are much higher in case of Feed in Tariff + Soft Support however the difference in net present value from capital / operating subsidy + soft support is only 3.2 million USD. Therefore from a government standpoint feed in tariff plus soft support is the way forward.

6 Annex 3: Sources and structuring of Finance

6.1 Sources of Finance

Two important sources of finance for technologies are public finance and private finance. Public finance institutions have traditionally financed initiatives in climate change. By definition, public finance deals with revenue and expenditure of public authorities and their adjustments to each other. Usually there are specific mandates for public finance under which the revenues are collected and spent. Figure 3 gives a detailed structure of sources of public finance.

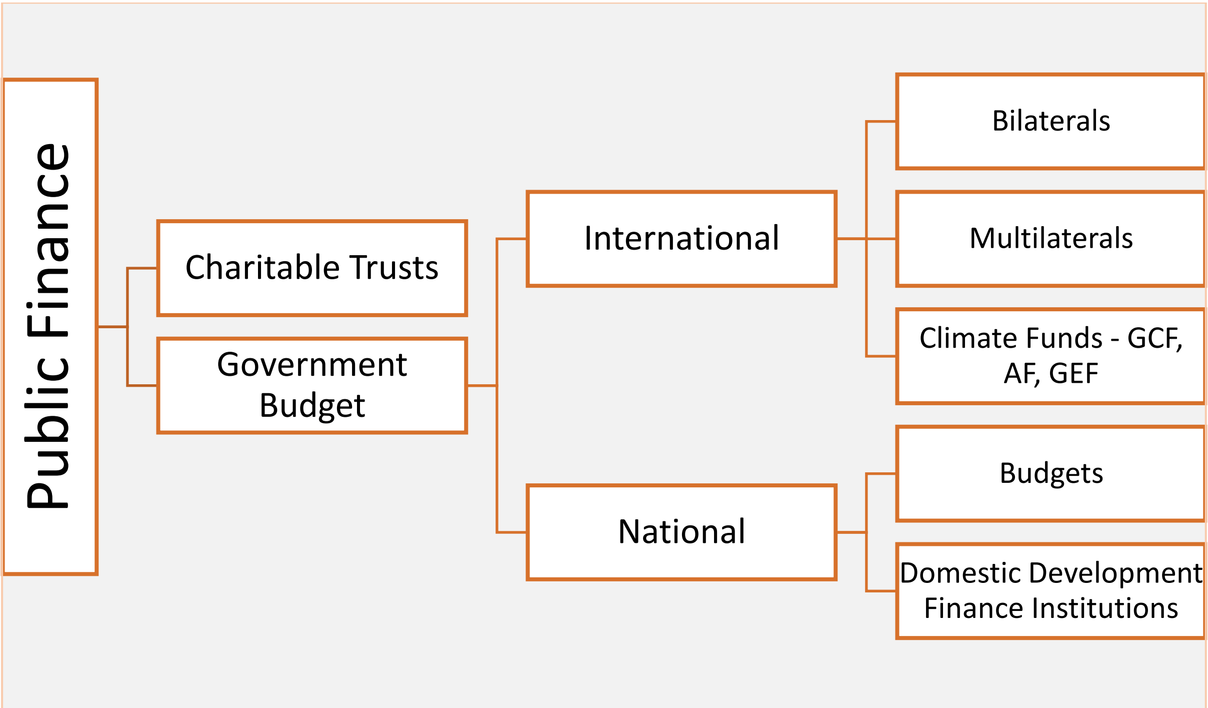

Figure 3: Sources of Public Finance

Government budget forms the crux of public finance. Within a country, climate initiatives in technologies can be financed through budgetary allocations i.e. from direct and indirect taxes, targeted taxes like cess, cross-subsidies and the like. Hydrocarbon taxes, waste disposal taxes, property taxes are common taxes used to fund climate initiatives in technologies. Environmental taxes are often taxed based on the principle of polluter pays and the revenue generated is used for restorative activities.

Climate initiatives in technologies can also be financed through domestic development finance institutions. These institutions provide loans, finance of community development and options for microfinance to finance initiatives. National Bank for Agriculture and Rural Development (NABARD) in India has been instrumental in providing finance for many developmental initiatives for agriculture in India. Rooftop solar panels are becoming increasingly popular in Bangladesh due to initiatives from Infrastructure Development

Company, Ltd. (IDCOL), a state owned company that provides credit and grants to rural families in Bangladesh. [6]

International sources of public finance include bilateral and multilateral development finance institutions (DFI) and specific climate funds. In financing from Bilateral DFIs, the donor government has the key decision making power and is in direct connection between the recipient country. The bilateral DFIs could be an independent institute, such as the Netherlands Development Finance Company (FMO) or a consortium of bilateral development banks such as German Investment and Development Company (DEG), which is part of the German development bank KfW.[7] The multilateral DFIs channel finance through international organizations whose members are nation states, and forwarded to countries through various developmental programmes.[8]These include organizations like Asian Development Bank (ADB), European Investment Bank (EIB) and African Development Bank Group (AfDB).

Finally, there are climate funds like Green Climate Fund (GCF), Adaptation Fund (AF) and Global Environment Facility (GEF). Climate finance refers to local, national or transnational financing, which may be drawn from public, private and alternative sources of financing addressing requirements for climate change adaptation and mitigation initiatives.[9] Financing from these funds is usually available in the form of grants, soft loans and technical assistance and often has a pre-condition of contribution from the government. As of May 2016, about 36.46 billion USD were pledged, 21.31 billion USD deposited and 15.5 billion USD approved as climate funds. This includes funds from Certified Emission Reductions (CERs), investments and the private sector.[10] India, Brazil and Mexico have been the top three recipients of multi-lateral finance; Indonesia, Brazil and Regional Sub-Saharan Africa have been the top three recipients of bi-lateral finance.

Engagement of private sector in climate initiatives has increased in the last few years. The Non-State Actor Zone for Climate Action (NAZCA) was launched after the COP in Lima, which provides a forum for commitments to the non-state actors. For e.g. Bank of America committed to invest USD 125bn by 2025 to advance low-carbon economic solutions through lending, investing, and facilitating capital[11]

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[6] http://blogs.worldbank.org/climatechange/lighting-rural-bangladesh-rooftop-solar-carbon-credits

[7] http://www.oecd.org/dac/stats/development-finance-institutions-private-sector-development.htm

[8] http://www.oefse.at/fileadmin/content/Downloads/Publikationen/Workingpaper/WP29_Finance_Institutions.pdf

[9] http://unfccc.int/focus/climate_finance/items/7001.php

[10] http://www.climatefundsupdate.org/data

[11] http://climateaction.unfccc.int/company/bank-of-america

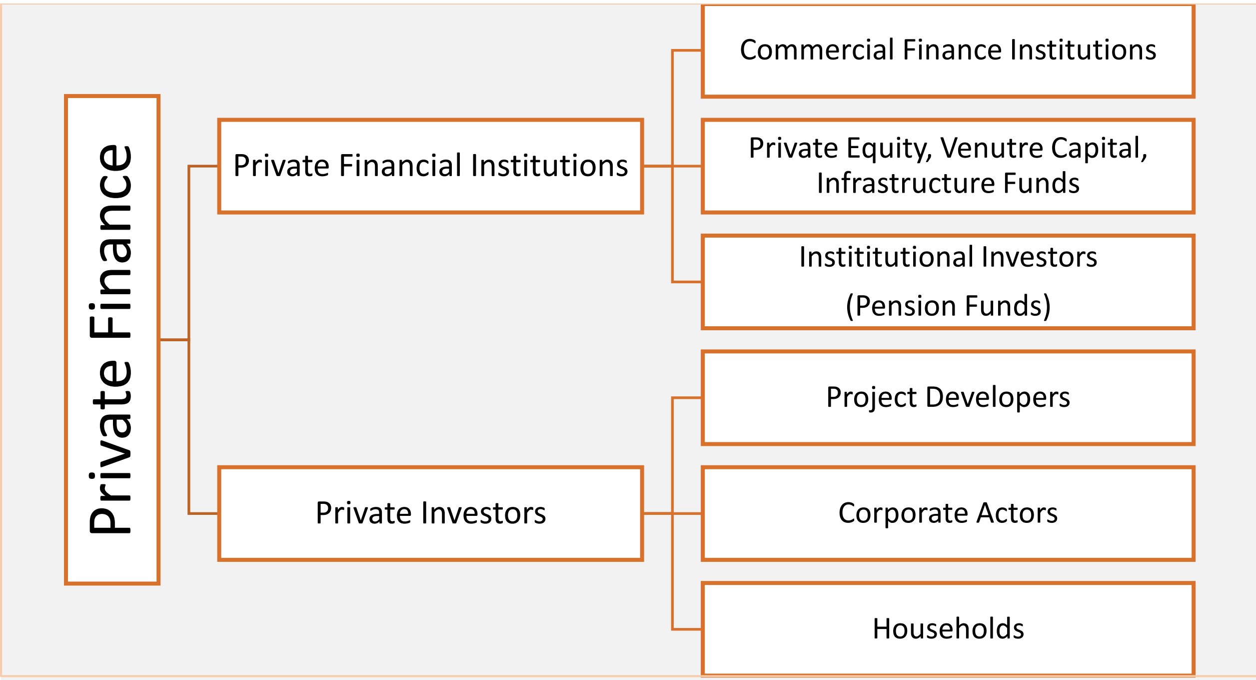

Figure 4: Sources of Private Finance

Apart from public sources of finance, private finances are also available either in part or for fully supporting the implementation of technologies. Especially in the context of market technologies, private partnerships can create self-sustaining business models with some support from the government. Private partnerships can also be useful in market development for new technologies and demonstrating their viability. In some cases, investments from the private sector can also be mandated. For example, India has mandated that companies with net profits above a certain threshold have contributed 2% of their profit for corporate social responsibility. The difference between technology projects in development and those for adaptation is very thin, making it easier to qualify for sources of multilateral finance.

Private finance is available in form finances from commercial finance institutions, investments from venture capitalists, private equity and infrastructure funds. Apartment from this, there are institutional investors such as mutual funds, insurance companies, pensions, hedge funds etc. Investments can be in the form of loans, equity, guarantees and subordinate contributions. Similarly, there are private investors such as project developers, other corporate actors and even households

It would be difficult to say which of these are available at cheaper rates as it would largely depend the risks associated with technology project. In general, micro finances and finance from multilateral agencies may be cheaper than the commercial finance institutions. Many times for projects where there are no demonstrated financial flows, private finance can only be available if certain enabling conditions are met. For example in the case of electric vehicles, a market has to be created, infrastructure has to be created and support for research and development has to be provided for private firms to invest in the technology.

Access to finance from the private sector may be relatively easier but it comes with guarantees, higher interests and quite often with reporting requirements[12]. The quantum may not be enough for ambitious projects. Public finance from multilateral agencies may be available for longer term and ambitious projects.

6.2 Structuring Finance

Financing diffusion of technology has two aspects. *First* is the investments that create assets. This comprises of costs that are incurred in infrastructure, equipment etc. *Second* is the non-investments. These are costs that are incurred for securing services such as technical expertise, knowledge products, training etc. Broadly, these can also be classified financial and technical investments.

The finance component in the TAPs can have two components. The first component is of technical assistance. The measures and activities in this component be in to support capacity building, knowledge generation, design of policies, structuring of institutional arrangements and the like. These are also the non-investment components. The investment component can be loans or grants to implement a policy or to establish a research and development or training institution for capacity building. Likewise, there is a financial component. The financial component elaborates the financial aspects to support and implement the activities identified in the TAP. The equity component is usually from the private sector. Depending upon the scale and nature of technology, the loans can be both from private and public sector. Capital and interest subsidies are provided by through public funds.

[12] http://www.gdrc.org/icm/ppp/private-funds.html

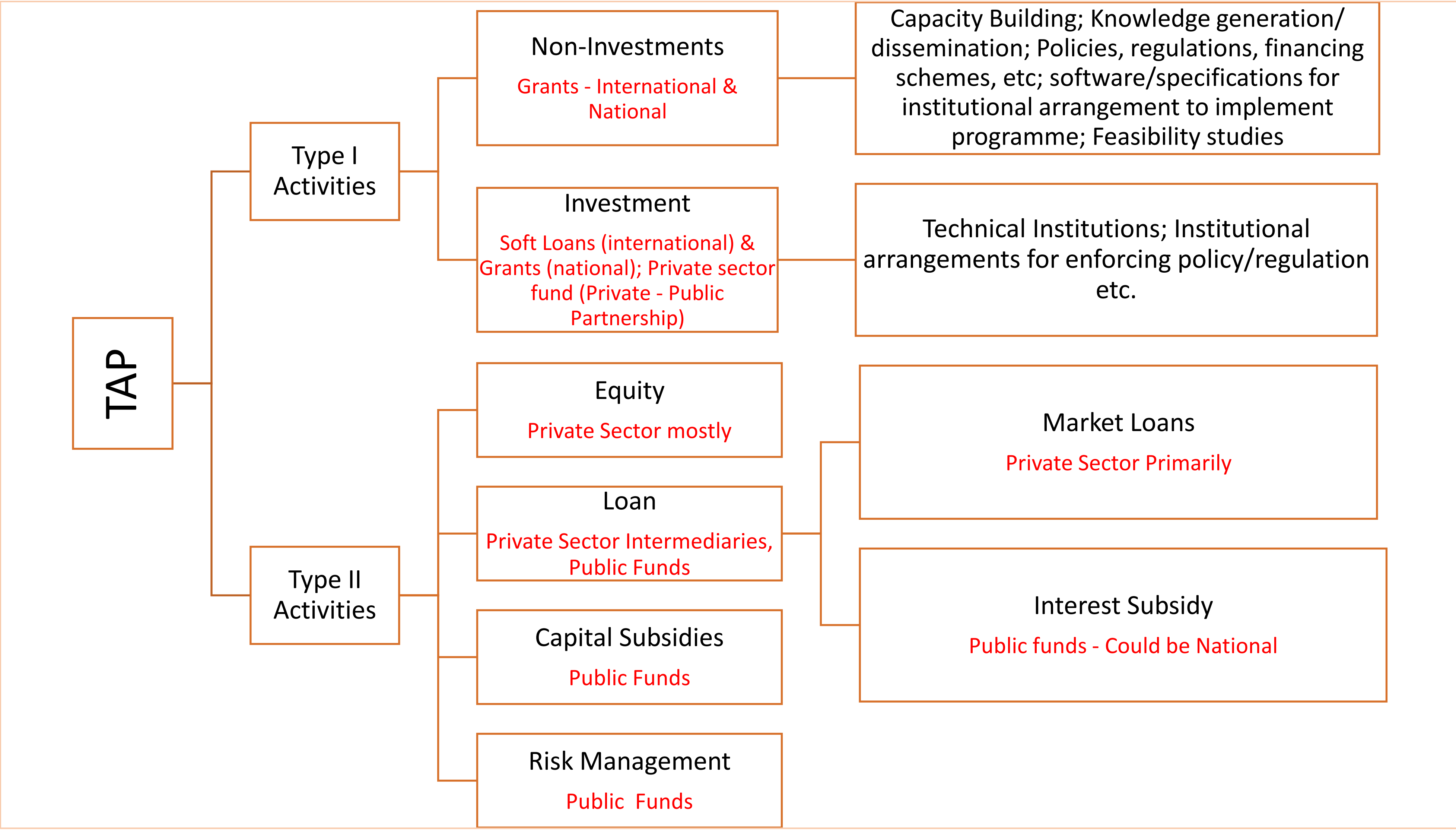

Figure 5: Structuring Finance in Technology Action Plan