6.1. The context

It is seen that the policy framework of a government is critical for promotion of RETs in a country. The implementation of these policies takes place through several programmes targeting different RE sectors. The programmes are usually designed assuming a straight line growth and are expected to follow the typical stages technology and market development cycle, comprising research and development, demonstration, deployment and diffusion. Further, the rationale or the sector-wise allocations are linked to these stages - If the technology is at the nascent or development stage; it receives R and D support and is also supported for demonstration. If the technology is mature as in the cases of small hydro, wind and to some extent biogas, these are supported for dissemination or diffusion through a set of incentives. The experience also indicates that powerful States or industry lobby or other political considerations succeeds in receiving higher or lower levels of budgetary allocations and incentives. Figure 6.1 gives RE sector-wise allocation over the Five Year Plans and Figure 6.2 gives allocation of resources to different RE sectors within the overall budget.
Possible Use of Diffusion Modelling as a tool for designing future Renewable Energy Programmes

**Figure 6.1:** Five-Year Plan Budgetary Allocations for Key RE Sectors (in Rs. Million)

![Budgetary Allocations Chart]

**Figure 6.2:** RE Sector-wise Five Year Plan Outlays

![Sector-wise Outlays Chart]

Source: Planning Commission

TERI University-Ph.D. Thesis, 2010
It can be seen that the biogas sector, being a socially driven programme, had received more than 50% of the total budgetary outlay for the RE sector during 1980s. This corresponds to the target setting as shown in Figure 6.3. This also reflects the process of subsidy allocation assuming a straight line growth of biogas installations. The financial resources however have varied as shown in Figure 6.4.

Figure 6.3 Target based biogas plant diffusion (No. of installations)

Source: MNRE Annual Reports
Figure 6.4 Five Year Plan budgetary allocations for biogas sector (in Rs. Million)

Figure 6.5 gives the resources allocated for Solar PV, a highly capital intensive and an emerging technology. During 2009, the government has proposed a national solar mission because of which the financial outlays have increased significantly.

Figure 6.5 Five Year Plan budgetary allocations for solar PV sector (in Rs. Million)
Wind sector, which has been almost commercialized, received a progressively declining share of the budget in the total outlay. However, wind sector receives indirect subsidies in the form of import concessions, depreciation and other tax benefits, which also affect the fiscal budget of the Government of India.

Solar thermal technologies (water heaters) were also introduced with subsidies initially and the subsidies were withdrawn in 1994 considering that the technology has become mature. But, the government re-introduced subsidy and has increased the share of allocation from 2007-12 to accelerate the diffusion of solar thermal technologies.

Although the extent of influence of policies on diffusion is difficult to assess, it is possible to analyse the differential impacts using a theoretical framework. Chapters 5 and 6 presented the two distinct approaches adopted for diffusion of two mature technologies – wind power and biogas under different environments. This Chapter analyses diffusion parameters of different technologies in the same environment (common States where biogas and wind programmes are implemented) and also at a national level. A case is then made for the use of diffusion parameters to design a programme using advanced cookstoves as an example. Finally, the diffusion trends obtained through the model are compared with the actual diffusion trend and the implications of the use of diffusion models are presented.

6.2. A comparison of diffusion parameters – biogas and wind power

Table 6.1 gives a summary of the diffusion parameters for wind and biogas. It is observed that while the p and q values are similar in some States for the same technologies, there are significant differences in t* and NGRTI (which is the rate of diffusion at TI as a fraction of total potential).

TI or t* in the case of wind is lower implying that the market based approach could accelerate diffusion significantly. The value for t* for biogas is higher implying that the subsidy based, state run programmes take a long time to complete the diffusion. Table 6.2 summarises the two critical parameters t* and NGRTI for biogas and wind in India.
Table 6.1 Summary of diffusion parameters for wind power and biogas

<table>
<thead>
<tr>
<th></th>
<th>Andhra Pradesh</th>
<th>Gujarat</th>
<th>Maharashtra</th>
<th>Tamil Nadu</th>
<th>Karnataka</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind power</td>
<td>0.001</td>
<td>0.009</td>
<td>0.0001</td>
<td>0.014</td>
<td>0.0004</td>
</tr>
<tr>
<td>Bio-gas</td>
<td>0.0001</td>
<td>0.014</td>
<td>0.0025</td>
<td>0.0073</td>
<td>0.0004</td>
</tr>
<tr>
<td>p</td>
<td>0.196</td>
<td>0.244</td>
<td>0.379</td>
<td>0.462</td>
<td>0.379</td>
</tr>
<tr>
<td>q</td>
<td>0.099</td>
<td>0.06</td>
<td>0.07</td>
<td>0.068</td>
<td>0.5</td>
</tr>
<tr>
<td>t*</td>
<td>27</td>
<td>32</td>
<td>20</td>
<td>18</td>
<td>11</td>
</tr>
<tr>
<td>dN/dt/m</td>
<td>0.05</td>
<td>0.01</td>
<td>0.02</td>
<td>0.12</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Table 6.2 Wind and biogas diffusion parameters for India

<table>
<thead>
<tr>
<th>Wind Power</th>
<th>Biogas</th>
</tr>
</thead>
<tbody>
<tr>
<td>t* (in years)</td>
<td>NGRTI</td>
</tr>
<tr>
<td>All India</td>
<td>16</td>
</tr>
</tbody>
</table>

6.3. Use of t* and NGRTI for designing programmes

6.3.1 A thought experiment of designing a market based programme of advanced cookstoves using diffusion parameters

The above analysis shows that diffusion parameters – t* and NGRTI represent the speed of the diffusion. The case of diffusion of wind power gives a value of 16 years for t* and 8% for NRGTI. Any programme of promotion that is desired, such as the National Solar Mission or promotion of solar water heaters by UNDP, can in principle plan the programme to achieve fast diffusion. Since the National Programme on Improved Cookstoves was closed, rather suddenly, several advanced cookstoves have been developed and promoted by commercial players such as Philips, Shell Foundation, BP, etc. Since these stoves reduce black carbon emissions, there are renewed interests from the government. The choice is again between a subsidy based programme or a market oriented one. One can be ambitious with a t* of 10 years, NGRTI of targeting the ultimate
potential of 120 million stoves. With these numbers, we can get $p = 0.001$ and $q = 0.64$. The diffusion curve for these numbers is shown in Figure 6.6. The actual cumulative achievements of NPIC are shown in Figure 6.6. The difference in diffusion speed is quite obvious.

**Figure 6.6** Advanced cookstoves diffusion programme (in Million No.) For $t^* = 10$ years
One of the problems with such an approach is that one is never sure how the diffusion will proceed and it will be impossible to allocate programme funds. Hence, such a programme has to be flexible, with possibilities of adjusting activities and funding levels continuously. As the diffusion will be slow in the beginning (Figure 6.6 (a)), the programme would not fix high annual targets,
hence there will be lesser pressure for meeting the targets. The initial period can then be used for market promotion activities such as awareness generation, creation of testing facilities, development of supply chains, R and D for product fine-tuning etc.