

# Development of Technology

## 7.1 Introduction

Availability and development of technology is an integral part of capacity expansion programme of any manufacturing enterprise. While considering and approving the Phase-II and III capacity expansion programmes, Board of Directors considered the status and further requirements for technology to sustain the proposed capacity expansion schemes. Accordingly, audit examined the adequacy of Research and Development efforts of BHEL to acquire and absorb contemporary technology in its production process.

BHEL was ranked (July 2011) ninth in Forbes List of World's most innovative companies and was also awarded SCOPE<sup>43</sup> meritorious award for R&D, Technology Development and innovation in 2011-12. With a view to developing necessary skills and technology base for product engineering, product development and field engineering, BHEL established (August 1973) Corporate Research and Development (R&D) Division<sup>44</sup> at Hyderabad. All production units of BHEL also undertake limited R&D activities in respect of the equipments being manufactured by them.

## 7.2 Technical Collaboration Agreements

For design and manufacture of various types of equipments, BHEL entered into 10 Technology Collaboration Agreements (TCAs) and two Memoranda of Understanding (MoU) during August 1976 to November 2010 with foreign Original Equipment Manufacturers (OEM) for 14 major products<sup>45</sup> including one for exploration of oil well as detailed in *Annexure VI*. The TCAs did not contain provisions to provide source codes and 'know why' of the technology to BHEL. On an Audit query about the efforts made to obtain 'know why', BHEL expressed difficulty in obtaining source codes as well as 'know why' from technology partners under the TCAs as the latter were not willing to transfer technology. In the absence of arrangements to absorb technology from foreign partners, in-house R&D assumes significant importance so as to reduce dependence on technology partners under TCA in the long run.

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<sup>43</sup> *Standing Conference of Public Enterprises*

<sup>44</sup> *In addition to five specialized institutes viz., Welding Research Institute at HPBP-Trichy, Centre for Electric Traction and Hydro Laboratory at Bhopal, Ceramic Technological Institute at Bangalore, Pollution Control Research Institute at Haridwar and Amorphous Silicon Solar Cell Plant (ASSCP) at Gurgaon.*

<sup>45</sup> *Natural Circulation Waste Heat Steam Generators, Steam Turbines, Generators, Gas Turbines, Once through Boilers, Pulverisers, Pumps, Forging of rotors & generators, Centrifugal Compressors, Oil Rigs, Gera Boxes for pulverisers and bowl mills, Variable pitch Axial flow fan, C&I Automation and water treatment Equipment.*

Management stated (June 2012) and further explained (April 2013) that

- the concept of encouraging indigenous manufacture of supercritical equipment in the country took roots with the conceptualization of Bulk Tender (11 nos. 660 MW sets and 9 nos. 800 MW sets) floated by NTPC Ltd. and Damodar Valley Corporation in October 2009 based on a Cabinet decision, which *inter-alia* mandated the need for complying with technology absorption and a commitment by all bidders for adopting a phased manufacturing programme to participate in the bids. Several domestic companies formed Joint Venture entities with global Original Equipment Manufacturers (OEMs) for this purpose.
- With the intent of allowing various utilities to gain familiarity with new supercritical technology, CEA had framed guidelines for eligible bidders which *inter-alia* specified that all bidders must, along with their bid for Boilers and Steam Turbine-Generators (STGs) submit, a Deed of Joint Undertaking (DJU) in which all the executing parties (*i.e.* the bidder, the technology provider, the Indian manufacturing company and the Indian promoter of the JV-as applicable) shall be made jointly and severally liable to the Purchaser for successful performance of the Contract. Certain domestic tenders for supercritical power projects insist on submission of a DJU. As BHEL gets qualified only by virtue of technical collaboration agreements, the submission of DJU by technology provider becomes mandatory for BHEL's qualification in the tenders. Insistence of compliance with the specific conditionality of DJU places BHEL in a disadvantageous position *vis-a-vis* its technology collaborators, as such conditionalities are used by the collaborators to negotiate a larger share of business from BHEL in the contracts awarded, though BHEL has the requisite capabilities.

Reply of the Management is to be viewed against the fact that purchasers had insisted on DJU wherever the bidders did not meet the specified qualifying criteria of designing and manufacturing supercritical sets on their own. Thus, there is a need for BHEL to acquire and upgrade to contemporary technology for its core business activities.

Audit examined the R&D expenditure and activities of BHEL and units as discussed in the following paragraphs.

### **7.3 R&D Expenditure**

Working Group on Power constituted by Planning Commission for XI Plan (Working Group) compared R&D Expenditure of BHEL with GE, Siemens, Alstom, Hitachi and Mitsubishi Electric during 2003-05 and observed (February 2007) that expenditure on R&D incurred by BHEL ranged between 1.007 *per cent* and 1.211 *per cent* of turnover while the corresponding expenditure of other organizations ranged between 1.8 *per cent* and 6 *per cent* of their turnover. Working Group *inter alia* added that since technology advancements and R&D had not so far been properly addressed, manufacturing organizations (BHEL, ABB and

Siemens) must enhance their budget allocations for R&D substantially by providing 3 to 4 *per cent* of turnover for technology development.

Details of R&D expenditure incurred by BHEL during 2007-12 as percentage of turnover are shown in Table 28.

**Table 28**

| Year         | R&D Expenditure <sup>46</sup><br>(₹ in crore) | Turnover<br>(₹ in crore) | Percentage of R&D<br>Expenditure to<br>Turnover. |
|--------------|---|--------------------------|--|
| 2007-08      | 295.79  | 19304.64                 | 1.53   |
| 2008-09      | 421.09  | 26212.33                 | 1.61   |
| 2009-10      | 369.88  | 32861.11                 | 1.13   |
| 2010-11      | 421.73  | 41566.13                 | 1.01   |
| 2011-12      | 444.24  | 47228.00                 | 0.94   |
| <b>Total</b> | <b>1952.73</b>                                | <b>167172.21</b>         | <b>1.17</b>                                      |

Expenditure on R&D was, thus, not only less than the desired levels as envisaged by the Working Group but also declined as a percentage of turnover over the last three years ended March 2012.

Management stated (April 2013) that as per annual reports, R&D expenditure for the previous five years was ₹ 464 crore, ₹ 690.01 crore, ₹ 829.27 crore, ₹ 981.86 crore, ₹ 1198.82 crore for the years 2007-08, 2008-09, 2009-10, 2010-11 and 2011-12 respectively.

Reply of the Management is to be viewed against the fact that figures taken by the management were as per the Directors' Report included in the annual report and not as per the audited annual accounts of BHEL. On verification by Audit, it was observed that the figures indicated by the Management also included expenditure of ₹ 167.62 crore, ₹ 268.92 crore, ₹ 459.39 crore, ₹ 560.13 crore and ₹ 754.58 crore for the years 2007-08, 2008-09, 2009-10, 2010-11 and 2011-12 respectively, incurred by way of modifications, design and development to meet customer-specific requirements to execute their orders and were thus billed to customers as part of turnover. As per Accounting Standard 26 (Para 6) 'Development has been defined as application of research findings or other knowledge to plan or design for the production of new or substantially improved materials ..... prior to the commencement of commercial production or use'. The expenditure incurred to meet customer specific requirements under contracts in the process of order execution is a part of commercial production and is, therefore, not Research and Development expenditure as per Accounting Standard 26. Thus, there was a need for matching and reconciliation of figures of Directors' Reports with the annual accounts of BHEL.

Management agreed (September 2013) to include suitable clarifications in the Directors' report from financial year 2013-14.

Audit further observed that R&D expenditure incurred by BHEL as a percentage of its turnover and also in absolute terms was significantly less than that incurred by its competitors

<sup>46</sup> As per Annual audited accounts of respective years

during the last four years (for which data was available based on the annual reports of the competitors<sup>47</sup>) as shown in the Table 29.

Table 29

| Sl.No | Particulars                     | SIEMENS  | ABB                      | ALSTOM                                   | BHEL   |
|-------|---------------------------------|--|--------------------------|--|--|
| 1     | Main Business                   | Energy, Industry, Healthcare (in Million Euro) | Energy (in Million US\$) | Energy, Transportation (in Million Euro) | Energy, Industry, Transmission, (in ₹ crore) |
| 2     | Turnover/ Revenue <sup>48</sup> | 296,471  | 136,286                  | 79,246                                   | 1,47,868                                     |
| 3     | R&D Expenditure                 | 15,167   | 4,517                    | 2,529                                    | 1657   |
| 4     | Percentage of R&D to Turnover   | 5.12   | 3.31                     | 3.19                                     | 1.12   |

Expenditure of BHEL on R&D (1.12 *per cent*) was, thus, the lowest in relation to its turnover compared to main international competitors. This was despite availability of adequate cash reserves<sup>49</sup> as well as directions of the Board of Directors (May 2009) to enhance R&D expenditure upto 4 *per cent* of turnover. Further, Principal Scientific Advisor to Prime Minister also emphasized (August 2011) that BHEL needed to bridge the knowledge gaps in core and specialized areas required for indigenous R&D, especially in knowledge economy regime.

Management stated (September 2013) that during 2011-12, R&D expenditure of BHEL was 2.42 per cent which was much higher than the corresponding figures of companies in the similar field like L&T, Siemens (India), ABB (India), Thermax, Crompton Greaves, *etc.*

While Audit appreciates that the expenditure incurred by the company was higher than Siemens (India), ABB (India), *etc.* as stated by the Management, a better comparison would be possible with global manufacturers and international competitors of the company as against only Indian subsidiaries of the these competitors. The Board of Directors of BHEL in their 433<sup>rd</sup> meeting held on 7 and 8 May 2011 themselves recognized that the R&D expenditure of BHEL was significantly less as compared to its international competitors like Siemens, ABB, Alstom, *etc.* Further, in a reply to audit query BHEL informed (March 2012) that 8 orders aggregating ₹ 6725.86 crore in respect of power equipment equivalent to 2,104 MW were lost (even after emerging as the lowest in terms of quoted price) during 2007-08 to 2011-12 due to superior operational parameters of the equipment like higher output, lower fuel cost, offered by competitors. This underscores the need for taking measures including more focused and result oriented R&D efforts to match the operational parameters of

<sup>47</sup> Annual accounts of (i) Siemens (years ended Sept 2008, 2009, 2010 and 2011); (ii) Alstom (years ended March 2009, 2010, 2011 and 2012); (iii) ABB (years ended Dec 2008, 2009, 2010 and 2011) and (iv) BHEL (years ended March 2009, 2010, 2011 and 2012).

<sup>48</sup> Source: Balance Sheets of respective companies

<sup>49</sup> Cash reserves held by BHEL at the end of March 2009, 2010, 2011 and 2012 were ₹ 8364.16 crore, ₹ 8925.00 crore, ₹ 9186.53 crore and ₹ 6311.62 crore respectively.

customers. This would help improve the order book position and consequent capacity utilization of BHEL.

Management stated (April 2013) that there was loading to the quoted price of BHEL by customers due to various operational parameters (not related to technology gaps) or contractual aspects and no contract was lost due to inadequacy of technology.

Reply of the Management is to be viewed against the fact that in response to audit query, Management informed that loadings in cases pointed out by Audit were on account of higher fuel cost, lower output of offered sets, higher cost per KW and other boilers offered in place of CFBC<sup>50</sup> boilers. Board of Directors in their 433<sup>rd</sup> meeting held on 7 and 8 May 2011 recognized the need for immediate acquisition of cost effective CFBC technology. BHEL would only gain by recognizing the need for further upgradation of technology and devising an appropriate strategy to continuously match superior operational parameters offered by competitors.

## 7.4 Strategic Plan

### (i) Setting up of new Centers of Excellence – Welding Research Institute

Strategic Plan of BHEL for the period 2007-12 was prepared in May 2007. The draft Roadmap for Strategic Plan for 2007-12 envisaged that HPBP- Trichy was to set up a new Centre of Excellence for Advanced Fabrication Technology (COE)<sup>51</sup> by the end of March 2010 in two phases. The COE was envisaged to increase productivity in manufacturing and product quality through introduction of advanced welding technology in various units of BHEL. Accordingly, Corporate Office approved (May 2008) the proposal submitted (April 2007) by HPBP Trichy for Phase-I of COE at a cost of ₹ 16.60 crore.

Audit observed that Phase I of COE was completed in July 2011 as against the scheduled date of March 2010. While delay of 6 months out of the total delay of 16 months (March 2010 to July 2011) in completion of Phase I of the COE was on the part of foreign vendor for one of the equipments, delay of 10 months was due to delay on the part of BHEL in finalization of vendors and placement of orders. Corporate Office decided (September 2010) to commence Phase-II after conducting welding process and technology audit in all units of BHEL. Accordingly, after completion of welding process and technology audit, the proposal for ₹ 49.07 crore under Phase-II, to be completed within 24 months from the date of approval, was submitted by HPBP Trichy (October 2011). The proposal envisaged acquisition of 12 new technologies for increased productivity and product quality. The proposal was yet to be approved by Corporate Office of BHEL (September 2013).

Management stated (April 2013) that some of these facilities leading to enhanced capabilities and technologies had immediately been commissioned and are operational since

<sup>50</sup> *Circulating fluidized bed combustion*

<sup>51</sup> *New Center of excellence envisaged to increase the productivity in manufacturing and product quality through introduction of advanced welding technology in various units of BHEL [i.e. Ranipet, Hyderabad, Bhopal, Jhansi, Haridwar, Trichy (valves), Trichy (Welding research institute)]*



2010 at the respective intended units of BHEL and benefits of Phase-1 were indeed being availed by BHEL. Management added (September 2013) that delay in Phase I was also due to damage of an equipment in transit.

Reply of the Management is to be viewed against the fact that apart from damage of one of the equipments in transit, there were ordering delays in four out of 10 equipments envisaged in Phase-I. Similarly, the benefit of 12 new technologies envisaged in Phase-II remained to be availed.

Thus, benefits have been reaped only partially so far and the project which envisaged increase in productivity in manufacturing and product quality through introduction of advanced welding technology in 2010-11 is yet to be completely implemented (September 2013).

### **(ii) Non-induction of Qualified and Experienced Experts at Lateral Levels**

Strategic Plan 2007-12, *inter-alia*, envisaged lateral recruitment for desired competencies required for specific positions and functions in specialized areas. The Board of Directors of BHEL also suggested (May 2009) that the organizational structure of R&D should be reviewed keeping in view the need for rationalization of manpower with highly qualified experts with minimum non-technical staff.

After assessment of manpower requirements, a requirement of 178 experts to be recruited through lateral entry was approved (November 2010) by CMD, BHEL. Against this only six experts had been laterally inducted up to March 2012 and another 42 experts were recruited in August 2012. Remaining 130 posts were yet to be filled up (March 2013).

Management stated (April/September 2013) that despite best efforts, only 42 qualified persons joined against 172 planned due to non-availability of qualified candidates. Research and development activity was being complemented by a team of 261 qualified subject matter experts engaged in full time R&D at Corporate R&D, Hyderabad.

The fact remains that 130 additional experts planned to be recruited through lateral entry were not appointed which underlines the need for strengthening R&D effort and take on the challenges in technology and innovation effectively.

## **7.5 System for incurring R&D expenditure**

BHEL formulated R&D Management System in 1970's which was revised in November 2005 and was further replaced with a system document namely "Corporate Engineering & Product Development (CEPD) Management System Manual" in March 2011. As per requirements of CEPD Manual, BHEL has set up technical committees and product committees for different products at Unit level. Technical Committee *inter alia* scans recent developments in technology in the world and their potential application to products of BHEL and decides action plan for bridging identified technical gaps. Product committee *inter alia* evaluates and recommends new R&D projects and raises Project Initiation Reports (PIRs) for product development, up gradation and quality improvement. PIRs for projects upto ₹ 25 lakh are approved by Head of the Unit and those of higher amounts are submitted to Corporate R&D and Corporate office of BHEL for approval as per delegation of powers.

Audit observed that there were no time limits for evaluation and taking decision on PIRs proposed by Unit level committees on identified technical gaps. During 2007-08 to 2010-12, Corporate Office took between 31 and 898 days for sanctioning expenditure in respect of 106 out of the 176 PIRs referred to it. Further, CEPD Manual does not contain any criteria and guidelines for taking decision about Technical Collaboration, Collaborative R&D and outsourcing R&D activities.

The Management stated (April/September 2013) that all projects committed as per Strategic Plan 2017 are monitored for timely initiation and completion through IT enabled tool. There is a constant endeavour to expedite the approval process. Management added that new R&D Policy stipulated the criteria for arriving at decisions through tools like value-ability matrix which would enable the most suitable choice between technical collaboration, in-house development/outsourcing/collaborative development, *etc.* to be made.

Audit appreciates the efforts made by Management in this regard. However, there is also a need to fix time limits for taking decisions on proposed PIRs to effectively monitor the progress.

## 7.6 R&D Activities

As indicated in para 7.1 *supra*, R&D activities were mainly carried out by Corporate Research and Development (R&D) Unit<sup>52</sup> at Hyderabad. Besides this, production units of BHEL also undertook limited R&D activities in respect of the equipments being manufactured by them. Audit reviewed records at Corporate Office and Corporate R&D Hyderabad. Table 30 summarizes the details of various types of projects undertaken by Corporate R&D unit Hyderabad during 2007-12:

<sup>52</sup> *In addition to five specialized institutes viz., Welding Research Institute at HPBP-Trichy, Centre for Electric Traction and Hydro Laboratory at Bhopal, Ceramic Technological Institute at Bangalore, Pollution Control Research Institute at Haridwar and Amorphous Silicon Solar Cell Plant (ASSCP) at Gurgaon.*

**Table 30***A – No. of projects; B – Outlay (₹ in crore)*

| Sl. No       | Category of Projects         | 2007-08   |              | 2008-09   |              | 2009-10   |              | 2010-11   |              | 2011-12   |              | Total      |               |
|--------------|------------------------------|-----------|--------------|-----------|--------------|-----------|--------------|-----------|--------------|-----------|--------------|------------|---------------|
|              |                              | A         | B            | A         | B            | A         | B            | A         | B            | A         | B            | A          | B             |
| 1            | Cost Reduction               | 4         | 0.55         | 1         | 0.81         | 2         | 1.02         | 3         | 1.53         | 2         | 1.90         | 12         | 5.81          |
| 2            | Quality Improvement          | 21        | 5.87         | 12        | 3.63         | 35        | 17.21        | 30        | 11.63        | 35        | 15.01        | 133        | 53.35         |
| 3            | Import Substitution          | 1         | 0.47         | --        | --           | 1         | 0.42         | 1         | 0.45         | 0         | 0            | 3          | 1.34          |
| 4            | New Product                  | 15        | 9.43         | 9         | 10.06        | 17        | 28.51        | 11        | 10.35        | 19        | 16.77        | 71         | 75.12         |
| 5            | Enhancing Business Potential | 11        | 4.96         | 11        | 7.02         | 12        | 13.29        | 15        | 11.19        | 11        | 8.51         | 60         | 44.97         |
| 6            | Basic Research               | 5         | 0.79         | --        | --           | 3         | 0.83         | 2         | 0.39         | 3         | 0.68         | 13         | 2.69          |
| 7            | Knowledge Management         | 3         | 0.57         | 1         | 0.20         | --        | --           | --        | --           | 0         | 0            | 4          | 0.77          |
| <b>Total</b> |                              | <b>60</b> | <b>22.64</b> | <b>34</b> | <b>21.72</b> | <b>70</b> | <b>61.28</b> | <b>62</b> | <b>35.54</b> | <b>70</b> | <b>42.87</b> | <b>296</b> | <b>184.05</b> |

Audit examined the above 296 projects and observed that R&D activities carried out by Corporate R&D unit at Hyderabad related mainly to peripherals/ components/ sub-systems of major equipments. Projects relating to up-dation/ upgradation/development of a major product, as a whole, were not taken up.

The unit Management stated (January 2012) that the observation of Audit was factual. The corporate Management added (April/September 2013) that holistic development plans are indeed pursued by BHEL through Mission projects and Technology plan projects under the Strategic Plan 2017. However, Indian utility operators have always insisted on proven designs/technology choices making it impossible for indigenously developed new designs to be tried out and evaluated.

While Audit appreciates action proposed to be taken under Strategic Plan 2017, further professionalization of R&D efforts for major products would help BHEL to more effectively take on competition by remaining in the forefront of technology and strengthen its order book for better utilization of its manufacturing capacity.