ENTERPRISE
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# ENGINEERING DESIGN SECTOR RESEARCH AND FEASIBILITY STUDY

# REPORT

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# EXECUTIVE SUMMARY

This research of Armenia's engineering services sector has been conducted to evaluate the current state of the sector, analyze its development perspectives and design strategy for sector's development.

The study report includes definition of the sector, survey of managers of Armenian engineering companies and the summary of their opinion, global analysis of engineering services industry as well as the mapping describing sector's potential in Armenia. The report conclusion describes possible strategy aspects of sector's development.

### *Survey Results*

There are about 50 companies representing engineering services sector which are mainly specialized in the field of design of power construction and hydraulic work. The majority of companies are of medium size comprising of 20-100 employees. Almost 50% of the workforce employed in the engineering services sector is comprised of engineers and scientists.

In 2009, the majority of Armenian engineering companies had an average income of 50-100 million Armenian drams. Most of the companies observed have 100% of their income from engineering services. For 2009, the overall turnover estimated for Armenian companies providing engineering services was 10.5-13.5 billion Armenian drams. In coming three years an average annual increase of 11% is expected.

Domestic sales of Armenian companies providing engineering services amount to nearly 85%. 15% is exported to other countries, mainly to USA.

**Main obstacles hindering development of the engineering sector and support needs according to company managers participated in the survey**

| Development obstacles | Support needs and areas |
|---|---|
| • Low-qualified graduates<br>• Not affordable financial resources<br>• Poor tax regime and legal framework<br>• Absence of strategy for sector's development<br>• Low use of state-of-the-art technologies<br>• Export and import regulations<br>• Limited domestic market<br>• Underdeveloped marketing capabilities | • Development of human resources<br>• Marketing support and getting new orders<br>• Support in strategic planning<br>• Attracting of financial resources<br>• Selection of export markets and support to export<br>• International certification<br>• Promotion of cooperations and joint efforts |

### *Engineering services global market*

Main market components of engineering services sector are the engineering services provided by specialized companies as well as research and development (R&D) activities performed by industrial companies.

According to the report of USA National Science Board "Key Science and Engineering Indicators-Digest 2010" R&D expenditures worldwide are estimated to have exceeded $1 trillion in 2007, at twice the rate during the last decade.

The economy of the USA is the main consumer of engineering services. It accounts for about 40% of the global market. European share of engineering services expenditures fell by one third.

Outsourcing of engineering services by European companies has the most wide-spread geographical distribution. Sectors such as mechanical engineering, electronics and chemical industry are tended to internalization at the most part.

A range of developing countries like India, China, Brazil, Philippines became to outsourcing zones for engineering services due to big concentration of graduates having technical education.

Currently, R&D designs are the most outsourced functions in foreign countries. IT and financial and accounting services are the next in the range.

It's expected that engineering service providers from China and India currently active in the lowest segment of the market will considerably improve the quality of services offered resulting in higher offshore expenses in their countries. A range of new founded market participants such as Nigeria, Philippines, South Africa, and Brazil will compete in the lowest segment of the industry. Malaysia, Czech Republic and Russia will offer services of higher quality.

### *Competition models in the engineering services sector*

The market of engineering services has its peculiar logic forming main business competition models.

Basic competition models currently popular in the engineering services sector can be divided into five types each different by its format of relations to customers/markets and by unique value offerings which are represented by companies using this model:

Model 1: Research and development centers, mainly of transnational corporations;

Model 2: Providing of services in the outsourcing market;

Model 3: Providing of complex services by specialized companies;

Model 4: Regional representations of global companies;

Model 5: Opportunistic model which is providing of engineering services by industrial companies (mainly not regularly).

### *Mapping of capabilities of Armenian engineering services sector*

To compile a mapping of capabilities of the Armenian engineering services sector a bilateral evaluation system has been used (surveys of company managers and sector experts). Based on surveys conducted with engineering service providers the most active branches of

the engineering sector have been selected according to the number of active companies, turnover, workforce productivity and internalization degree.

From the other side, based on experts' evaluation the previous, present and expected future capabilities of the sector have been compared and a total index of capabilities has been calculated for each sector.

According to the resulted appraisal sectors of high technology, construction and infrastructure have been accepted as the most promising directions.

### *Engineering services sector development strategy*

As a unifying macrolevel vision development of engineering services sector can be anticipated in two parallel directions. The first direction emphasizes growth based on local factors while the second gives weight to the influence of foreign market factors.

**Direction 1: Development direction from foreign markets**

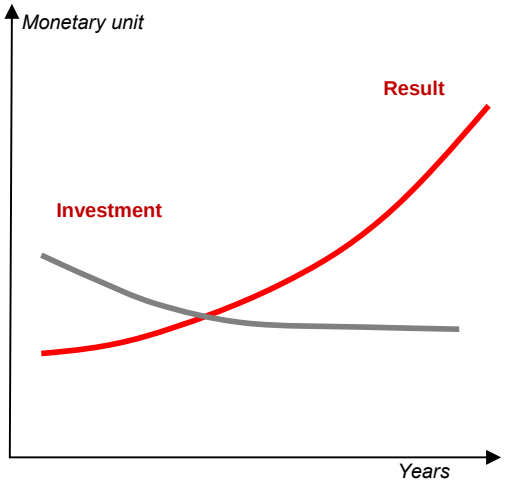
Development direction arising from foreign markets is similar to the model currently functioning in the information technology sector and suspects involvement of the country in the global value chain by specializing in provision of any function or functions.

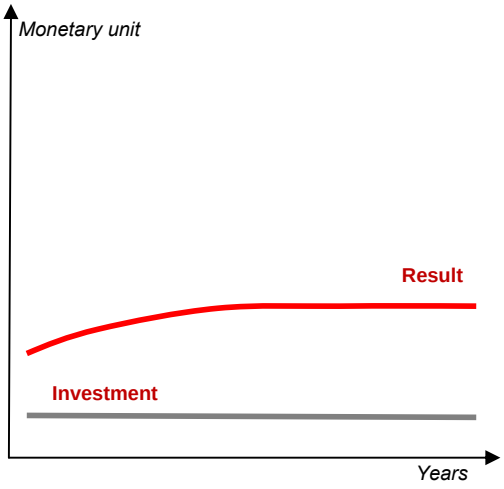
It should be noted, that Direction 1 includes two main scenarios for the sector's development; both of them are different by degree of intervention by governmental and other public bodies.

According to the first scenario the future growth of the sector shall be based on fundamental structural interventions which will create necessary infrastructure and scientific potential to turn Armenia into an R&D center.

In case the second scenario is used invested trivial resources can always bring only short-term and purely quantitative results.

Below is the comparative correlation of invested efforts and obtained results for two different scenarios of Direction 1.



General directions of interventions necessary by first scenario of Direction 1 are described below.

| Horizon 1 (1-5 years) | Horizon 2 (5-10 years) |
|---|---|
| **Horizon 1** | **Horizon 2** |
| **EDUCATION**<br>Professional training<br>Non-professional training<br>Promotion of education-industry association<br>Modernization of educational infrastructure | **EDUCATION**<br>Registering Armenian State Engineering University in international lists of leading technology universities |
| **MARKET/DEMAND**<br>Orders for Armenian engineering companies<br>Targeting of global companies<br>Target communication<br>Support to attract multinationals | **COUNTRY BRANDING AND ATTRACTION OF INVESTMENTS** |
| **DEVELOPMENT OF BUSINESS CAPABILITIES IN EXISTING ENGINEERING COMPANIES** | **SUPPORT TO ARMENIAN TECHNOLOGY COMPANIES** |
| **IMPROVEMENT OF BUSINESS ENVIRONMENT** | **TECHNOLOGY COMMERCIALIZATION INFRASTRUCTURE** |

The second scenario of Direction 1 supposes trivial external intervention in the engineering sector, or its absolute absence. In this case, the following activities shall be carried out:

- *Courses to prepare specialists*

- *Preparation of managers*

- *Strengthening of cooperation between sector participants*

- *Sales offices in target countries*

**Direction 2: Development of local factors**

The second direction is based on options provided by domestic market, mainly in the field of infrastructures. Within this direction, the local demand has to give the initial impulse which will lead to extensive growth and enlargement of the sector. On the other side, development of R&D activities will be important for transfer to value-added activities. The effect of the latter can be visible after a certain critical mass is obtained within the sector.

Strategic initiatives necessary for the second direction of engineering sector's development are described below.

| Horizon 1 (1-5 years) | Horizon 2 (5-10 years) |
|---|---|

| | |
|---|---|
| **EDUCATION**<br>Professional training<br>Non-professional training<br>Promotion of education-industry association<br>Modernization of educational infrastructure | **DEVELOPMENT OF EXPORTING POTENTIAL** |
| **STANDARDS**<br>Transfer to internationally adopted norms and standards | **STATE PROMOTION TO EXPORT** |
| **MARKET/DEMAND** | |
| **INTERSECTORAL COOPERATION** | |

The mentioned development directions of the Armenian engineering sector can have a parallel growth while being different by their development logic and strategy.

**Main development characteristics of engineering services sector**

| | **Direction 1**<br>**High technology R&D center** | **Direction 2**<br>**Engineering service providers in the field of infrastructures** |
|---|---|---|
| Industry/Economy | High technologies | Infrastructures and construction |
| Possible business model | R&D centre of global companies | Provider of niche comprehensive services |
| Geography of potential markets | USA, EU, Japan | Stage 0: Armenia, stage 1: CIS, stage 2: Iran and developing countries from Africa |
| Main consumers of services | Industrial multinationals, global engineering companies | Governmental organizations, donor organizations, municipal and infrastructural organizations |
| Required key capabilities | • High-level educational system<br>• Large number of engineers<br>• State-of-the-art research infrastructure and capabilities<br>• Language skills (mainly English)<br>• Incentive system R&D activities | • Hands-on extensive experience<br>• High-quality engineers<br>• Application of internationally adopted standards<br>• Project Management skills and experience<br>• Relations to potential markets<br>• Language skills (mainly English and Russian) |

# INTRODUCTION

This research of Armenia's engineering services sector has been conducted to evaluate the current state of the sector, analyze its development perspectives and design a strategy for the sector's development.

Definition of Armenian engineering services sector was given in terms of classification of economic activities as well as international definitions. Within this research study, the second revision of NACE classification served as basis for definition of Armenian engineering services sector: Engineering activities and related technical consultancy including design of transportation facilities, design expertise; design of hydraulic facilities, water-supply and sewerage systems, design expertise; design of power facilities, design expertise; design of telecommunication and security systems, design expertise; other engineering services and related technical consultancy.

Managers of active companies have been surveyed in order to evaluate the current state of Armenian engineering services sector, to reveal main activity directions of companies providing engineering services, to identify development potential and existing obstacles.

Growth of engineering services worldwide and its tendencies have been studied to assess Armenia's engineering services sector development capabilities and opportunities. The possible way of development of Armenian engineering services sector was examined in the context of main business models available in the global market. The mapping of opportunities of Armenian engineering services sector has been compiled considering the most promising directions of the sector. Possible demand sources, export opportunities, factors of Armenia's attractiveness in these sectors as well as the most appropriate and feasible business models have been examined for all directions of engineering services.

The developing strategy of Armenia's engineering services sector will be proposed in two main directions on the assumption that the examined directions can have a parallel upgrowth but their development logic and strategy essentially differ from each other.

# CHAPTER 1: SECTOR OF ENGINEERING SERVICES

## SECTOR DEFINITION

The sector of engineering services is quiet extensive and closely interconnected with a range of other economy sectors. On one side, engineering activities are part of manufacturing companies' main activity while on the other side they adjoin to other economic activities such as the information technologies sector. In particular, IT and engineering services are jointly represented in the field of Electronic Data Automation (EDA) including development of software packages for chip design.

Sector definitions mainly have been given based on classifiers of economic activity (NAISIS, NACE, ISIC) and are used by national and international statistical services. For different international organizations and research institutes[1] these definitions serve as a basis though in some cases, for the purpose of the study researchers expand or limit the sector by changing the kind of activities involved. In research study "Booz Allen Hamilton" ordered by India's leading IT association "NASSCOM" consulting company experts have studied engineering services sector perspectives in India considering only "pillar" engineering services which include the following sectors: "1. Aerospace, automotive, construction and industrial, telecommunication and infrastructures; 2. Product and component design, plant design, process engineering and plant maintenance and operation[2]."

As per the broader definition all services applying physical laws and principles of engineering in design, development and application of machines, materials, instruments, processes and systems are engineering services. Within this sector, services include consulting, feasibility study, implementation of initial and final design, providing of technical services when investing construction or engineering solution, supervision and monitoring of engineering projects.

According to some international studies of engineering services sector architectural services, in particular the building design are also included in the market definition. Sector definition differs also by international statistical classification standards.

The North American industry classification system (NAICS) excludes from the list of engineering services geographic surveying and cartographic services (except of geophysics), hardware and software, industrial design, environmental consulting services. This classification also omits design and construction of buildings, structures, traffic and other facilities.

The UN International Standard Industrial Classification (ISIC) of all economic activities represents a classification similar to NACE. According to Statistical Classification of Economic Activities in the European Community (NACE, Rev. 2)[3], by which the RA National Statistical Service is guided too, engineering activities and related consultancy are

[1] CBI, NASSCOM, Booz Allen Hamilton, First Research, Report Linker

[2] "Globalization of Engineering Services - The next frontier for India", NASSCOM, Booz Allen Hamilton

[3] Until January 1, 2010 the National Statistical Service of Armenia was guided by NACE classification, Rev.1, where architectural and engineering activities are not clearly separated (code 74.2 - Architectural and engineering activities and related technical consultancy).

subordinated to the group “Architectural and engineering activities and related technical consultancy” (code 71.1).

**Table 1: Classification of architectural and engineering activities according to NACE classification, Rev. 2**

| Code | Description |
|---|---|
| **71** | **Architectural and engineering activities** |
| **71.1** | **Architectural and engineering activities, related technical consultancy** |
| **71.11** | **Architectural activities** |
| **71.11.1** | Town and city planning, design expertise |
| **71.11.2** | Other architectural activities |
| **71.12** | **Engineering activities and related technical consultancy** |
| 71.12.1 | Design of transportation facilities, design expertise |
| 71.12.2 | Design of hydraulic facilities, water-supply and sewerage systems, design expertise |
| 71.12.3 | Design of power facilities, design expertise |
| 71.12.4 | Design of telecommunication and security systems, design expertise |
| 71.12.9 | Other engineering services and related technical consultancy * |
| **71.2** | **Technical testing and analysis** |

* The class “Other engineering services and related technical consultancy” has a broader definition and includes:

- engineering design by applying of physical laws and principles for creation of projects including mechanisms, materials, instruments, structures, systems; consultancy for projects involving machinery, industrial processes and industrial plant, water management, electrical engineering and electronics, mining engineering, chemical engineering, mechanical, industrial and system engineering and other engineering consultancy activities,
- design of projects including sanitary and pollution control engineering, acoustical engineering and similar systems,
- oil and gas field exploration, geophysical, geological and seismic surveying,
- geodetic surveying activities including land and boundary surveying, hydrographic surveying, subsurface surveying, cartography and spatial information.

This class excludes:

- test drilling for oil and gas field exploration,
- test drilling and test hole boring for civil works,
- development or publishing ready-made (non-customized) software,
- activities of computer consultants and other related activities,
- technical testing and analysis relating to engineering,
- research and development activities,

- special design activities,
- aerial photography.

### Definition of Armenian engineering services sector

Pursuant to foregoing classification of economic activities the NACE classification, Rev.2 has served as basis for definition of Armenian engineering services sector within this research study. Activities listed in class 71.12 “Engineering activities and related technical consultancy” will be considered as engineering activities. This definition will make it possible to define sector’s main indicators through a statistical analysis obtaining internationally comparative data.

For the purposes of this research companies providing engineering services will be identified according to the following principle:

1. Company’s main activities correspond to any kind of activities mentioned in the class 71.12 of NACE classification, Rev.2 or engineering services are the key point of company’s main activities;
2. Company’s engineering activities mainly embrace providing of engineering services or providing of engineering services to companies operating in other economic sectors.

It should be mentioned that sector statistics up to and including 2009 have been conducted by National Statistical Service based on definition of NACE classification, Rev.1 where architectural and engineering services sectors are not clearly separated. In addition, in companies with diversified activities (e.g. construction firms providing also engineering services) where services fraction is not clearly separated in the turnover company’s overall revenue can relate only to one activity (e.g. construction).

This is why sector’s appraisal given by this research study can not be compared with the NSS appraisal.

## ENGINEERING SERVICES AND RELATED SECTORS - STUDY CONCLUSION AND IMPLMENTED INITIATIVES

The Competitive Armenian Private Sector (CAPS) is one of the USAID projects that implemented the most embracing initiative in the Armenian engineering services sector. Interest of American company "Cambric" to open a branch in Armenia has given start to this initiative.

In 2008, sector of engineering and industrial design services has been selected for CAPS support. A number of events have been implemented, in particular, training courses in partnership with the Cambric Corporation, a US-based engineering services firm and American University of Armenia, engineering workforce survey, support to foreign investments in this sector.

***Workforce development***

***Training courses for engineers of Armenian branch of Cambric Corporation.*** In 2008-2009, over the past seven months, 30 engineers have participated in a training program under the direct assistance of CAPS, Enterprise Incubator Foundation (EIF) and Industrial Technologies Company. Cambric Corporation provided 5 specialists to conduct the training programs for advanced CAD/CAM software applications, project management for engineering services, and procedures for delivering client-specific support. Participants who successfully have completed this training were eligible for full-time jobs with the Cambric Services Armenia Company.

To launch the initiative of workforce development a two month training for the 3D modeling tool Pro/Engineer has been jointly organized by CAPS and the Engineering College of the American University of Armenia. 10 individuals from engineering companies and from State Engineering University of Armenia have participated in this training.

***Armenian Engineering Workforce Assessment***. The assessment was conducted by Ameria consulting company during the period from January-March 2008 with a sample of 82 Armenian engineering companies (companies main activities included production, engineering design and consultancy). The main purpose of the assessment was to investigate the current status of the engineering workforce in Armenia, needs of new specialists and requirements for their qualification. 35 companies from the sector of engineering design and services and 10 companies representing the sector of civil architecture and construction have participated in the survey.

According to survey results the total number of engineers employed by the firms that were surveyed is 1969 and more than half of companies need to employ new workforce, an average of 9 per company. Mechanical and electrical engineers were both in short.

***Support to foreign investments***

In 2008, Cambric Corporation, a US-based engineering services company, established its Armenian branch through CAPS support.

### *Sector promotion*

A joint initiative of the CAPS project and EIF is publication of an e-guide for Armenian engineering cluster i.e. preparation of an electronic guide for companies providing engineering services.

### Other educational initiatives in the engineering sector

In 2006, Union of Manufacturers and Businessmen of Armenia (UMBA) took the initiative to establish partnership with German leading engineering company FESTO to support the Armenian mechatronics sector (mechatronics=mechanics+electronics). As a result the State Engineering University of Armenia was equipped with a FESTO complete learning system which provides a good opportunity for students and engineers to acquire practical skills. Due to the limited use of the learning system Armenian branch of FESTO decided to establish a complete learning center to more effectively use the learning system providing training opportunities for students and broader circle of manufacturing company employees.

Yerevan State College of Informatics following the UMBA initiative also bought three types of FESTO learning systems which allow organizing practical trainings for both students and company employees. This learning center also serves as a good base for research groups of engineers from various colleges to implement own research and development projects.

### Other initiatives in sectors related to engineering services

Mapping of the high tech sector implemented by Ameria CJSC and contracted by EIF as well as preparation and publication of investment guides in business forums and exhibitions implemented by Armenian Development Agency were initiatives also relating to engineering. These initiatives concerned the following sectors: electronic engineering, mechanical engineering (including design and production of high precision machines), pharmaceutics, chemical industry and biotechnology.

# CHAPTER 2: SURVEY OF ENGINEERING SERVICE PROVIDERS

## SURVEY METHODOLOGY

### Survey purpose

This survey of Armenian engineering services sector has been conducted mainly for the purposes to evaluate the current state of the sector, to determine the main activities of engineering companies and to identify development potentials and existing obstacles.

### Target group

According to the definition described above the survey sampling includes all engineering companies operating in Armenia with a total number of 52 as per the initial sampling. Survey has been conducted exclusively with top managers of companies. Survey sampling has been discussed with EIF and confirmed by the latter. List of companies can be found in Annex 2.

### Survey preparation

Before conducting this survey the research team has studied available analytical materials concerning the engineering sector as well as the international experience in this field. In addition, discussion was held with representatives of the Armenian engineering sector to reveal and brighten sector's main challenges (executives of leading companies, representatives of educational institutes and branch associations).

The survey was composed based on discussions with EIF and qualified experts representing the sector and updated on results of trial surveys (Annex 3). It includes the following range of questions:

- General characteristics and data about company
- Main and secondary directions specializations
- Description of main products and/or services of the company
- Sales volume and dynamics
- Applied technology and production processes
- Consumer markets and ways for sales
- Export experience
- Human resources
- Experience in intersectoral and intra-sectoral collaboration
- Opportunities for applying new technologies
- Main obstacles of development and necessary ways and directions to support.

**Statistics of survey results**

The survey was conducted in the period from March 5 to 25. Table 2 shows survey statistics.

**Table 2: Survey statistics**

| Survey participation | Number of companies |
|---|---|
| Participated in the survey | 49 |
| Participated in the survey, field of activity does not correspond | 6 |
| Activity terminated | 2 |
| Not participated in the survey | 7 |

86% of companies operating at the time the survey was conducted have participated in the survey. Services rendered by 6 participating companies and by one company not participated in the survey do not correspond to the engineering services definition (ELECTROSEVKAVMONTAG, ELECTROPROJECT, HAEK SHINARARUTYUN, HARWAL MACHINERY, SG DESIGN ELECTRONICS, SNART, NATIONAL INSTITUTE OF METROLOGY). Company managers mainly could not participate in the survey due to shortage of time or being absence from Armenia. Mostly face-to-face surveys have been carried out, 5 were telephone surveys and 6 companies filled out the survey questionnaire by themselves.

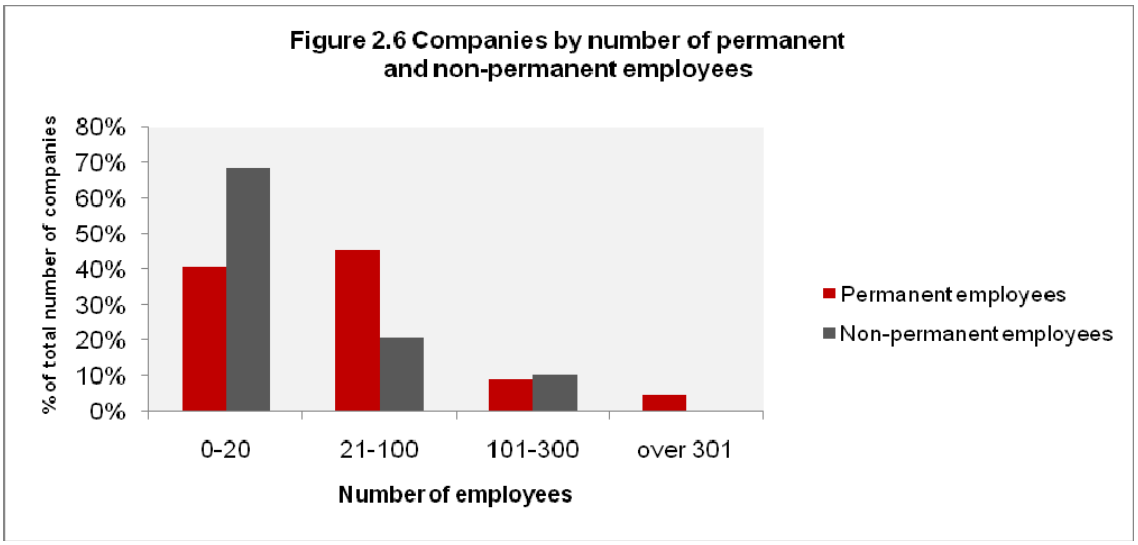
## SURVEY RESULTS

### Main characteristics of companies

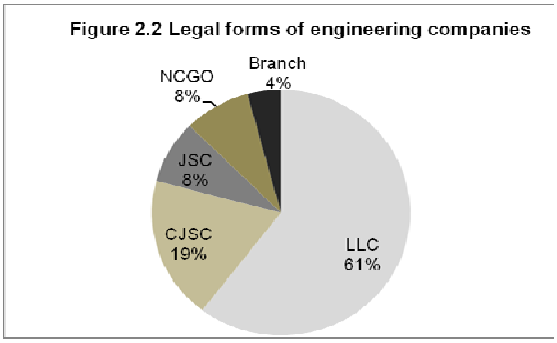
For the sectoral analysis of engineering services 49 companies have been studied the activities of which entirely or partly embrace providing of engineering services (engineering services companies hereinafter referred to as companies).

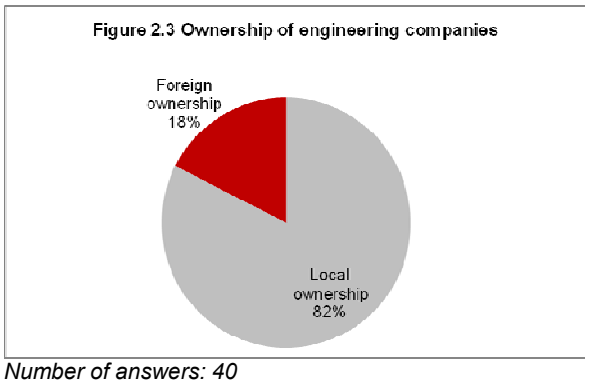
The major part – 20% of companies surveyed were established due to privatization of previous research institutes or state organizations. Another 11% have changed their legal form over the time and operate as legal successors of previous companies.

The dynamics of engineering start-ups establishment in Armenia is an evidence for the fact that the sector has a revival as from 2001. Exactly in this period of time 43% of surveyed companies were established while in the decade from 1991 to 2000 only 10 companies have been created. The years 2007 and 2008 had an inflow of companies in the largest number: 12 start-ups.




61% of active engineering companies are limited liability companies comprising the absolute majority and one-fifth CJSCs. Non commercial governmental organizations also have a great share in the studied sample: ca. 8%. 4% of companies have the status of a foreign company branch.



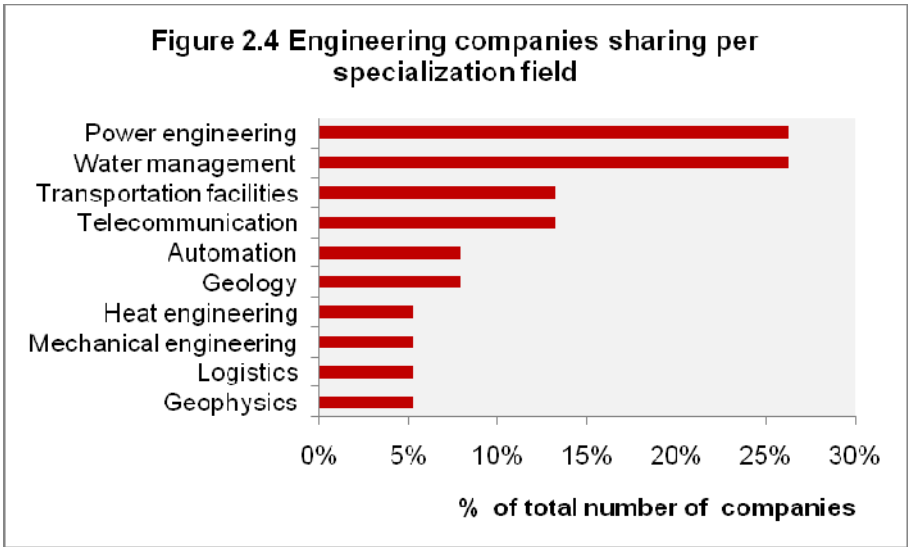




*Number of answers: 40*

Approximately one-fifth of companies have a foreign ownership share. Foreign owners are mainly from USA, the others represent Germany, Greece, Russia and France. The major part of companies is with absolute foreign ownership of 100%.

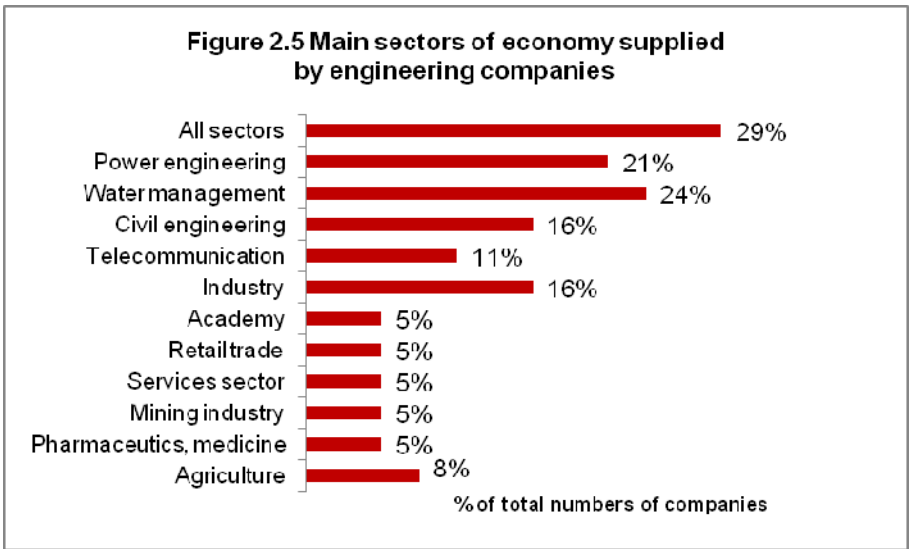
**Activities of engineering companies**

The companies being studied are mainly specialized in the field of design of power engineering and hydraulic engineering followed by transport engineering and telecommunication sectors.




*The most part of companies is active in several specialization fields.*

The biggest consumers for engineering services in Armenia are sectors of power engineering, water management and construction. Engineering services are mostly required also in telecommunication and industry sectors: Many companies develop engineering solutions which can be applied in any sector of economy.

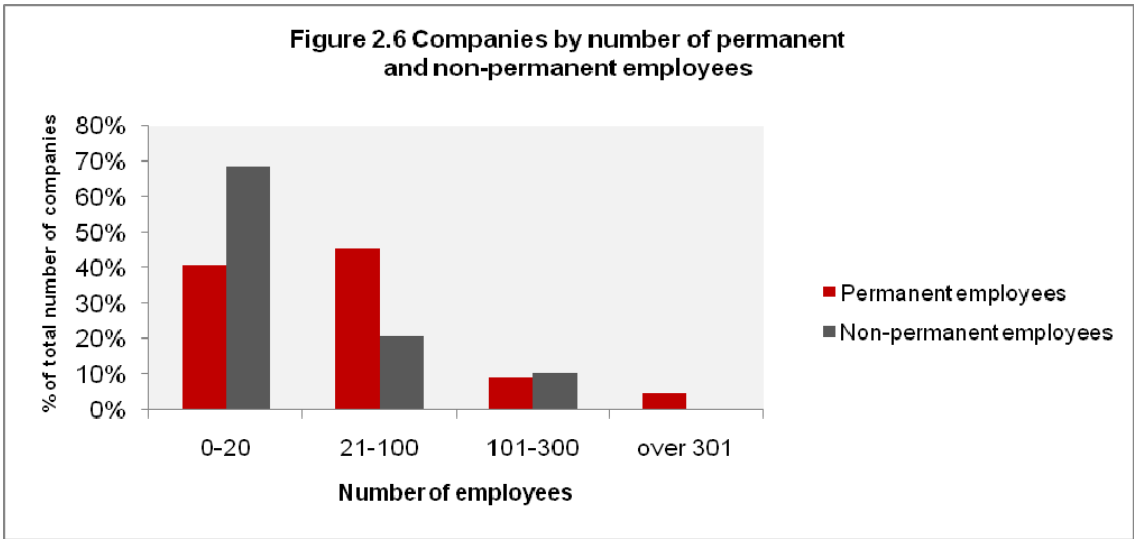



*The most part of companies supply many sectors of economy*

International quality control systems are uncommon tools used by companies. So, 40% of surveyed sample are exporting companies, but only one-tenth of engineering companies can provide any kind of quality certificate and these are mainly branches of foreign companies. These companies mainly have established ISO standards and are certified by European organizations.

### Characteristics of human resources

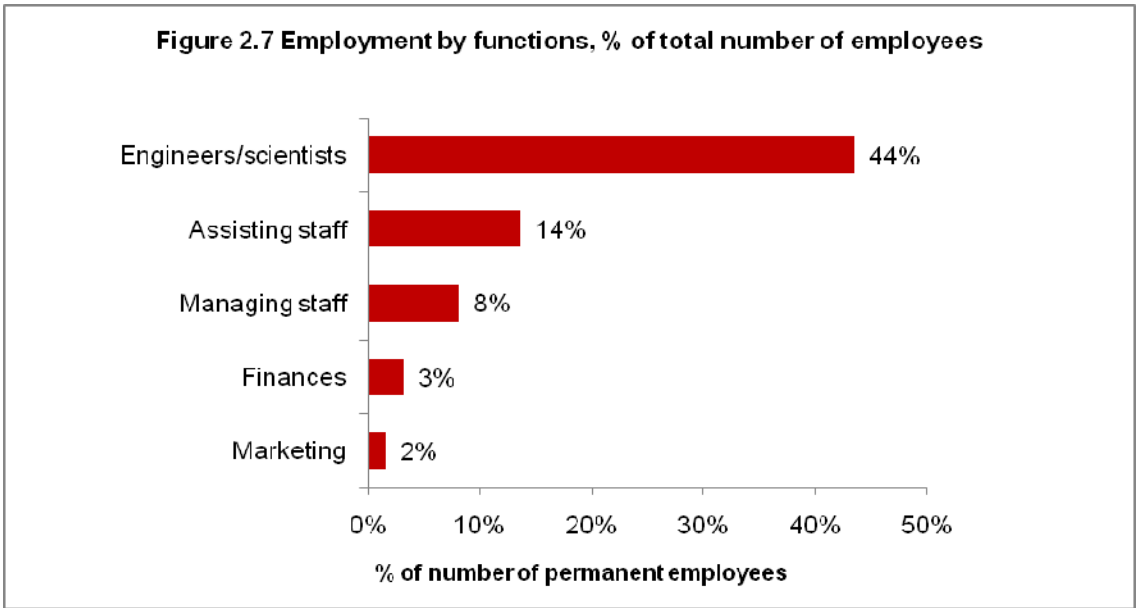
Depending on the staff companies mostly are of medium size, comprising of 20-100 employees. A small number of companies having over 100 employees are mainly involved in large-scale construction projects with their permanent and non-permanent staff. Such companies have not only a large number of permanent employees, but also there is a large amount of workforce being hired for separate projects. About 60% of companies have up to 20 non-permanent employees.



*Number of answers: 44*

The total number of employees working in the Armenian engineering services sector is about 2,900. [4]

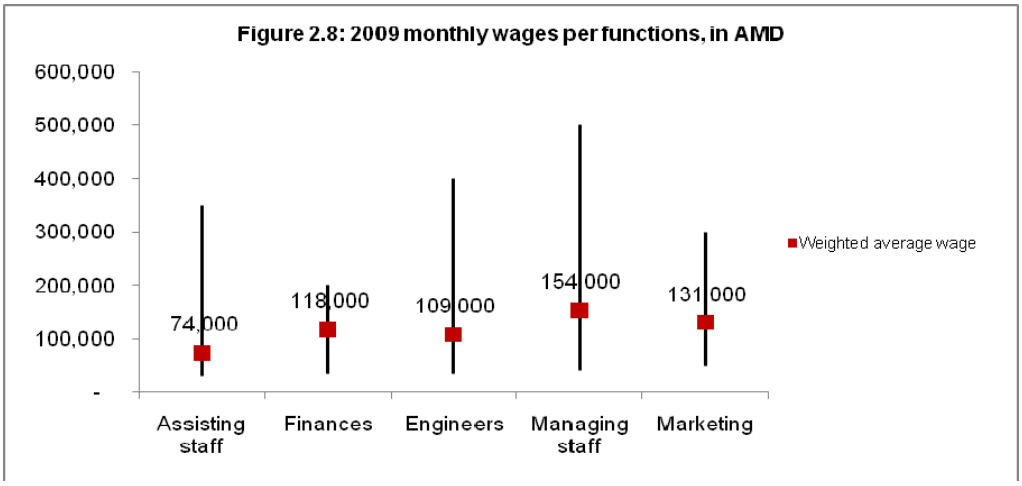
The half of workforce employed in engineering services sector is comprised of engineers and scientists. Assisting staff has also a quiet big portion while marketing specialists are only 2% of the workforce employed in the sector. The shortage of market management specialists in the sector is an evidence for the fact that company managers undervalue the market management function as well as lack of skilled specialists.




*The diagram does not include the working class.*
*Number of answers: 44*

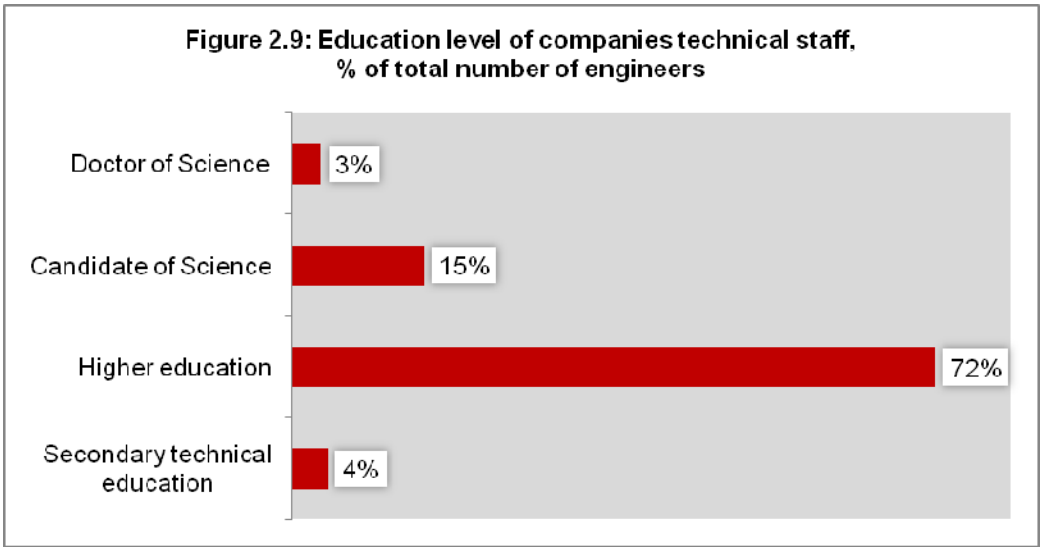
According to the weighted average the managing staff has the highest salaries. It should be noted that differences between salary levels are too high because of presence of many companies in the sector (from NCGOs to foreign branches). And this difference is especially notable among managers and engineers. The minimum salary of the latter is 30,000 AMD and the maximum salary - 350,000 AMD.

[4] The working class is not included. Evaluation of number of employees of nine companies not participated in the survey as well as of companies who have participated yet not answered to questions concerning the employees is also included.



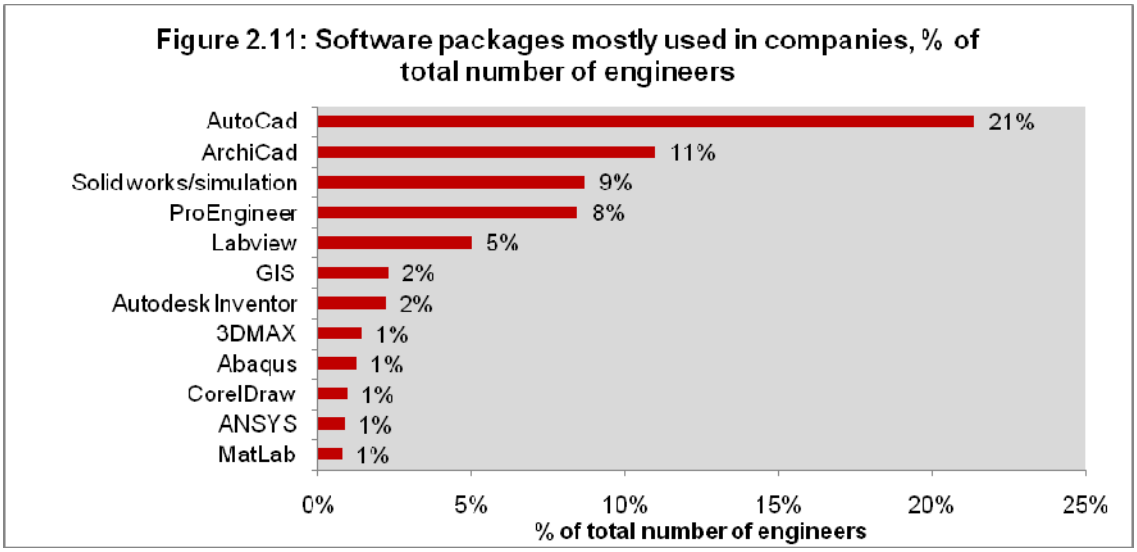

*Wages shown are weighted per employee number in each specialization field*

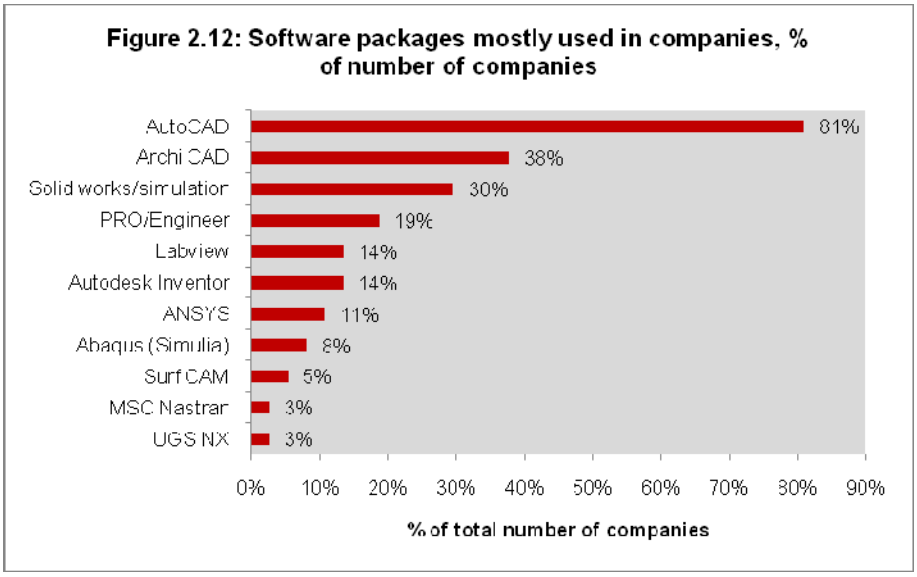
About 80% of engineers have higher education. The share of specialists having postgraduate education is also notable in the research staff and equals 17% which is due to high involvement level of scientists in research institutes.




The vast majority of engineering services company employees speaks Russian while the same is not with English the knowledge level of which is only 20%. About 13% of employed engineers worked abroad including the former USSR. There is only a very small number of specialists studied or participated in trainings abroad or having professional certificates.


At present, specialized software packages mostly used by Armenian companies are the following: AutoCad, ArchiCad, Solid Works, ProEngineer and Labview. About one-fifth of the engineering staff masters AutoCad.

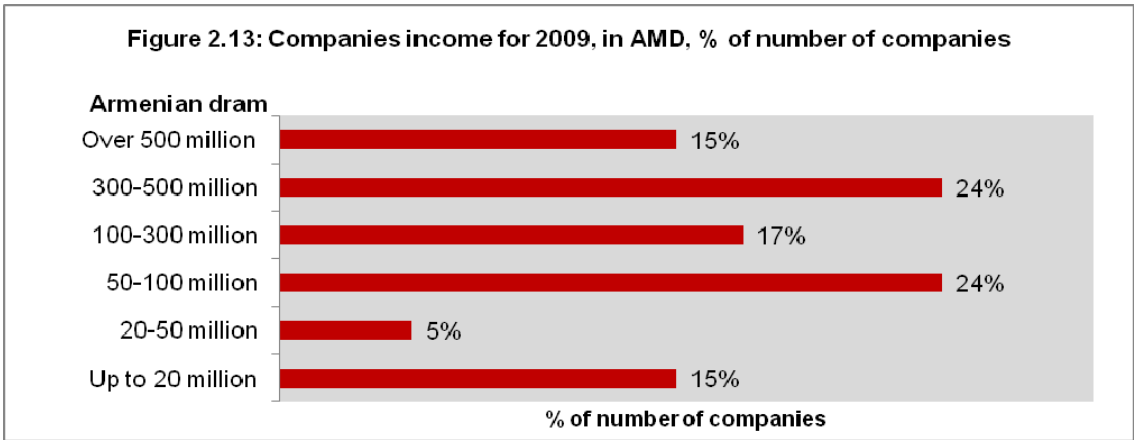





*Number of answers: 38*

### Turnover of companies

In 2009, the majority of Armenian engineering companies had an income of 50-100 million Armenian drams. More than 40% of surveyed companies operate within the scope of 100-300 and 300-500 million Armenian drams. Companies with an annual turnover of more than half a billion drams comprise 15% of all companies.



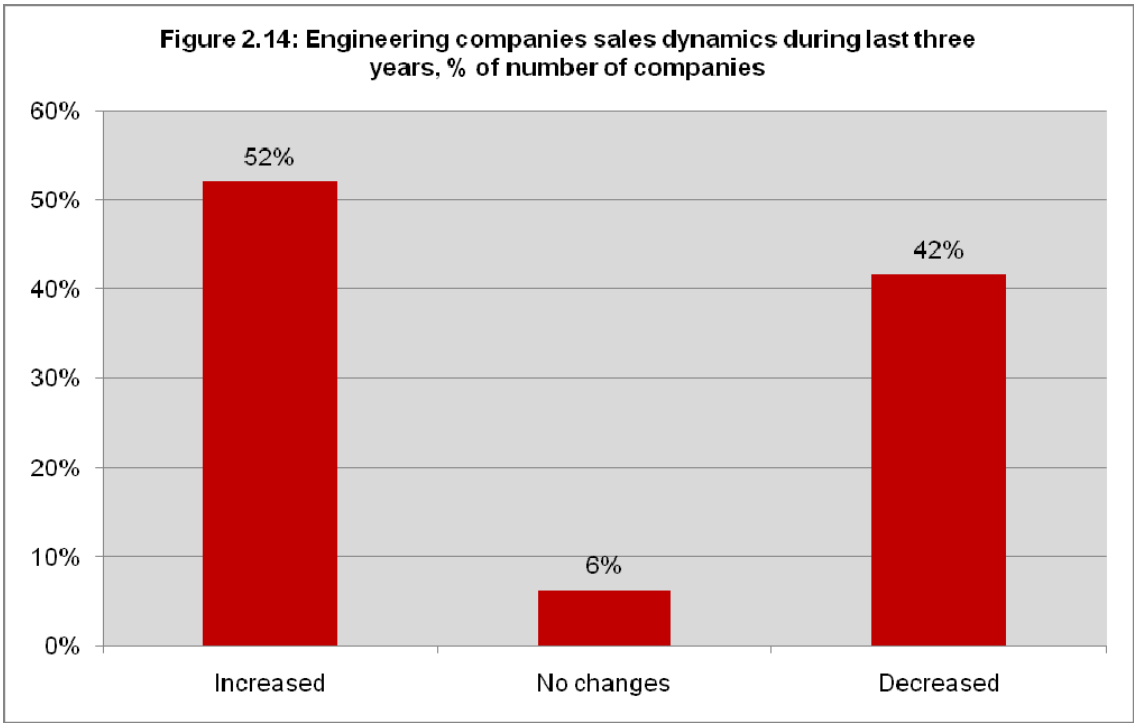

*Number of answers: 40*

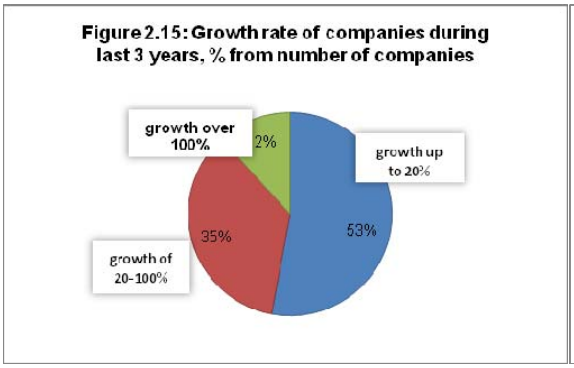
According to the averaged data Armenian engineering services sector showed visible positive dynamics in 2007-2009 with a growth of 40%. This tendency is yet unevenly distributed among active companies.

According to the company managers appraisals the financial crises between 2008 and 2009 had a particular impact on the sector's activity.

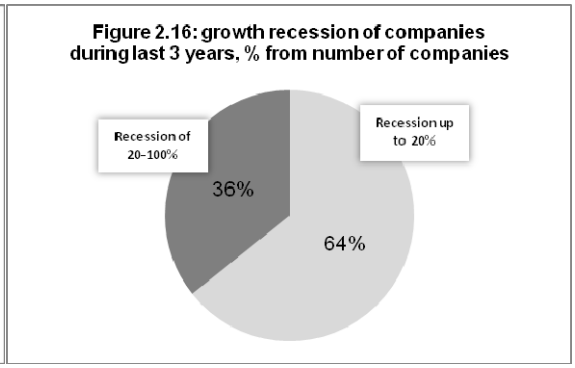
In 2009, due to shortage of orders companies had a notably decreased income (5-70%), as a result of which 40% of companies have shown negative average development dynamics during last three years. In this period, the average rate of annual recession was 30%.

At the same time, more than half of companies could maintain positive growth tendencies during three years. Such companies have recorded an average annual growth rate of 5-20%. There are also a small number of companies having an increasingly large growth rate of 100-700% in this period of time. 6% of companies had no changes in their sales volumes.




*% from number of companies recorded growth*

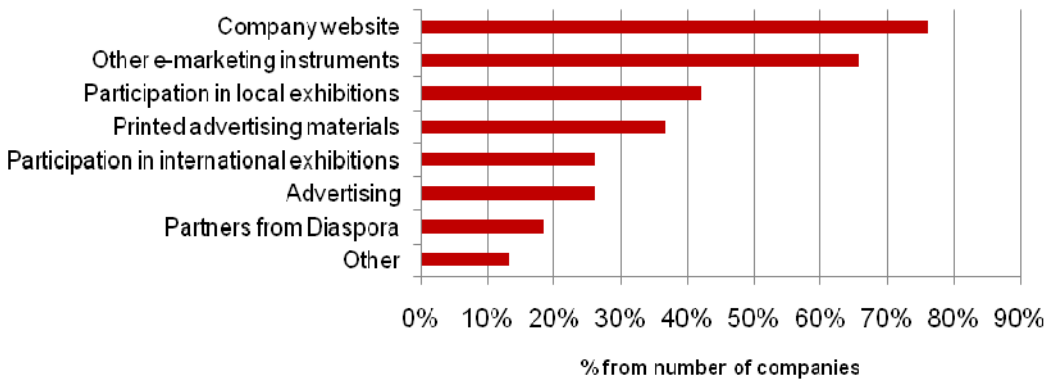



*% from number of companies recorded recession*

## The market management policy of companies

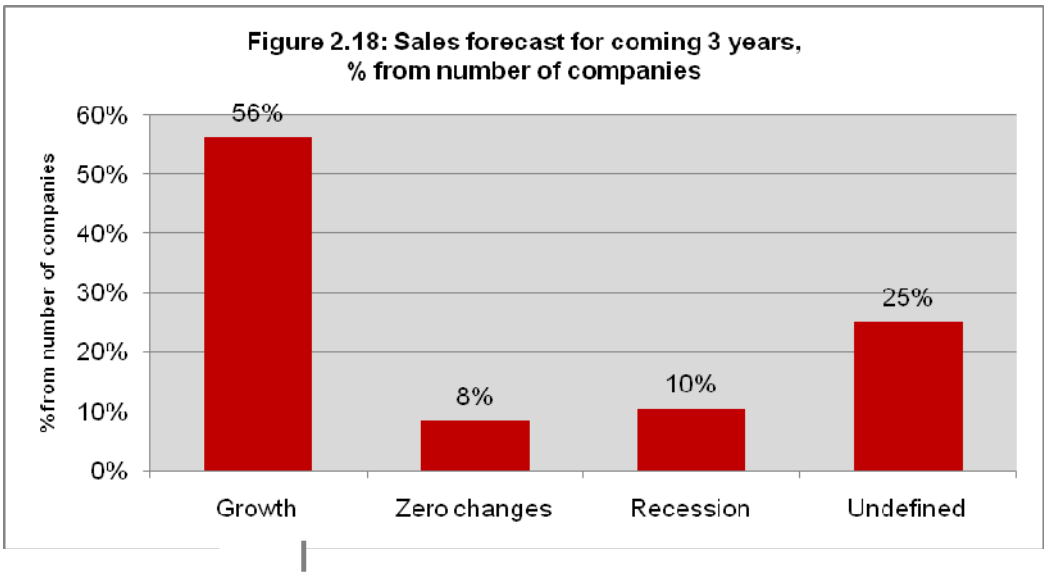
The engineering companies of Armenia are characterized by having a quiet weak and passive market management policy. Websites and other small elements of e-marketing are the mostly used promotion instruments for companies. Participation of companies in exhibitions is at the lowest level. Only 25-40% of companies have ever participated in local or international specialized exhibitions. To increase information awareness of the company's activities 40% of companies use advertising materials. Direct television advertising is rarely used by companies. To promote export activities and to gain new orders about 20% of Armenian engineering companies collaborate with partners from Diaspora.

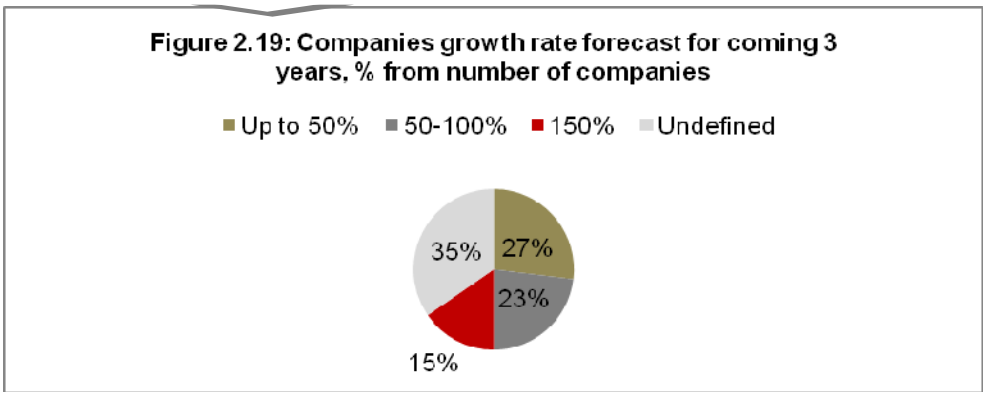
**Figure 2.17: Promotion instruments used by companies, % from number of companies**




### Strategy and forecasts of companies

In the period between 2008 and 2009 many of Armenian engineering companies have felt the negative impact of the financial crisis on their business activities. Nevertheless, the vast majority of company managers is optimistic and has clear plans to expand their activities in coming three years. About 50% of companies expect to record a growth rate of 100% and 15% forecast to increase their sales volume in about 1.5 times. Though, 35% of company managers who expect to have growth have no certain ideas what are the growth rates. There is a small number of companies expecting negative or at best zero changes for the near future while a major part of companies has even no idea what to expect in the future.

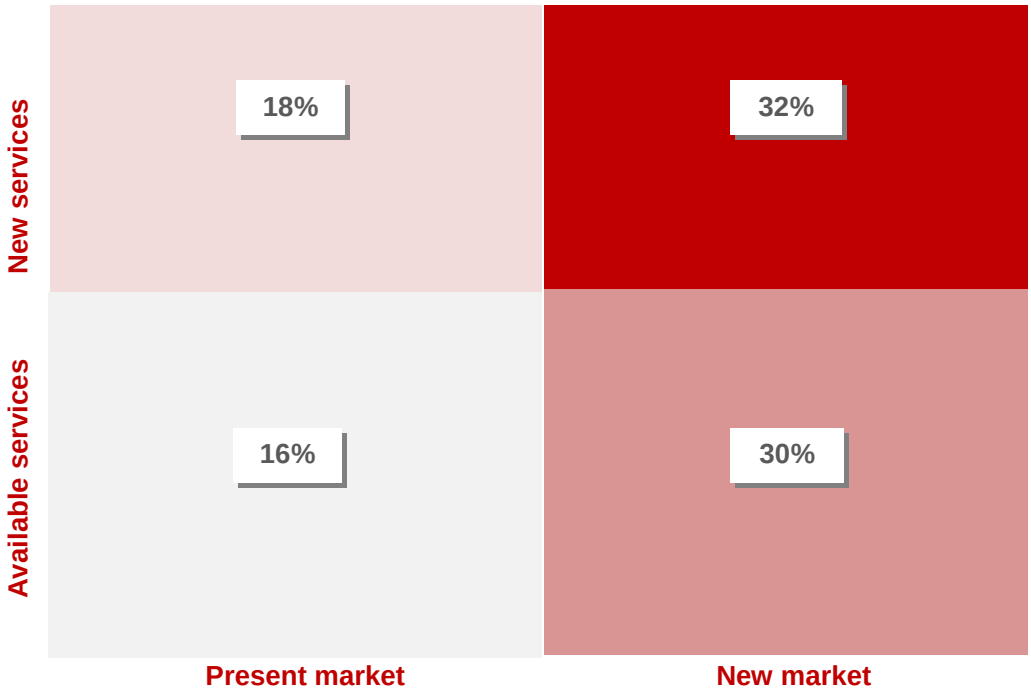



***% from number of companies expecting to have growth***

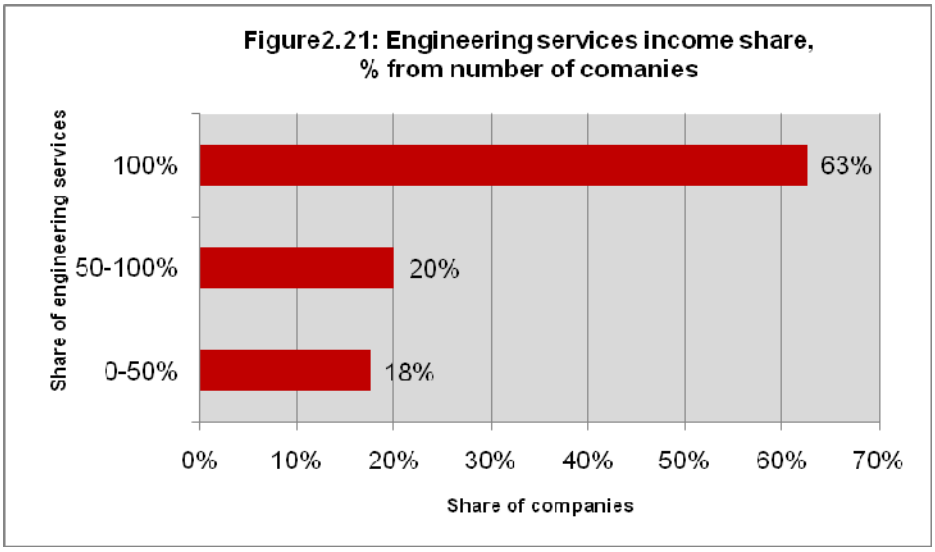
Based on positive forecasts for economic growth the majority of surveyed companies – 62% plans to enlarge their capabilities (including marketing capabilities) operate in new markets. At that, more companies (32%) plan to capture new markets with new products. This strategy for enlargement of companies is specific for sectors being in earlier stages of their development when services and products are underdeveloped and companies have yet no strong position in the markets. On the other side, such diversification requires availability of first-class capabilities which are still too limited in Armenian companies. This also means that strategy managing and planning capabilities need to be more developed.

Figure 2.20: Planned enlargement of companies for coming 3 years,
% of number of companies




## *Income derived from engineering services sector*

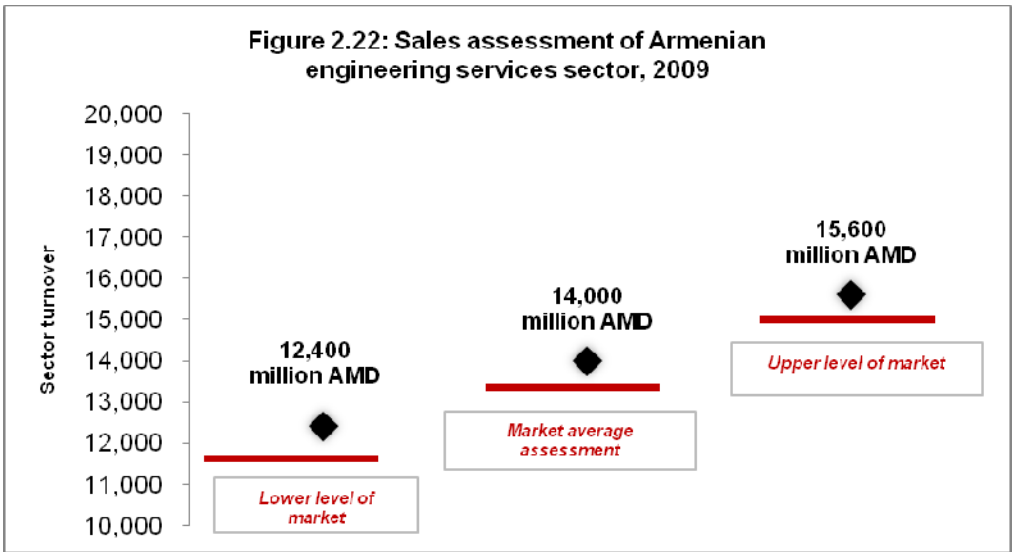
For the majority of surveyed companies engineering services are profitable for 100%. One-fifth of companies is only partly specialized in engineering services. In about 20% of companies, income derived from engineering services amounted to 50% of total annual income of year 2009.




*Number of answers: 39*

Armenian engineering services sector has been evaluated based on revenue of considered companies for engineering services (calculated in percentage from total revenue of companies) as well as approximation of sales of few companies not participated in the survey (calculated on sector averaged data).

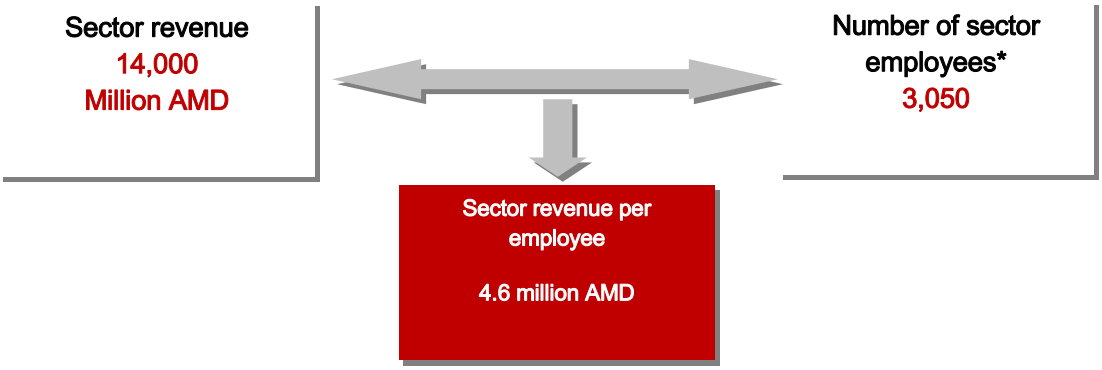
To receive a more realistic picture for the engineering services sector three possible assessments have been given for the sector: minimal, maximal and averaged.




***The engineering services sector involves services of Armenian engineering companies provided in Armenia and abroad.***

In 2009, the productivity of the workforce i.e. income per employee amounted to 4.6 million Armenian drams which is equal to 12,100 USD (exchange rate: 1USD=380AMD).

**Figure 2.23: Engineering services sector revenue**



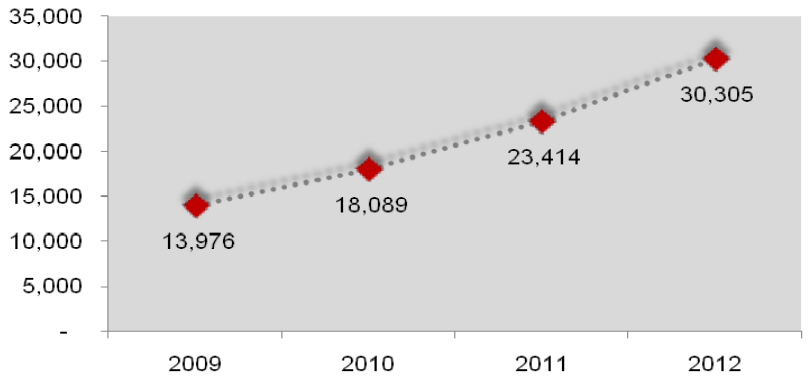

** Working class not included*

According to the National Statistical Service (NSS) the turnover of 2009 in engineering services sector was 10.8 billion AMD. It should be mentioned that the NSS has made the turnover assessment only based on NACE 1 definition for the sector where the architectural and engineering sectors are not clearly separated. In addition, in companies with diversified

activities (for example construction firms providing also engineering services) where the activities fraction is not clearly separated in the turnover the total revenue of the company can be recorded only for one activity (e.g. construction). That is why the NSS appraisal can definitely not be compared with appraisal of the survey.

Engineering services sector forecasts for coming three years are made based on expectations of company managers for own sales dynamics. Expected growth rates mentioned by company managers are weighted according to revenue of the companies. The resulted weighted average annual growth of 29% has been used to give a growth forecast for the entire sector.

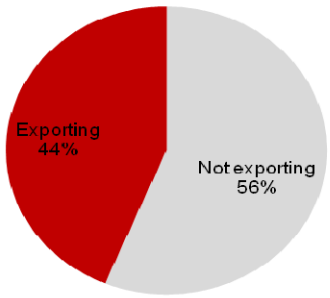
**Figure 2.24: Forecast for engineering services sector, in million AMD**



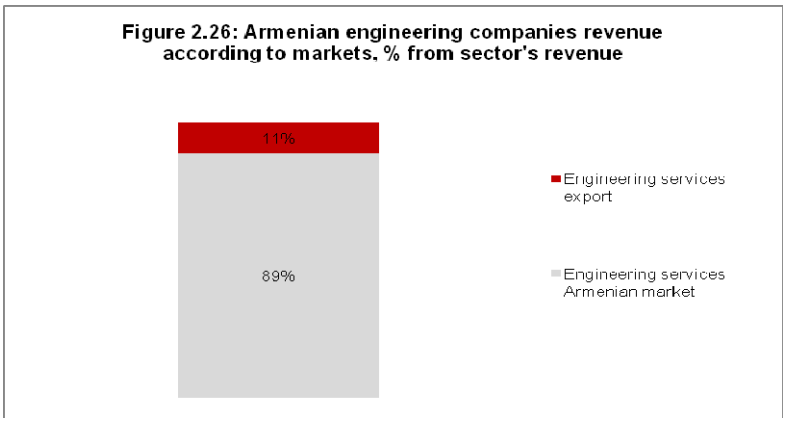

## *Export of engineering services*

44% of surveyed companies export their products. At that, one-forth of exporters are foreign-owned companies. The main export markets for Armenian engineering companies are the USA, Russia, Iran as well as some European and Arab countries.

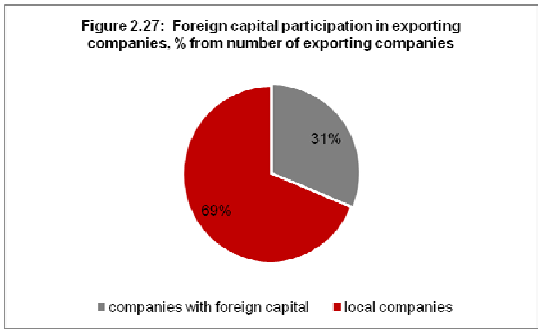
**Figure 2.25: Engineering services exporters**

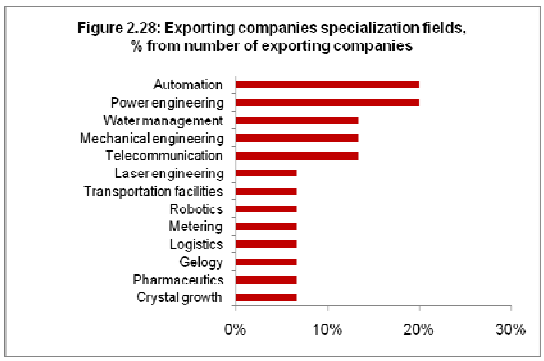



Summary of total domestic sales of services of Armenian engineering companies is about 90%. The other 10% is exported to different countries.

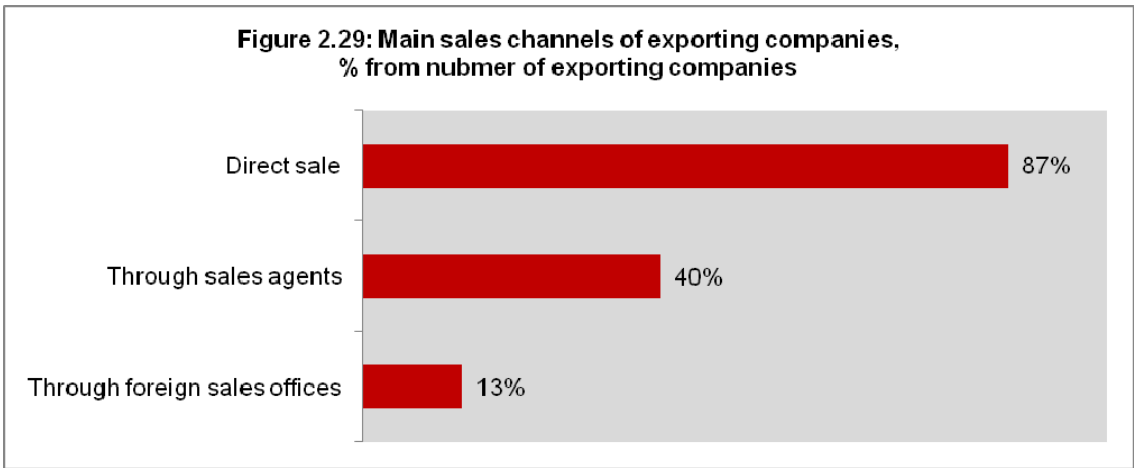



The most part of exporting companies are with foreign capital participation and mainly specialized in automation and power engineering.

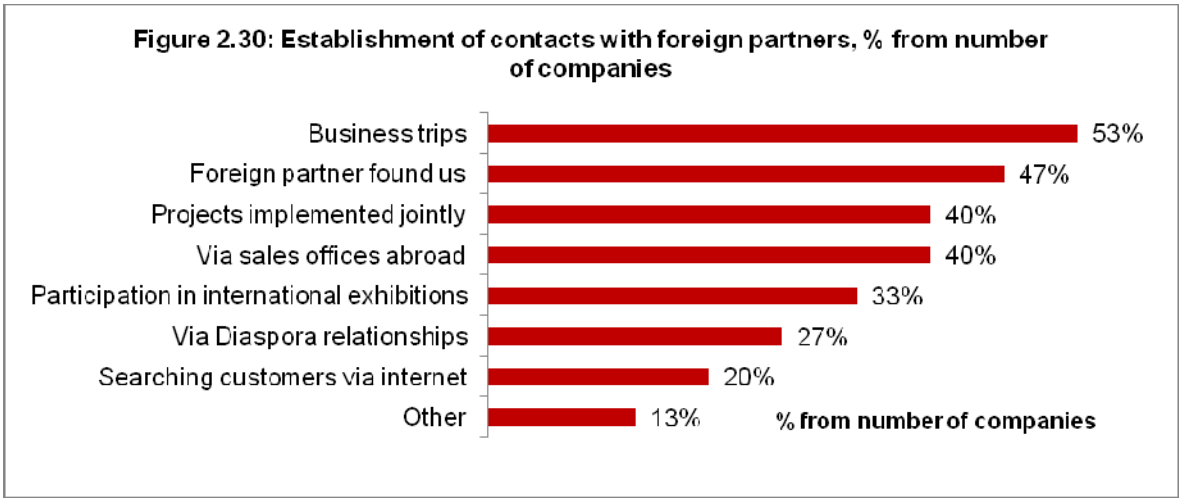


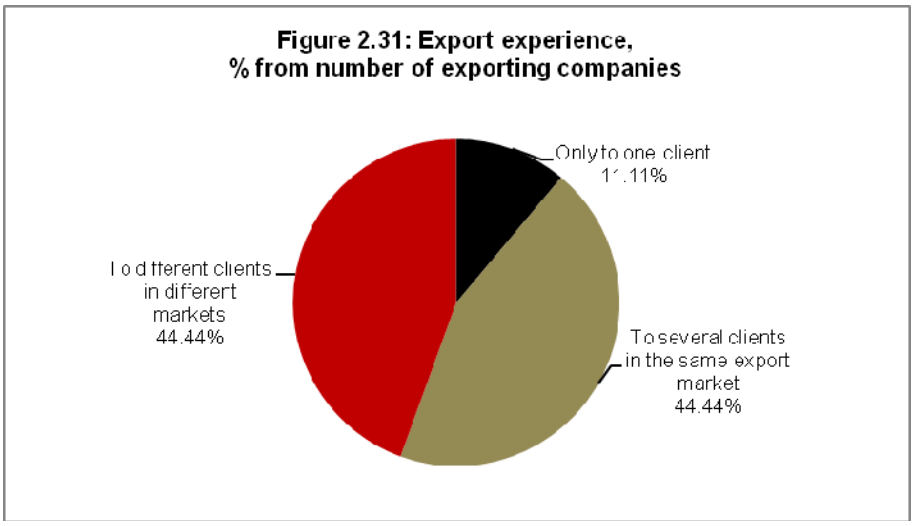

The main export channels used by exporting companies are the direct contacting and direct sale to the end-customer. However, over one-third of companies have sales agents.



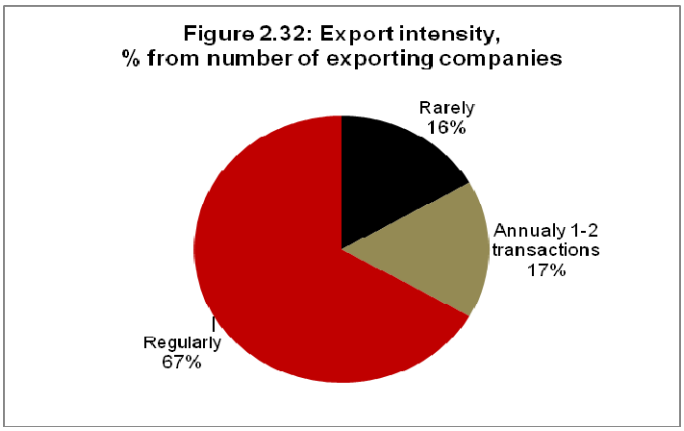

In order to gain new orders companies often take business trips, visit target markets and establish personal contacts with foreign potential customers. In most cases local companies have less initiative and foreign companies often contact local companies by themselves via business directories or company's website. Contact to Diaspora and searching customers via internet are less effective and rarely used by companies.



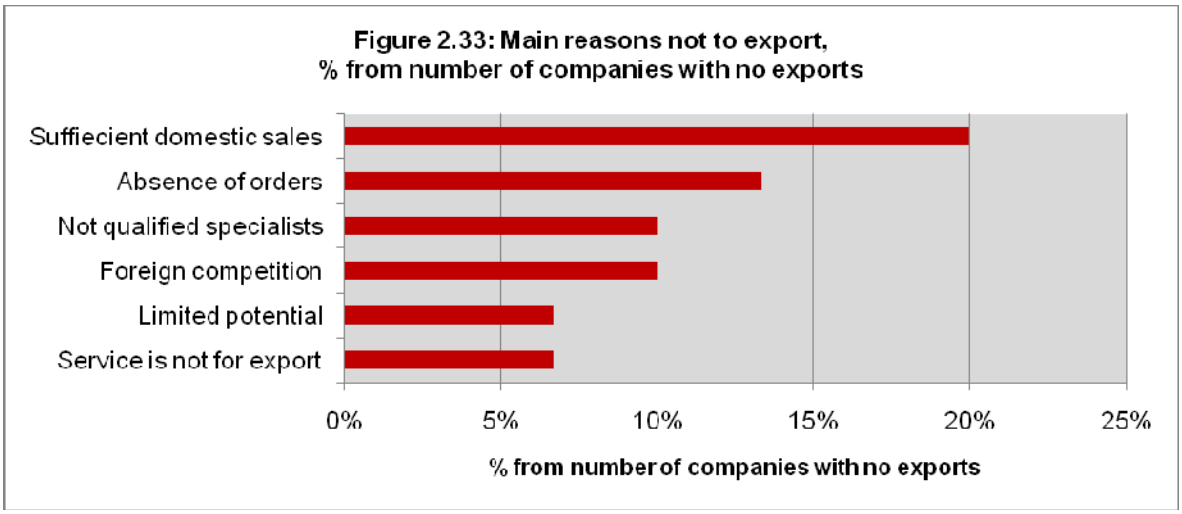

The majority of exporting companies mainly work with different clients whereby 44% are in various markets and other 44% - in the same market. This fact evidences that export of services of engineering companies is quiet diversified by geographical regions and clients.




The most part of exporting companies regularly carry on export transactions while for 16% of exporters exports have a rare and occasional nature.




Companies having no exports argue this fact by sufficient volume of domestic sales. Many companies assess own human resources as not competitive to resist strong foreign competition. A number of companies have difficulties to find orders from abroad and some of companies consider that services of their main specialization field are not for export.

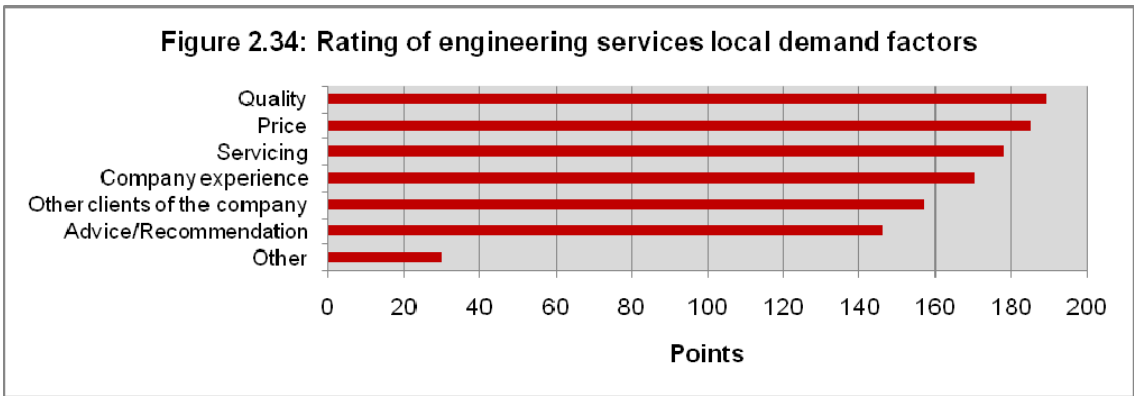



Some companies do not carry out export activities due to limited information resources, export corrupt environment, inconsistency of quality standards.

## *Nature of engineering services demand*

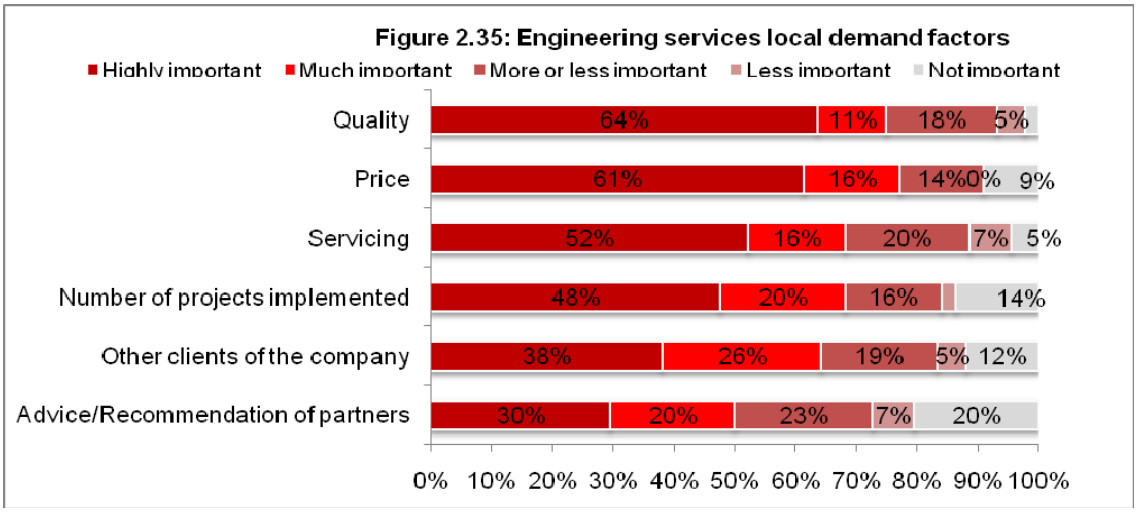
### Local demand

According to appraisal of company managers, for the clients, quality and price are the main factors being decisive when choosing a service provider in the Armenian engineering sector. These attributes along with company's service and previous experience become more important for large-scale public projects. Advice or recommendation of partners also applicable in the sector, though rarely.



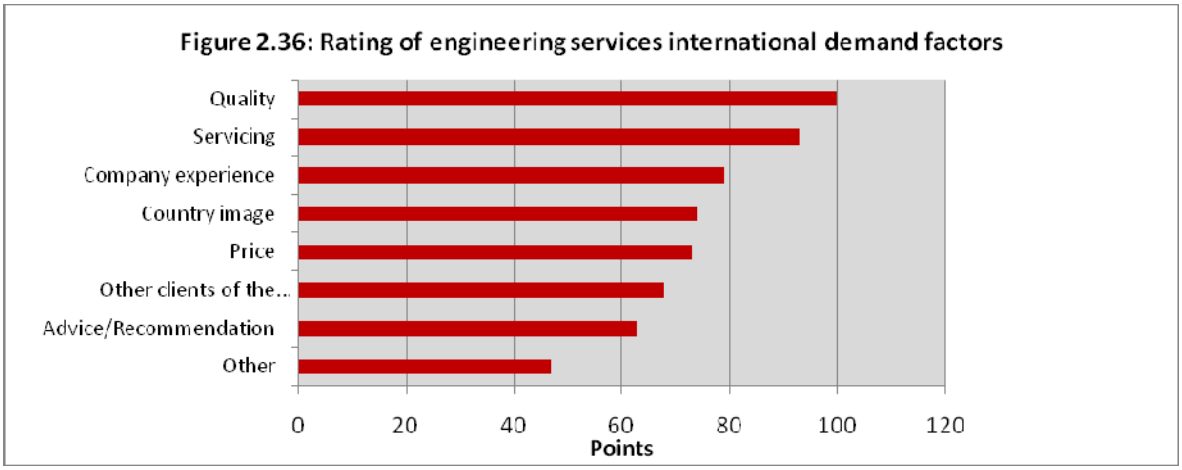

*Each factor was assessed on the scale from 1 to 5. Each factor in the chart is represented as a total sum of points that were assigned by company managers.*

In addition, discussions regarding the price factor are rather different. If all companies consider the quality level is more or less important, so about 9% of companies believe that the price is never important for purchasing.



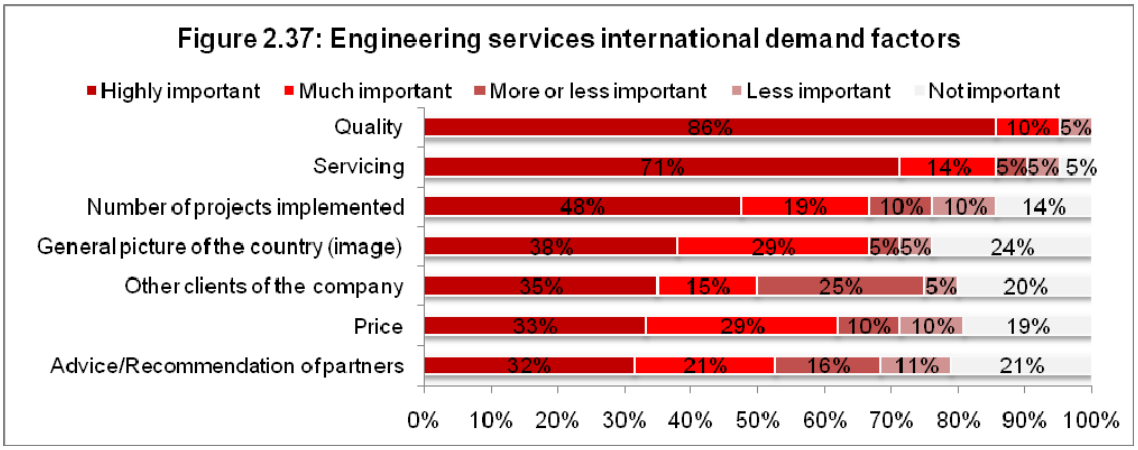

### International demand

The nature of international demand highly varies from local tendencies. In the importance rating scale shown above quality of provided services, servicing and previous experience of the company are at the highest position. For clients to place the first order it's also very important the general awareness and picture of the country. It is significant that the role of the price factor in this case is rather less important for the final decision.



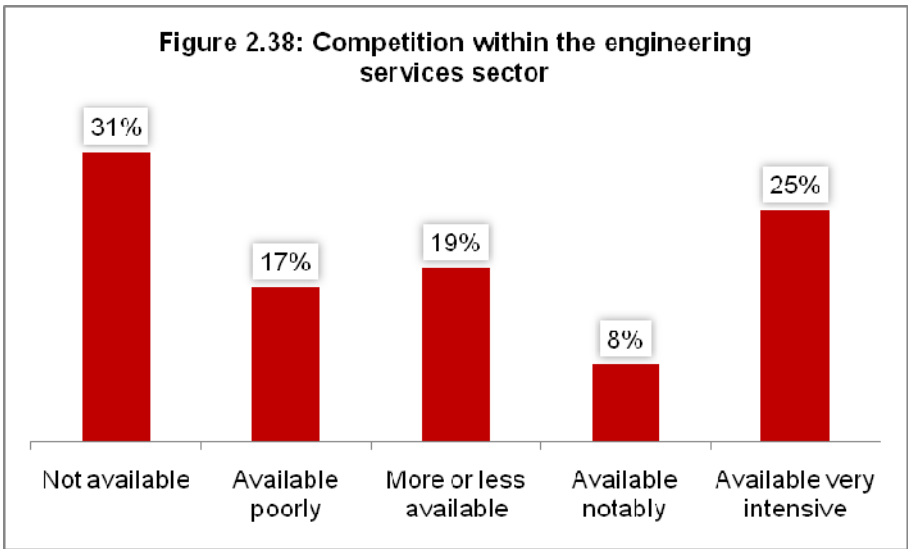

*Each factor was assessed on the scale from 1 to 5. Each factor in the chart is represented as a total sum of points that were assigned by company managers.*

86% of companies believe that the quality factor in the entire service package offered is highly important for international clients.

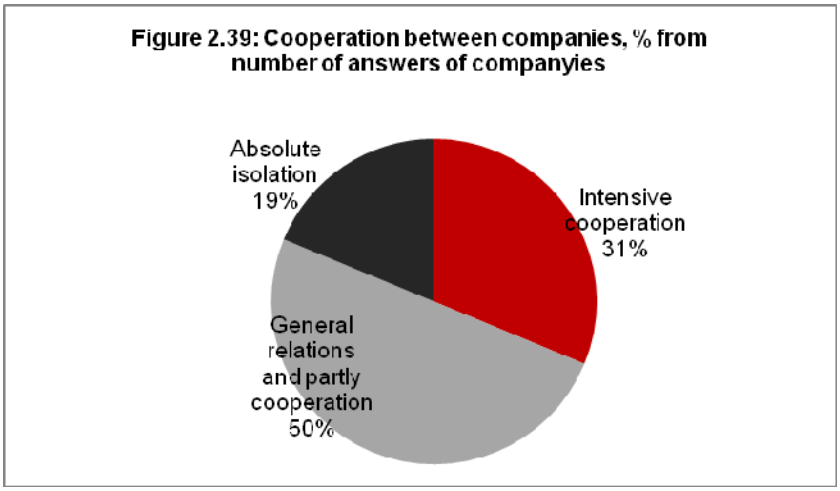



## *Competition between companies in the engineering service sector*

Company managers have assessed the competition between companies operating in the Armenian engineering services sector rather weak and poorly developed. So, about 50% of surveyed companies think that competition within the sector is either absent or negligible. On the other side, 25% of surveyed managers believe that there is a competition in the engineering services sector and it is very intensive. It is also interesting to note that most of company managers referred to the hidden competition available in the sector.




Regarding the cooperation between companies the majority believes that even if there is any cooperation, so it has a more formal and superficial nature. However, more than 30% of companies have mentioned the contrary that is that companies usually cooperate intensively on joint projects. This argument concerns particularly large-scale construction projects being implemented with participation of several engineering companies within their niche specialization fields.



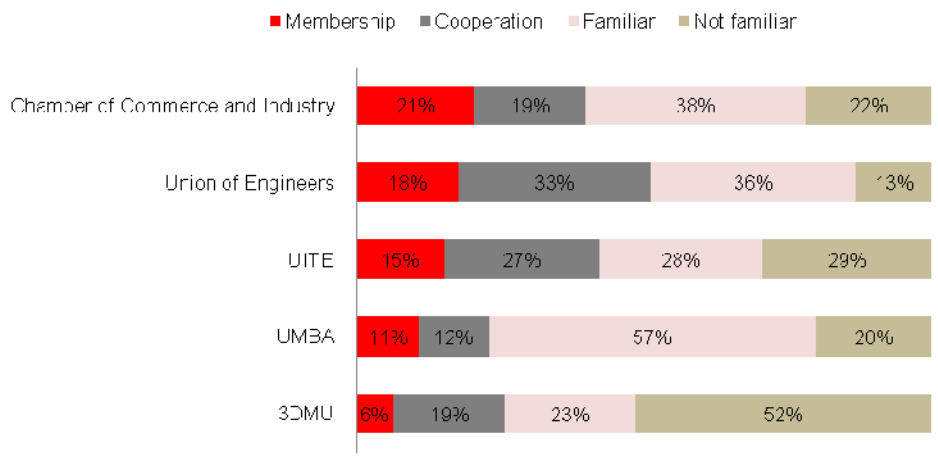

## *Business support services within the sector*

Armenian engineering companies have weak developed relations to various associations and unions. So, even if there is a number of economic development agencies and specialized business units operating within the sector, 13% of companies is not aware of any of such associations.

Union of Engineers, Union of Manufacturers and Businessmen of Armenia (UMBA) and Union of Information Technology Enterprises are the most known associations active in the sector.

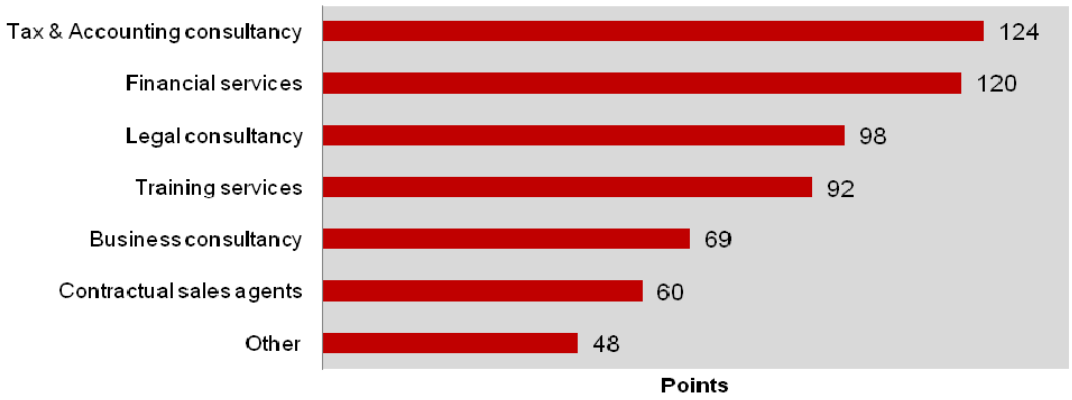
The RA Chamber of Commerce and Industry has the highest level of membership preceding the Union of Engineers. Armenian 3D Modeling Union established recently has been evaluated by companies as unsatisfactory (only 40% of interviewed companies are aware of existence of such association).

**Figure 2.40: Membership of engineering companies in business unions**




Company managers explain this lower level of membership of Armenian engineering companies in business services as a result of limited availability of the latter as well as underevaluation of their effectiveness by company managers. Support services widely used in this sector are tax and accounting consultancy. At present, financial services are the most requested yet less affordable business support instruments. About 8% of companies mentioned that they never have used any of business support services.

**Figure 2.41: Usage of business support services by engineering companies**

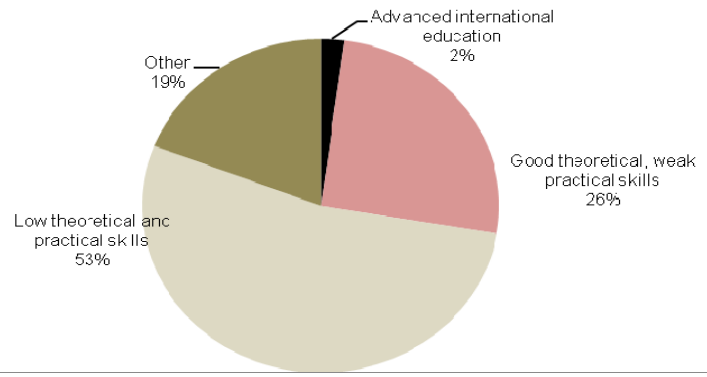



*Each factor was assessed on the scale from 1 to 5. Each factor in the chart is represented as a total sum of points that were assigned by company managers.*

### *Education system within engineering services sector*

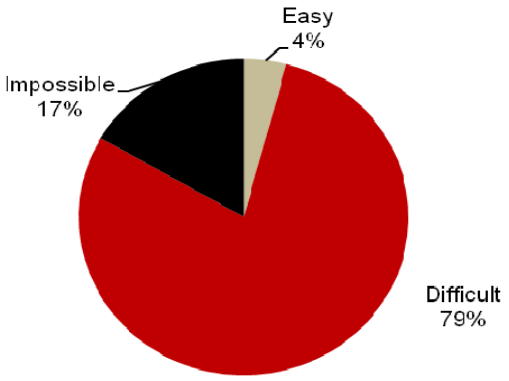
The quality of engineering education system is worrying. About half of company managers find that at present both theoretical and practical skills of graduates of technical universities are at the lowest level. Weak practical skills due to absence of corresponding labs and equipment 80% of companies consider as a serious omission for the sector. A small number of companies give also other characteristics for the sector's education system considering that graduates skills are not at the lowest level, however, it does not intersect the midpoint.

**Figure 2.42: Education system quality, % of total number of companies**



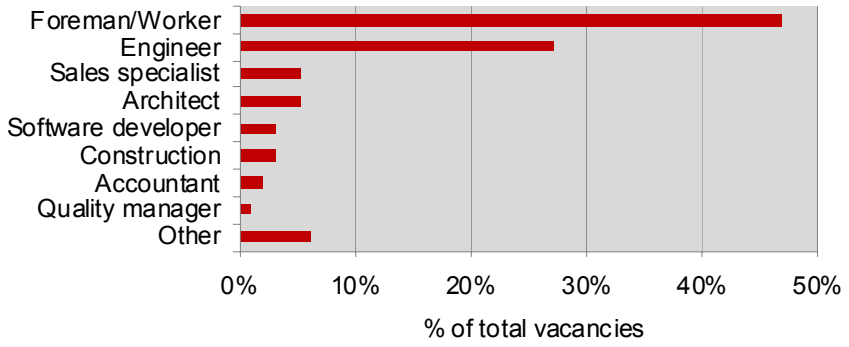

New graduate engineers are too far from having working culture due to missing linkage between theory and practice. That is why 80% of companies usually have difficulties to find necessary specialists. In addition, about one-fifth of companies interviewed mentioned that at present it is simply impossible in the engineering sector to find a specialist meeting all requirements.

**Figure 2.43: Ease of hiring required specialists, % of total number of companies**



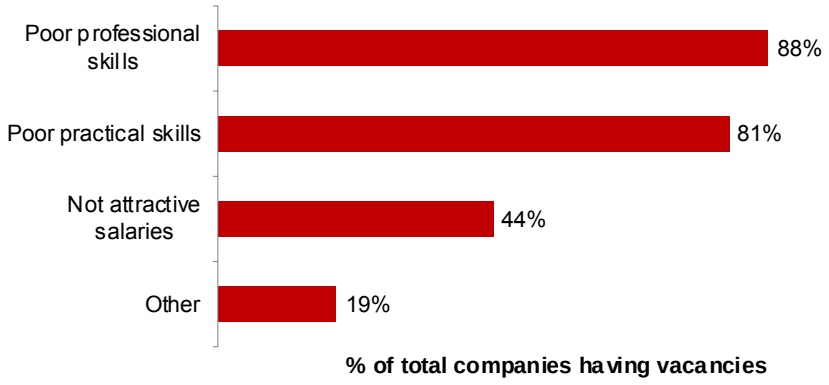

At present, 36% of engineering companies need to hire additional staff (number of answers: 44). Foremen and workers of different specializations (e.g. driller) are the most required specialists; the engineers are at the second place. Need for sales specialists comprise 5% of vacancies which evidences that the marketing function becomes increasingly important for the companies.

**Figure 2.44: Vacancies per specializations, % of total vacancies**




More than 80% of companies having vacancies mentioned that poor professional and practical skills are the main reasons for not finding employees with required qualifications. In addition, employers and job applicants often come into a conflict by agreeing the salary. Many of company managers think that engineers have ungrounded high expectations when it comes to remuneration. The nonadequate approach to the job and absence of working culture are also frequent occurrences in the labor market.

**Figure 2.45: Reasons of hiring difficulties**



### *Main impediments and needs of companies in the Armenian engineering services sector*

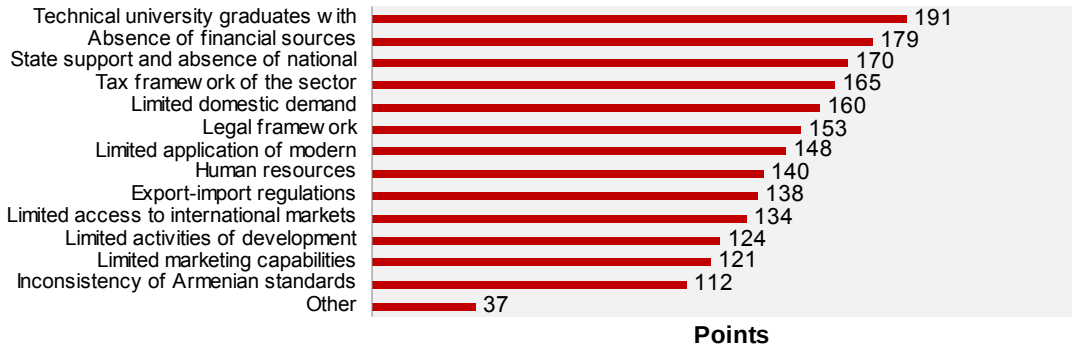
Company managers mentioned that there are numerous impediments in the Armenian engineering service sector, and that these impediments have deep roots. Very important is low qualification of the university graduates with engineering specializations. Dissipation of previous strong traditions of the engineering education can have a pernicious influence on the future development of the sector. It hinders alternation of generations which will result in strong reduction of sector's human resources in a few years.

The next important obstacle is the absence of financial sources, which is significantly limiting companies' operations. The loans provided by the banks are not affordable for many companies. That is why the companies have problems with expanding their services, and with exports.

According to company managers' opinion rather important obstacle is the absence of state support and operation of the regulatory framework, especially legal and tax regimes and export-import regulations. Many of companies think that the sector does not receive necessary support from the state; moreover, the state attaches no importance on the sector.

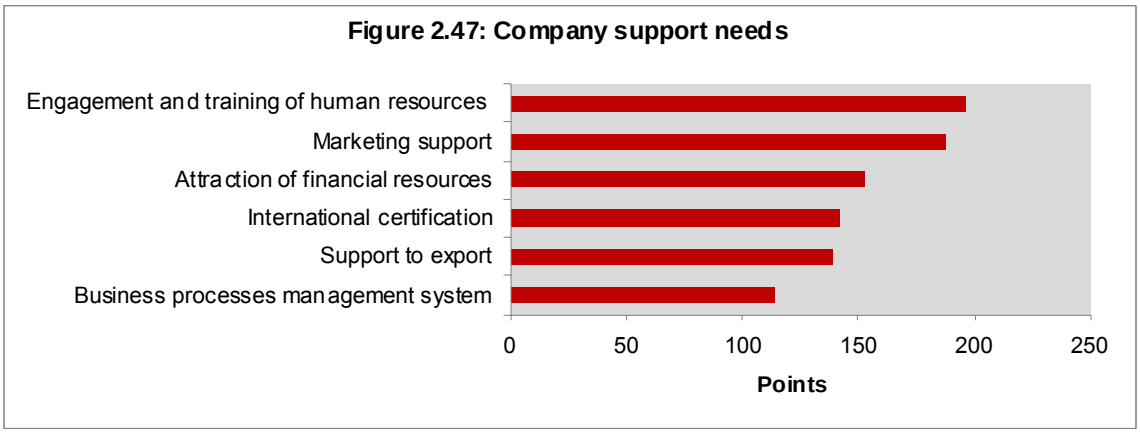
Small local market somehow limits the growth potential of the companies, and limited application of modern technologies limits companies' quality growth.

**Figure 2.46: Engineering services sector impediments**



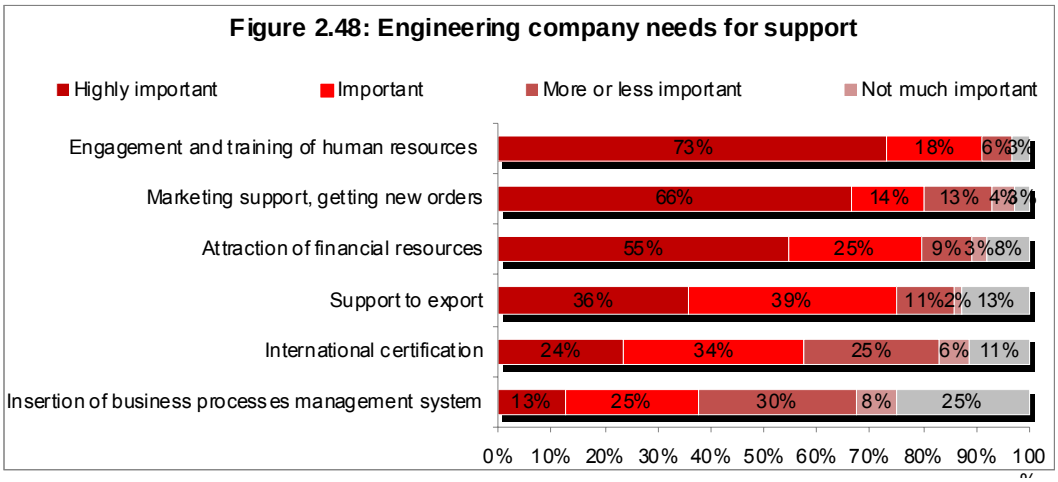

*Each factor was assessed on the scale from 1 to 5. Each factor in the chart is represented as a total sum of points that were assigned by company managers.*

According to the graphic below company needs are being formed on the basis of impediments of the sector. Improving the quality of human resources is of utmost importance for engineering service companies along with developing marketing skills. Company executives do not consider it so urgent to get international certification and the issue of business processes management is also of not an urgent importance.

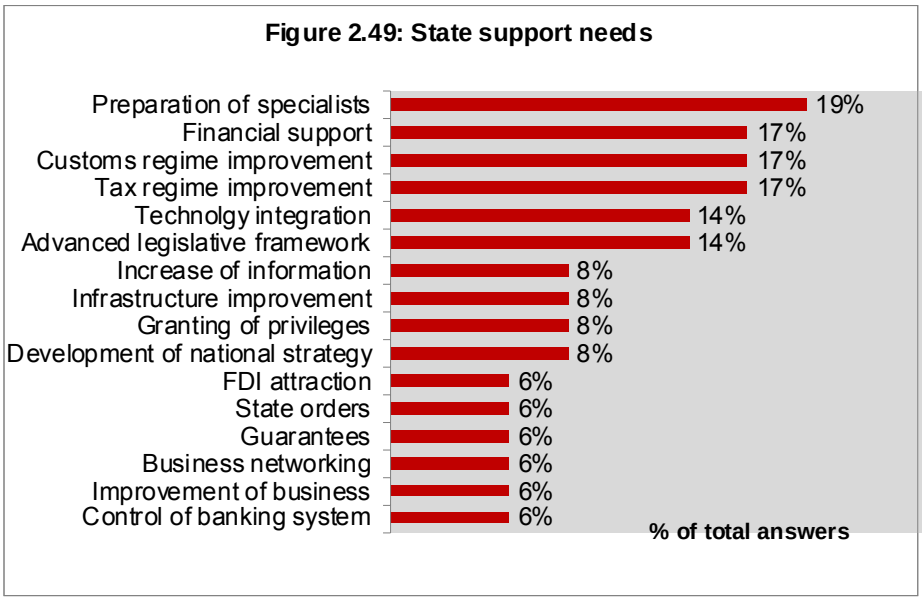



*Each factor was assessed on the scale from 1 to 5. Each factor in the chart is represented as a total sum of points that were assigned by company managers.*

Support needs for human resources and marketing received the most "Highly important" points. Engagement of financial resources and support to export follow the latter on the importance degree. On the other side, companies having no export intents or foreign representations also assigned many zero importance points to support to export.




The role of the state is highly important for the improvement of education system in engineering services sector. In the context of discussed impediments of the sector providing financial resources, governmental subsidies, improvement of tax and customs regimes as well as intensive integration of technologies in the sector are also urgent support needed from the state to address challenges of companies.




*Number of answers: 32*

## CONCLUSION

Summing up the engineering services sector research results in 4 large groups of structure factors (demand, resources, competitive environment and company strategies and supporting and related sectors) the sector state can be represented with following strong and weak points:

### Diagnostics of current state of engineering sector

**Competitive context and company strategies**

| Strong points | Weak points |
|---|---|
| Presence of foreign leading companies such as National Instruments, Cambric and EpigyArm | • Weak strategy management subsystem<br>• Weak access to foreign markets and orientation towards limited<br>• Limited competition in some segments of engineering services<br>• Imperfect legal framework and incompatibility of standards to international norms |

**Resources**

| Strong points | Weak points |
|---|---|
| • Inherited engineering traditions and workforce<br>• High level of education in mathematics and physics<br>• Limited yet expanding application of modern software packages | • Absence of graduates practical skills<br>• Low application of modern technologies<br>• Poor English knowledge<br>• Poor financing conditions |

**Demand factors**

| Strong points | Weak points |
|---|---|
| • Growing investments in infrastructures creating strong demand for engineering services<br>• Diaspora as linkage between companies and markets as well as source for missing competencies | • Less-developed industry which is the main consumer of engineering services<br>• Quality is important for the domestic market, but clients pay great attention to the price factor<br>• Limited domestic market |

**Supporting and related segments**

| Strong points | Weak points |
|---|---|
| • Advanced information technology industry supporting to provide engineering services by application of IT instruments<br>• Advanced IT industry and improving education in this sector favour the demand for high-qualified specialists to be increased<br>• Educational and supporting initiatives of international organisations | • Limited capabilities of sectoral associations and low level of cooperation between companies |

The following three phases in the development logics of Armenian engineering sector can be defined:

- ***Soviet era "industry prosperity":*** time until 1990, when a large number of engineers were educated and numerous planning institutions were established supplying large industrial complexes from all the Soviet Union.
- ***Post-soviet era:*** the 1990s, when relations to main clients were broken off and the local industry was fully disrupted. In this period a large number of qualified engineers moved to foreign countries or other sectors of economy and the demand for engineering services decreased to the minimal extent.
- ***Revival time:*** from year 2000 which is distinguished by a certain revival of engineering services sector. This revival was basically caused by two main tendencies. The ***first*** tendency was determined by strongly increased local demand. In Armenia, large-scale investments in infrastructures, especially in the fields of power engineering, telecommunication, construction of hydraulic facilities have significantly increased demand also for engineering services. In addition, rapid growth of civil construction has created great demand for engineering and other related planning services. Thanks to inherited engineering potential local companies could rapidly response to the generated demand. Directions of main activities of companies surveyed are evidence of that. The ***second*** tendency was mostly as a result of globalization of engineering services and developed information technology capacities already formed in Armenia. Armenian companies using the IT instruments began to provide engineering services to foreign companies. In these years start-ups have been established more intensively and leading international companies opened branches in Armenia (EpigyArm, National Instruments, Cambric).

There are about 50 companies representing Armenian engineering services sector, which are mainly specialized in the field of design of power engineering and hydraulic work. The majority of companies are of medium size, comprising of 20-100 employees. Almost 50% of the workforce employed in the engineering services sector is comprised of engineers and scientists.

In 2009, the majority of Armenian engineering companies had an average income of 50-100 million Armenian drams. Most of the companies studied have 100% of their income from engineering services. For 2009, the estimated overall turnover of Armenian companies providing engineering services was 10.5-13.5 billion Armenian drams. In coming three years an average annual increase of 11% is expected.

Domestic sales fraction of Armenian engineering companies is nearly 85%. The remained 15% is exported to other countries, mainly to USA.

**Main obstacles hindering development of the engineering sector and support needs according to company managers participated in the survey**

| Development obstacles | Support needs and sectors needing support |
|---|---|
| • Graduates with low qualification<br>• Not affordable financial resources<br>• Poor tax regime and legal framework<br>• Absence of strategy for sector's development<br>• Low use of state-of-the-art technologies<br>• Export and import regulations<br>• Limited domestic market<br>• Underdeveloped marketing capabilities | • Development of human resources<br>• Marketing support and getting new orders<br>• Support in strategic planning<br>• Involving of financial resources<br>• Selection of export markets and support to export<br>• International certification<br>• Promotion of cooperations and joint efforts |

# CHAPTER 3: RESEARCH OF ENGINEERING SERVICES GLOBAL SECTOR AND EVALUATION OF DEVELOPMENT CAPABILITIES AND OPPORTUNITIES OF ARMENIA

## ENGINEERING SERVICES GLOBAL MARKET

### *SECTOR DEVELOPMENT TENDENCIES*

Development of engineering services sector is a derivative from development dynamics of its main consuming industries – construction and industry. Parallel to the quantitative growth, the sector has experienced essential qualitative evolution thus, increasingly expanding the frames of its activities and consuming areas. For the formation of the sector, the gradual separation of services from the final product and offering services as a separate product was of great importance.

Being firstly represented in Great Britain in the 18$^{th}$ century engineering services global industry development were getting an upswing from late 1960s. Though over the time, the further growth of the sector has become quiet manifold and irregular. In the period between years 1960 and 1970 export of engineering solutions and consulting services was booming in European countries that were the main participants in the market. At that, in different countries the market has been developed in different ways. Thereby, if in France the engineering services sector mainly was developing as a derivative from the construction sector, so in Great Britain, Scandinavia and Netherlands an independent sector has been formed supplying numerous sectors of industry.

In the next decade, however, the demand within the sector was strongly reduced determined by global economic crisis. The sector experienced its revival again in 1980s in Central and Eastern European countries. In these countries private investments in large amounts contributed to the rapid growth of sectors being the main consumers of engineering services, such as the construction industry.

In general, development of engineering services sector is mainly based on following three factors:

- Governmental and private investments in consuming industries which are construction, manufacturing industry, power engineering, mining, infrastructure etc.;
- Research advance and level of demand improvement that is what is the level of usage of complex engineering solutions in production processes by local sectors of industry;
- Development and accessibility of internet technologies ensuring internationalization of services and country specialization.

### *Global demand for engineering services*

Due to missing precise definition of the sector as well as its crossing with other sectors statistical data on engineering services global market volume is not available. Though,

research performed in this sector allows evaluating the general picture and development characteristics of the sector.

Engineering services provided by specialized companies as well as R&D activities performed by industrial enterprises are considered as main components of engineering services market.

According to the report of USA National Science Board "Key Science and Engineering Indicators-Digest 2010" R&D expenditures worldwide are estimated to have exceeded ***$1 trillion in 2007, at twice the rate during the last decade***.

In 2008, for R&D total costs of 630 billion US dollar have been invested by 2000 largest R&D investors of the world which means an average annual increase by 8.6% during past three years[5]. The US companies have the highest R&D growth rate accounting for 37.7% and the share of EU and Japanese companies was 28.9% and 22.2% respectively.

Evaluations for specialized engineering services (design of facilities, power industry, hydraulic facilities etc.) are more fragmented and often include the related sectors, in particular construction services. According to the CBI research, in largest countries (USA, EU, China, Japan, Russia, Brazil, India) ***engineering and construction services markets have been together estimated at about 640 billion US dollar for 2009***.

The total revenue of top 200 international design firms amounted about 120 billion US dollar, the 45% of which was formed from foreign projects[6]. Design activities have the highest income share in the following industries: petroleum (31.7%), buildings (17.7%) and transportation (15%) and by geographic regions EU is the leader (25.4%) with Asia/Australia (20.5%) at the second and Middle East (18.2%) at the third places. Income received from African countries amounted 6.7% of the total.

**Figure 3.1: Income of top 200 design firms by geographic regions, 2008**

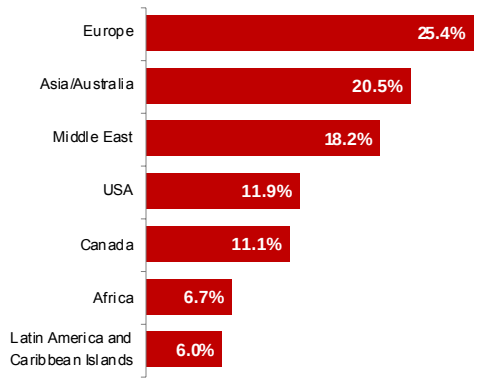
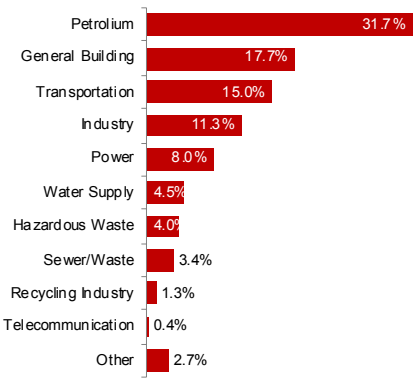



**Figure 3.2: Income of top 200 design firms by sectors, 2008**



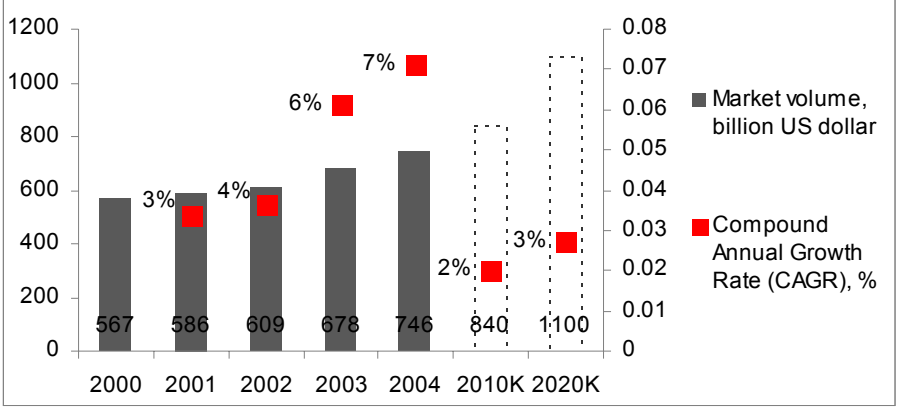

[5] The 2009 EU Industrial R&D Investment Scorboard, European Commision

[6] The Top International Design Firms-2009, Engineering News Record

More comprehensive examination of engineering services sector has been performed in the 2006 study by NASSCOM and Booz Allen Hamilton[7].

According to evaluation of consulting company "Booz Allen Hamilton" the global engineering services market has been estimated at 750 billion US dollar in 2004[8], an amount equal to 2% of global GDP. In the following five years the sector recorded an average annual growth of 7%. Forecasts for further development of the market are rather modest. In 2010, the market turnover expected will be 840 billion US dollar and in 2020 – 1,100 billion US dollar which means that in the period from 2004 to 2020 the compound annual growth rate is only 2%.

**Figure 3.3: Engineering services global market dynamics**




** For 2010 and 2020 Compound Annual Growth Rate (CAGR) was calculated for the periods from 2004 to 2010 and from 2010 to 2010 accordingly.*

*Source: Booz Allen Hamilton, NASSCOM, 2005*

The global demand for engineering services is being formed only by several countries; it is mainly concentrated in developed countries accounting for 91%. The economy of the USA is the main consumer of engineering services. It accounts about 40% of the global market. European share of engineering services expenditures fell by one third. Japan is also one of most important participants of the sector the market share of which amounts to 20% of global engineering services market. Other countries sell only 5% of entire engineering services. Canada and Korea also play quiet serious role in the global market. China among being one of the largest suppliers of engineering services also has a big domestic market.

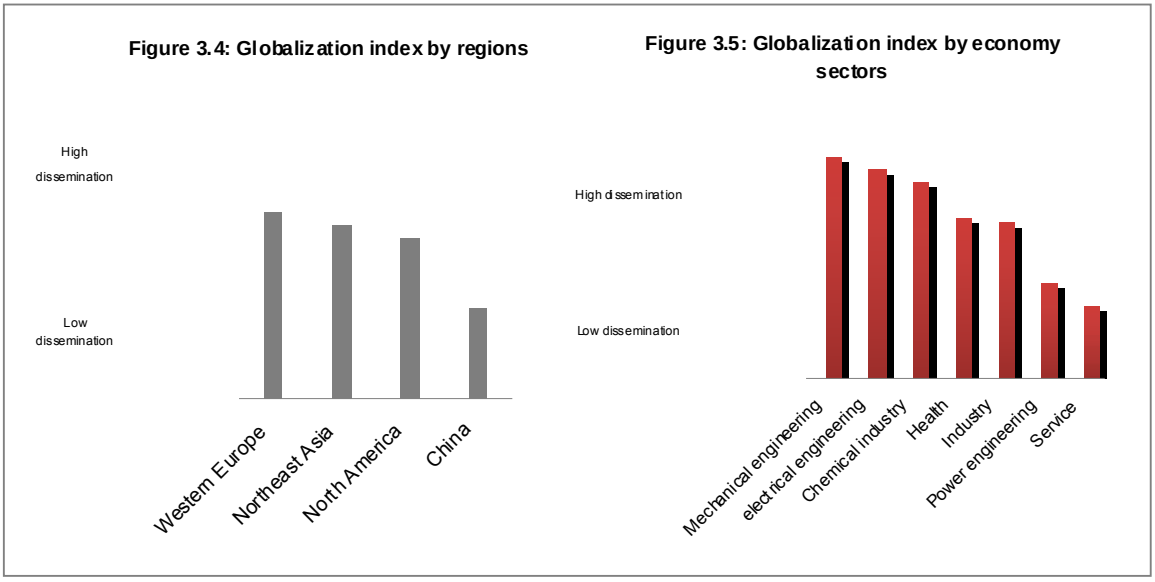
European largest markets for engineering services are Germany, France and Great Britain which is determined by rapidly growing construction and industrial sectors.

Sweden and Germany are the leaders among other European countries by the size of their building construction industry while the most rapid growing rate is expected for Poland and Romania. France and Germany make the largest investments in the infrastructural sector. Here, Poland also represents promising development perspectives.

[7] "Globalization of engineering services: the next frontier for India", Booz-Allen Hamilton, NASSCOM, 2005

[8] Considered only the "pillar" engineering services which include the following sectors: aerospace, automotive, construction,, high technologies/telecommunication, infrastructures, construction and industrial equipment. Software engineering not included.

Outsourcing of engineering services by European countries has the most wide geographic extension. They tend to internalization of their value chain more often than others. Mechanical engineering, electronics and chemical industry are sectors being globalized for the most part.

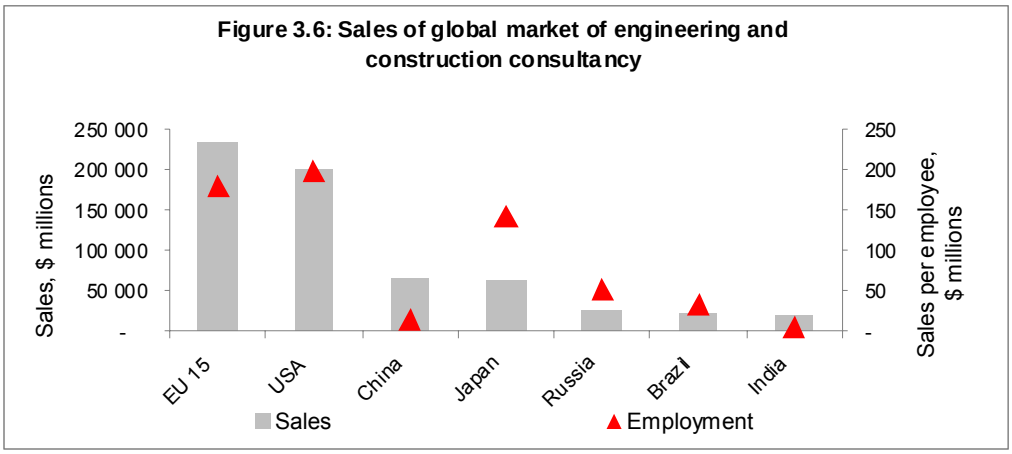



*Source: INSEAD Global Innovation Network Analysis, Booz Allen Hamilton, 2005*

## *Evaluation of engineering services market together with related markets*

Engineering services market can be evaluated also when studying the analysis of combined statistical data with related sectors.

According to CBI evaluation in 2009, the EU provided the highest level of sales in the engineering and construction consultancy sectors. The USA, EU and Japan have the highest level of workforce productivity. India's and China's annual sales per employee amount to 6 and 14 thousands US dollars respectively.



*Industrial engineering services are not included in the graphic.*
*Source: "The engineering services market for offshore and nearshore outsourcing in the EU", CBI, 2009*

Interesting is the fact, that India with its engineering and construction consultancy sales is even not in the top ten of countries, but is strongly distinguished by the large number of institutions available in the sector amounting to 225,000 comparing to the USA index of 60,000 and entire EU index of 90,000. China's market is also rich of active subjects. In general, the number of institutions registered in these two countries highly deviates from the average, thus displaying that the engineering sector is highly fragmented here and has numerous participants.

Germany's share in import of engineering and architectural services in Europe is about 40%. Other largest importers for this sector are Italy, Great Britain and Belgium. At the same time, Irish companies more often place orders for engineering and technical consulting services to foreign companies. Getting consultancy from abroad is typical for Great Britain and Denmark. Interesting is the fact, that Germany is a large importer, but only about 2% of German companies outsource engineering and technical consulting services to foreign companies.

**Figure 3.7: Import of architectural, engineering and other technical consultancy, 2004**
**$ millions**

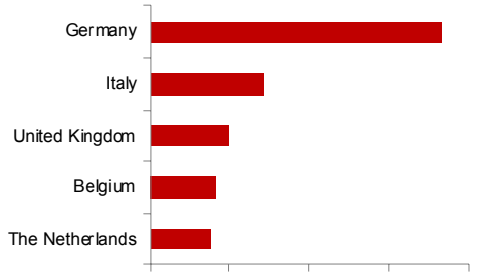
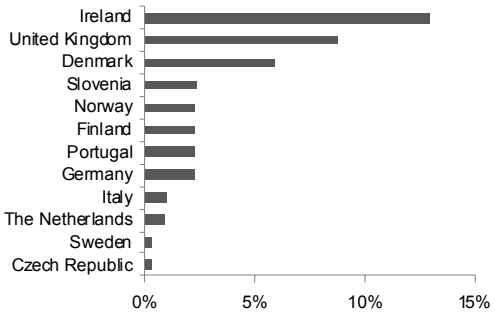



**Figure 3.8: Import of engineering and other technical consultancy, 2009**
**% of companies' total number**




*Industrial engineering services are not included in the graphic.*
*Source: "The engineering services market for offshore and nearshore outsourcing in the EU", CBI, 2009*

## *Main suppliers: sector internationalization and outsourcing zones*

Outsourcing processes has experienced essential qualitative changes over the time. In 1970s, when large international companies began to establish first production centers in foreign countries the main cause for that was the low-cost workforce in these countries. In a short time the arbitration of the cost-effective workforce (mainly workers) has been changed to "hunting for talents" when companies began to outsource more complex functions to foreign countries. Outsourcing of blue-collar-jobs was changed to outsourcing of white-collar-jobs.

It is expected, that compared to 2006 quality factors will become increasingly important for internationalization of certain functions in the period from 2010 to 2015. Foreign outsourcing

in order to cut the costs will be declined from present 96% to 70%. Instead of that, when obtaining services abroad companies will pay much more attention on opportunities for entering new markets, quality, increase of employee productivity and enhancement of company capacities.

**Main incentives for offshore outsourcing**

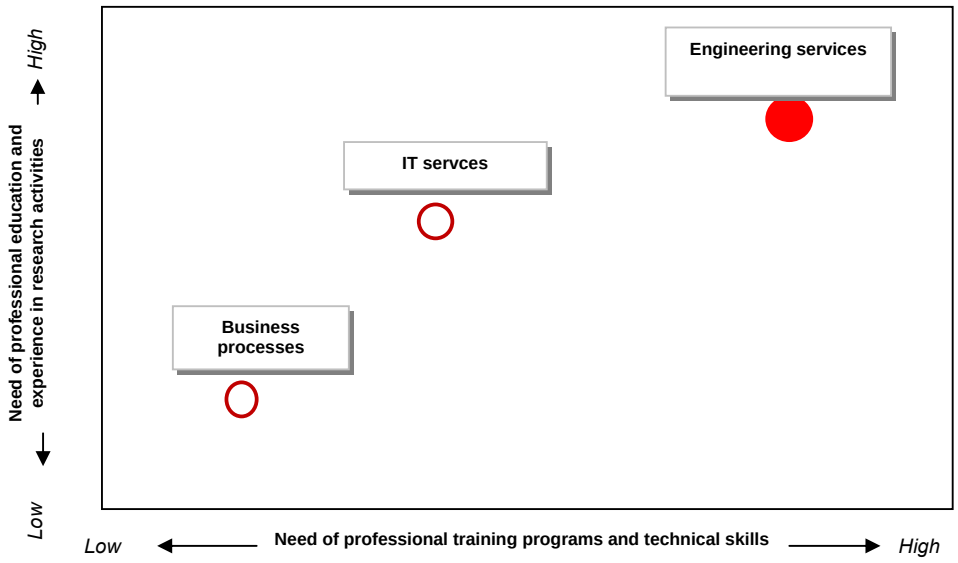
| *Importance* | 2006 | 2010-2015 |
|---|---|---|
| Costs minimization | High | Higher as medium |
| Access to markets | Lower as medium | Higher as medium |
| Quality of primary product | Lower as medium | Higher as medium |
| State support | Lower as medium | Medium |
| Time to market | Low | Lower as medium |
| Servicing | Low | Medium |
| Productivity growth | Low | Medium |
| Improvement of capabilities | Low | Medium |

A number of developed countries such as India, China, Brazil, Philippines became engineering services outsourcing zones due to high concentration of graduates with technical education.

Offshore outsourcing was extending over the entire value chains of companies from elementary business processes to complex solutions and designs.

Over the time, outsourcing of IT and business processes that do not require high professional skills and save the costs has been spread at a very rapid pace. On the contrary, outsourcing of engineering services requires strong professional qualifications. The following figure represents the map of qualifications required for outsourcing in these sectors. Professional skills are highly required for the engineering services sector while for outsourcing of business processes language and communication skills as well as associativity of cultural values are the main qualifications. For the IT sector professional education is also of high importance yet not as important as for the engineering sector.

**Figure 3.9: Qualifications required for offshore outsourcing of services**

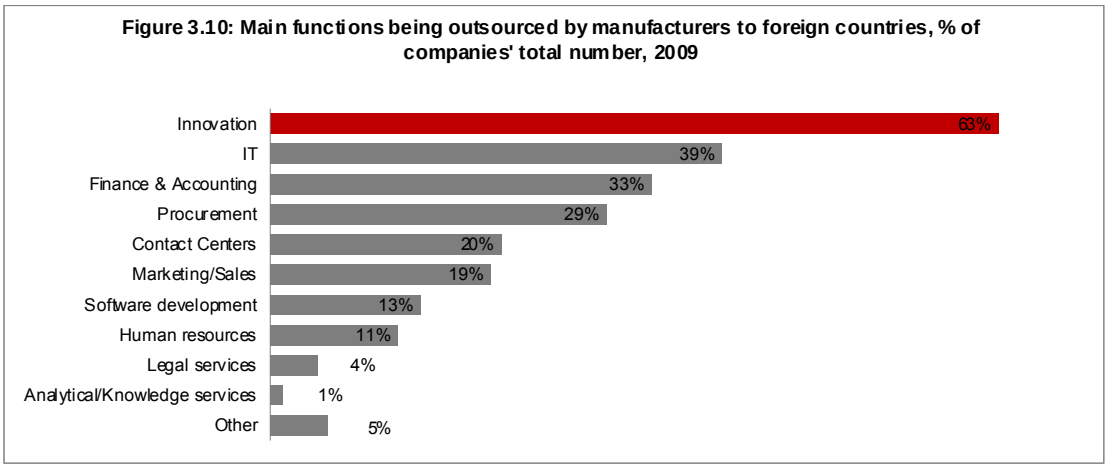



*Source: Booz Allen Hamilton, "Economy and values" Research Center*

Offshore outsourcing quality differs by countries. If the USA companies globalize simple business processes to minimize the costs and then gradually pass to outsourcing of more complex processes, so in Europe outsourcing has a more strategic nature and is less used to cut the costs. Nevertheless, it's expected that development of engineering services offshore outsourcing market in Europe will take a more rapid pace. Japanese companies are less tended to offshore outsourcing though some of largest Japanese companies widely globalize their functions.

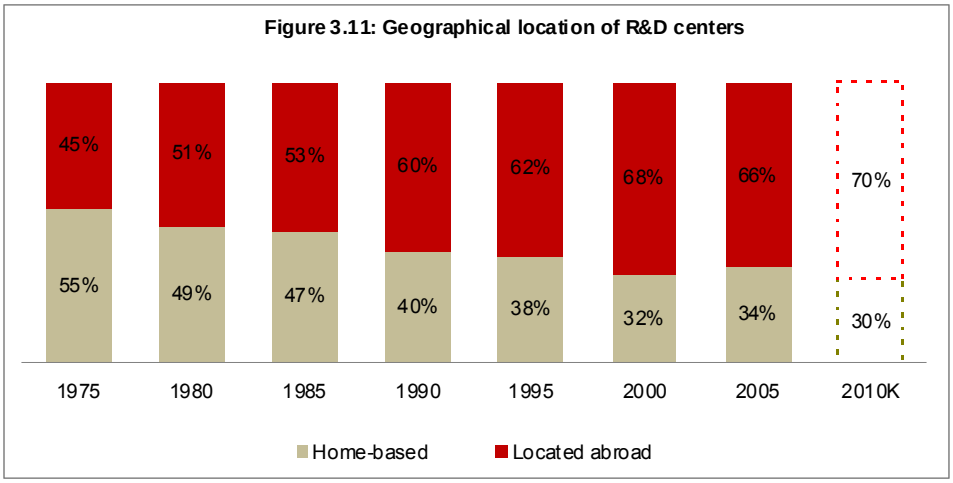
At present, innovation[9] is being more outsourced in foreign countries. In 2009, 63% of companies have performed innovation activities abroad. IT and financial and accounting services are the next functions being outsourced.

[9] "Innovation" includes engineering services, R&D and supporting activities and product design.




*Source: Duke University/The Conference Board Offshoring Research Network 2009 survey, 2009*

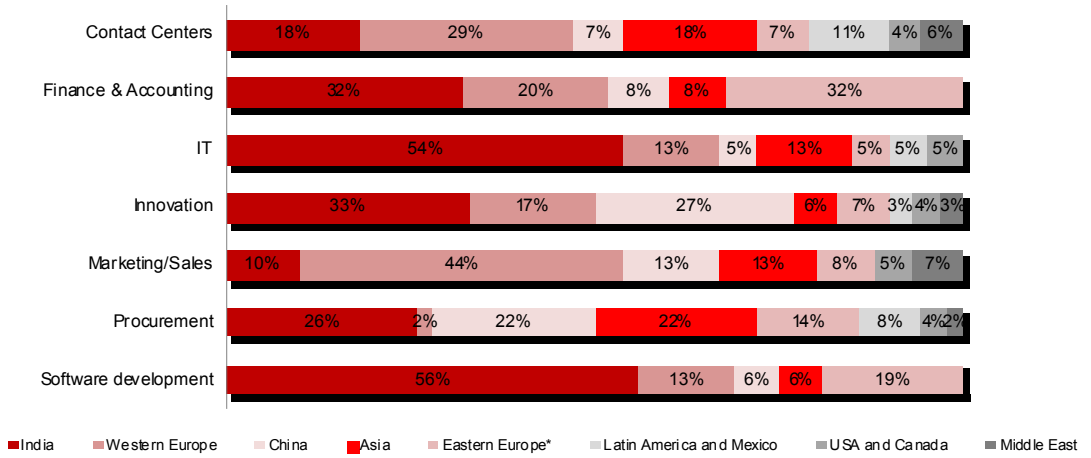
R&D outsourcing dynamics indicates outsourcing tends for more complex processes. As the figure below shows the share of offshore R&D centers increased from 45% (in 1975) to 66% (in 2004). According to the forecast for 2010 only one–third of R&D centers worldwide will be located in the home country.




*Source: INSEAD Global Innovation Network Analysis, Booz Allen Hamilton, 2005*

While Europe and USA traditionally were the largest centers for innovation activities India and China rapidly strengthen their position in this sector. In 2009, 60% of companies outsourced innovation to India and China.

**Figure 3.12: Countries/regions for offshoring of a certain function by manufacturers**




** Eastern Europe includes also Russian.*
*Source: Duke University/The Conference Board Offshoring Research Network 2009 survey, 2009*

Countries, in particular developing industrial countries, that are suppliers of engineering services in the global market are positioned mainly in the niche specialization sectors.

| Country | Specialization field in the engineering services market |
|---|---|
| India | Electronics |
| Russian | Aerospace |
| Bulgaria | Electronics |
| Romania | Mechanics |
| Czech Republic, Slovakia, Poland | Mechanical engineering |

Brazil and Malaysia are also quiet active offshoring zones. Philippines and Vietnam have growing presence in the global market of engineering services.

The figure below represents competitive position of some large offshore zones for engineering services by economical and political factors. India, China and Israel are quiet attractive almost by all considered factors. Though Poland has weak competitive positions by domestic industry, development of infrastructure as well as workforce availability and quality of professional education it is yet attractive as an offshore zone by global political conditions, legal framework and cultural and language values.

**Figure 3.13: Country attraction as offshore zone**

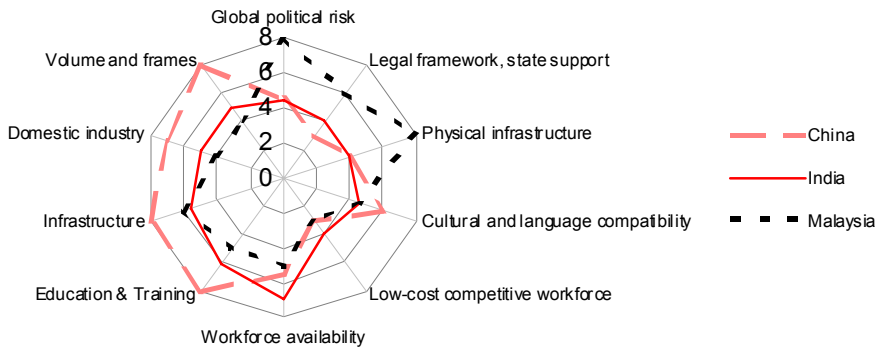
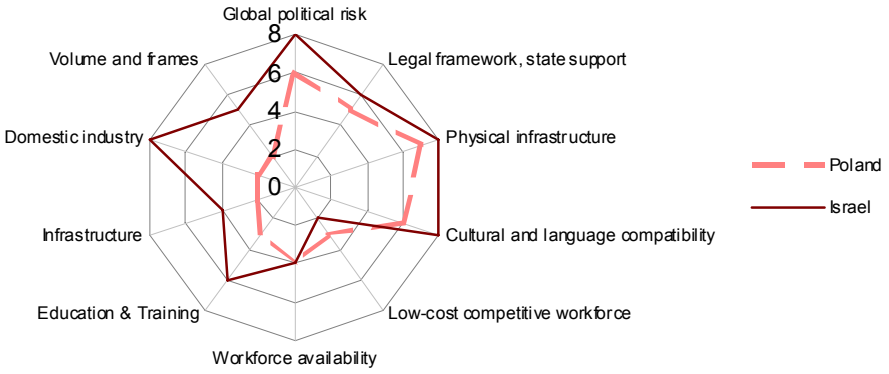


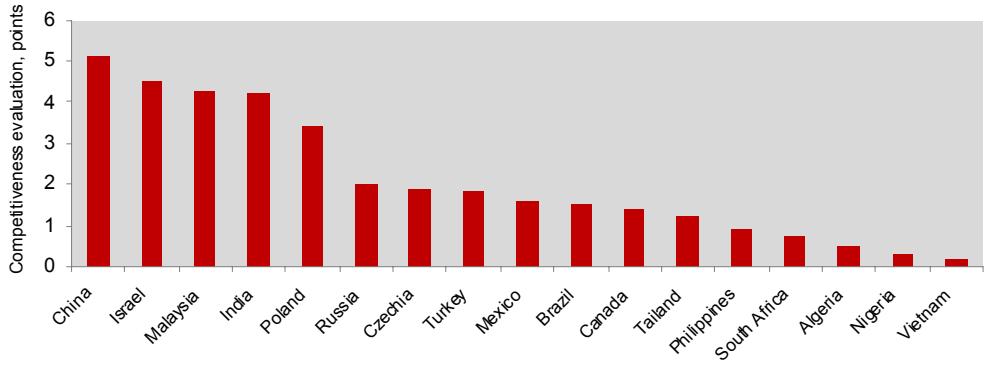

**Figure 3.14: Country attraction as offshore zone**




*Source: Booz Allen Hamilton, "World Investment Report" UNCTAD, 2005*

Competitiveness of countries evaluated by discussed factors is represented below. China, Israel, Malaysia and India are the most attractive countries for offshoring in this sector.

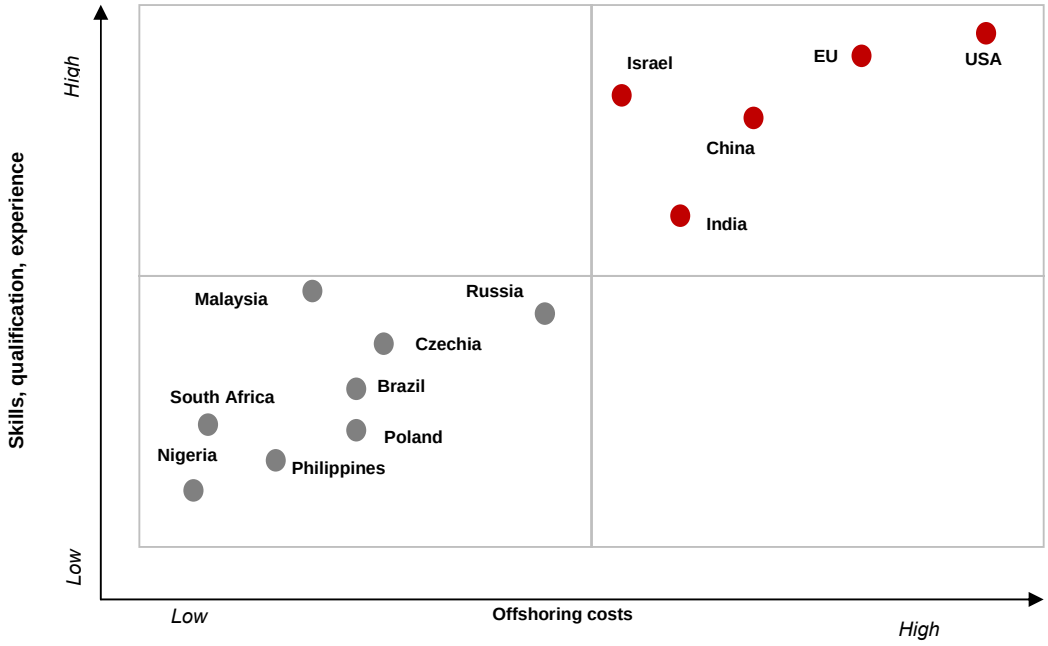
**Figure 3.15: Competitiveness of countries as offshore zones**




*Source: Booz Allen Hamilton, "World Investment Report" UNCTAD, 2005*

The market of engineering services suppliers is expected to be significantly expanded until 2020 where China, India, Southeastern Asian countries, Eastern Europe, Brazil, Mexico, Argentina, some African countries, Turkey, Egypt and Iran will be represented as the sector's largest participants.

**Figure 3.16: Global engineering market participants in 2020**

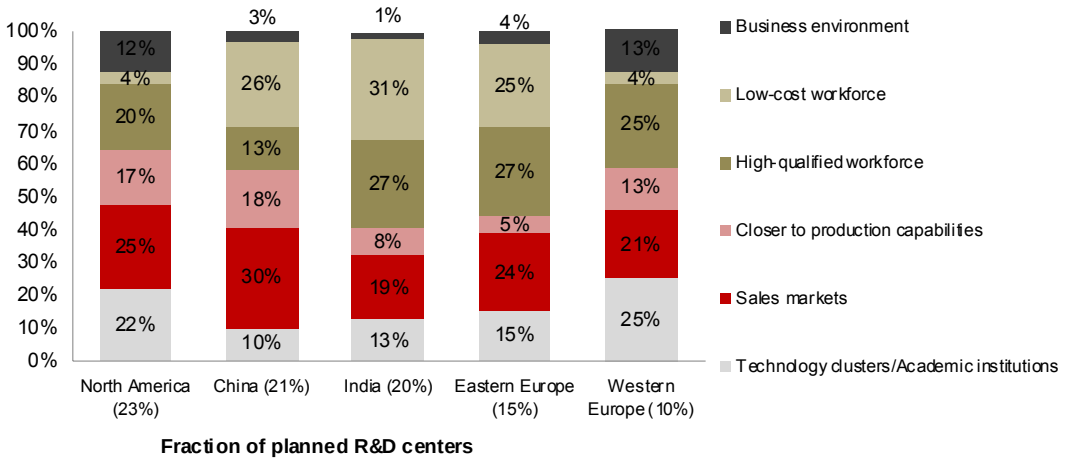



*Source: Booz Allen Hamilton, 2005*

It is expected that engineering services providers from China and India currently being active in the lower segment of the market will notably enhance the quality of offered services which will lead to increase of offshoring costs in these countries. A range of developing countries such as Nigeria, Philippines, South Africa, Brazil will compete in the lowest segment. Services offered by Malaysia, Czech Republic and Russia will have higher quality.

During coming years only one-forth of R&D centers to be established by American companies will have their location in the USA. The remained centers will work in China, India, countries of Eastern Europe and Western Europe. At that, if American companies choose India and Eastern Europe for high-qualified and low-cost workforce, so in case of China the large domestic market is the key factor.

**Figure 3.17: Reasons to select destinations for R&D centers planned by American companies**

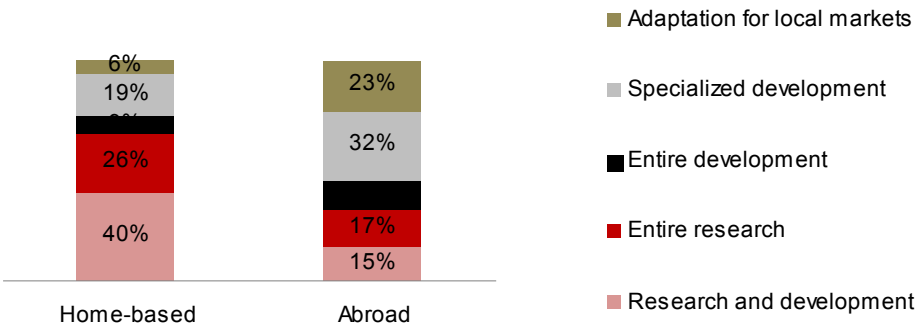



*Source: INSEAD Global Innovation Network Analysis, Booz Allen Hamilton, 2005*

Global companies' R&D centers located abroad are mainly professional centers possessing remarkable experience. There is also a large number of centers adapting products to market requirements. These comprise 23% of foreign R&D centers.

The majority of home-based R&D centers which is 40% works on R&D entire lifecycle and one-forth of centers conducts only the research completely. In general, 55% of offshore R&D centers work on design of unique solutions and their adaptation to the regional requirements while only 25% of local R&D centers operate in this area of activity.

**Figure 3.18: R&D center functions**



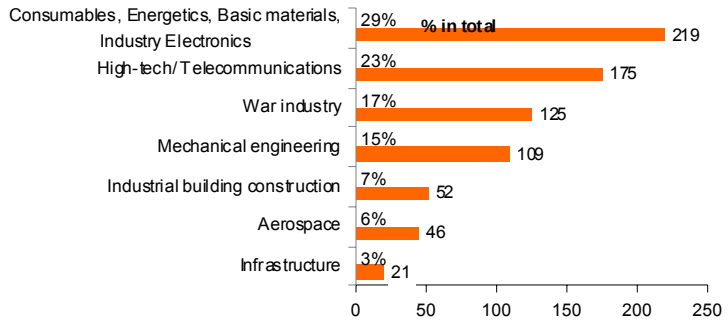

*Source: INSEAD Global Innovation Network Analysis, Booz Allen Hamilton, 2005*

## *Sector structure and segmentation*

Engineering services industry is very large as per its definition and comprises of many subsectors. High technologies, mechanical engineering, aerospace, civil engineering, infrastructures, industry, logistics, agriculture are the main specialization fields of the sector.

According to “Booz Allen Hamilton” 2005 research high technologies and telecommunication dominate within the engineering services sector. In the military sector of industry engineering services annual share is equal to about 125 billion US dollars.

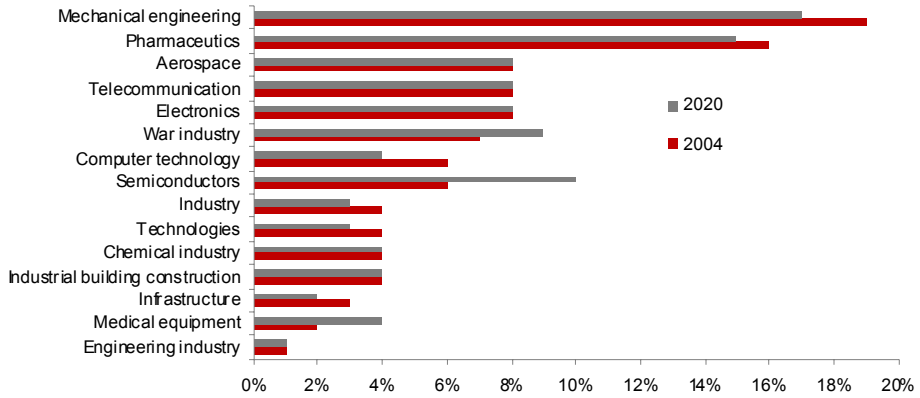
**Figure 3.19: Engineering services market by sectors, in billion US dollars, 2004**




*Source: Booz Allen Hamilton, “World Investment Report” UNCTAD, 2005*

According to forecasts, in 2020, density of military engineering as well as sectors of semiconductors and medical equipment will grow within the engineering services sector, compared to 2004. On the contrary, share of specialized engineering services in infrastructures, computer engineering and technologies will decrease. Sectors like chemical industry, electronics, telecommunication and aerospace will not experience essential changes in terms of presence in the engineering services global market.

**Figure 3.20: Engineering market by sectors, % of total**




*Source: Booz Allen Hamilton, “World Investment Report” UNCTAD, 2005*

## COMPETITION MODELS WITHIN ENGINEERING SERVICES SECTOR

Market of engineering services has its peculiar logic where the main business models for competition are formed. Development of Armenian engineering services sector shall be also observed in the context of existing models, yet the possibility to form a unique life model based on Armenia's special features (Soviet research heritage, Diaspora contacts, lost industrial capabilities, successful experience in the IT branch) shall also not be ruled out.

The basic competition models currently popular in the engineering services sector can be divided into five types each different by its format of relations to customers/markets and by unique value offerings which are represented by companies using this model:

Model 1: Research and development centers, mainly of transnational corporations;

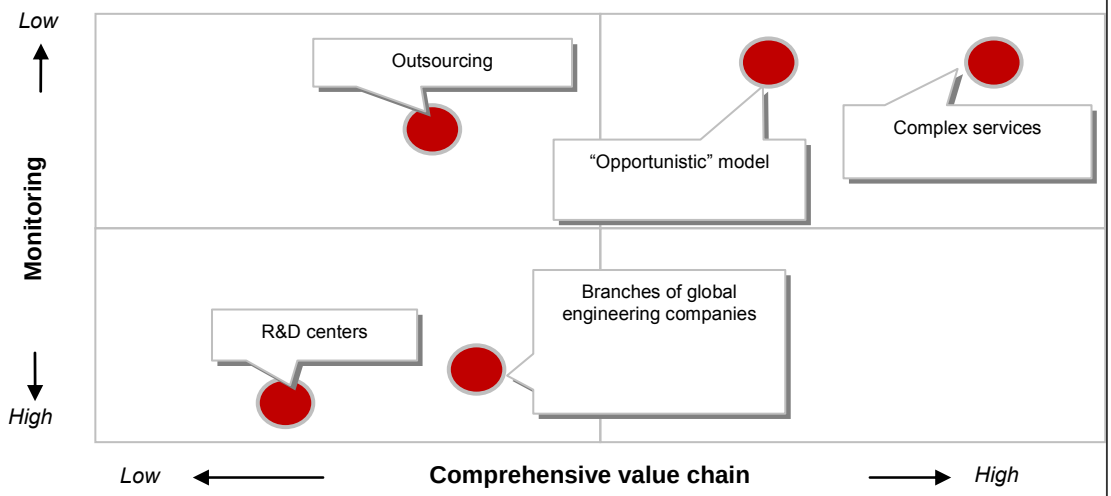
Model 2: Providing of services in the outsourcing market;

Model 3: Providing of complex services by specialized companies;

Model 4: Regional representations of global companies;

Model 5: Opportunistic model which means providing of engineering services by industrial enterprises (mainly not regularly).

**Figure 3.21: Competition models**




*Source: "Economy and Values" Research Center*
Note: Monitoring relates to monitoring of service provider activities by the customer, in particular high monitoring assumes that customer is the owner of service provider.

Engineering services competition models and their identifiers by main characteristics are described below.

| | R&D centers | Outsourcing | Providers of specialized services | Regional branches of global companies | "Opportunistic" model |
|---|---|---|---|---|---|
| Value offer | Unique research capabilities and innovation | Increase in productivity and minimization of costs | Complex solutions for engineering services | Entering into large domestic or regional markets | Professional niche solutions based on own know-how and using the opportunities available in the market |
| Comprehensive value chain | Narrow, mainly high value added activities | Narrow, mainly standardized solutions, entire solutions also can be included | Wide, complex solutions to end customers | Middle, includes also marketing, sales and client servicing functions | Narrow specialized |
| Main customers/market | MNCs mainly in the industry | Global engineering service providers, large and medium-size industrial enterprises | Construction and infrastructural organizations, governments, industrial enterprises | Local and regional construction and infrastructural organizations, governments, industrial enterprises | Various local and foreign industrial enterprises |
| Service Providers | R&D centers | Companies specialized in outsourcing | Providers of specialized engineering services | Global company branches | Mainly engineering affiliates of industrial companies |
| Main success factors and key capabilities | High-quality research staff<br>Research infrastructures<br><br>Effective national innovation system<br><br>Local R&D investments and fiscal and financial incentives | High-skilled, low-cost and high-performance engineering workforce<br><br>Project management capabilities<br><br>Internationally acknowledged certification<br><br>Market relations and service providing models | Large domestic market contributing to development of unique capabilities<br><br>Developed business capabilities in addition to technical skills | Large domestic market, free access to regional markets<br><br>Advanced technical and business skills<br><br>Language and cultural similarities and relations to the countries of the region | Industrial companies possessing large engineering capabilities |

### *Model 1: Research and development centers of transnational corporations*

According to this model foreign companies carry out their R&D activities through own branches where the client has the maximum control. Property protection and quality management are the main issues compelling global companies to prefer this model. Traditionally, R&D activities being as key functions of companies are mainly carried out in the headquarters of the company. However, increasing competition and price pressure force the companies to more effectively organize their innovation activities by engaging new talents and cutting costs. In this model, transnational corporations mainly from leading industrial countries (USA, EU and Japan) are dominant. Developed countries have the biggest share in inflow of R&D investments while share of R&D expenditures made by foreign branches in emerging countries increases faster within total R&D. Still in 2002, about 13% of investments were made by foreign branches of USA transnational corporations in emerging countries. The level of economic development of countries receiving investments determined their sectoral orientation. In developing countries investments include limited number of sectors and have been made mainly in following sectors: computer and electronics (more than 50% of investments made in emerging countries), chemical, food manufacturing and mechanical engineering.

The growth rate of R&D investments was different by economy sectors. According to OECD in the period from 2006 to 2008, the R&D expenditures carried out by 1000 EU largest R&D investors recorded the highest compound annual growth rate in following sectors: mining (70%), alternative power (40%), banking (24.8%), petroleum industry machinery and equipment and distribution (24.5%), gas, water and infrastructures (23.8%).

R&D expenditures as a rule are more significant when made by foreign companies in developing countries as in countries with higher level of development. In 2003, foreign branches had the biggest share in total R&D expenditures in Ireland (72%), Hungary (62.5%), Singapore (59.8%), Czech Republic (46,6%) except for Israel where the share of foreign branches was relatively smaller amounting to 20% of total which is determined by high level of local R&D investments.

Internationalization of R&D functions is being expanding. In 2005, world largest companies making R&D expenditures have been surveyed by UNCTAD where 69% of companies interviewed have noted that R&D expenditures will increase while 29% is convinced that they will remain at the same level. Countries of Eastern and Central Europe, CIS countries and Southeastern Asia are being considered as main target places for investments among emerging countries. If the first two were selected due to inherited R&D capabilities and availability of high-qualified specialists, so Asian countries are preferred due to rapidly growing huge army of young engineers, fast developing scientific and technical potential and the market. In China, the annual number of graduates with technical education (2.5 million) exceeds the USA index for about 1.5 times. In Russia and India, the army of technical and engineering specialists is replenished with more than 2 millions of graduates each year.

Main incentives for this model are:

- Limited number of technical and engineering specialists in home countries of MNCs;
- Involvement of new talents in own innovation network;
- Costs optimization mainly due to notably differences in labor costs;
- Adapting of services to local or regional market (for example, language and cultural differences);
- Usage of R&D incentives;
- Availability of advanced national innovation system in countries receiving investments.

Labor costs difference in developed and developing countries is utterly great, high by ten times. In 2008, labor costs in Eastern Europe (Poland, Czech Republic, Hungary, Slovakia) were lower by about 4 times than in developed European countries (Germany, Sweden, France, Belgium, Denmark)[10].

Fiscal and financial incentives mainly provided within the framework of EU Structural funding in form of grants which could reach up to 1.5 million euros were highly important for increase of foreign and local R&D investments in Eastern Europe and Ireland.

**Czech Republic: Engineering R&D center based on industrial traditions and research capabilities**

Engineering sector traditions rooted in 1800s, great potential of industrial production, qualified and relative low-cost manpower as well as EU membership (guaranteed business environment and free access to markets of other EU countries) make it possible for Czechia to become an important engineering R&D center in the Eastern Europe.

IT, nanotechnologies, renewable energetics and life sciences are industries being formed among

[10] Eurostat

traditional industries (mechanical engineering, aerospace, electronics, transportation and power engineering) and having a rapid pace of development. In 1990, Czech Republic with the most developed industry in the former socialist sector has liberalized the economy which was followed by immediate emerging of MNCs (Bombardier, Siemens, Honeywell, OTIS-United Technologies Corporation, Huisman Holding, Bosh, Acer, ABB, Panasonic, Tyco, Kostal FEI, On Semiconductor, Olympus) in the country to acquire the available research potential. By the way, in Czechia economic reforms were delivered without disruptions excluding demise of industrial and research potential which was not the case in some former Soviet republics including Armenia. In the period from 1990 to 2000 foreign direct investments accounted for an annual rate of about 2 billion US dollars and reached up to 10 billion US dollars in the time between 2007 and 2008. At first, global companies directed their investments to establish manufacturing enterprises though shortly after that they activated investments in R&D cooperating with research centers and universities. Today, about 1600 companies are involved in R&D activities and half of total R&D activities are being carried out by MNC branches. Research works are mainly concentrated in internationally known research centers (for example Tesla-Research Institute for Telecommunication Technology A.S. Popova /Prague). Czechia like other Eastern Europe countries intensively apply tax and financial incentives for the countries making investments in the R&D sector.

The Czech Republic is also leading by number of graduates with technical education. About 70000 students annually complete technical education in universities plus twice as many graduates with vocational education.

### Singapore: Regional center for engineering services

The unprecedented rate of growth in Asia and Middle East resulted in increased demand for energy, chemicals and consumables which, in its turn, has created growing demand for engineering services thus promoting inflow of new investments in many sectors of industry.

Singapore is today a global center for engineering services as a result of purposeful industrial policies and investments of MNCs since 1960s. Leading global brands providing engineering services such as Arup, Jacobs Engineering, KBR, Fluor, CH2MHILL, WorleyParsons, CB&I Lummus, Foster Wheeler, Yokogawa, Emerson, Rockwell Automation and M+W Zander operate in Singapore supplying both the regional and global markets. A range of services is provided from initial planning, consulting, and system design to management of projects and construction in petrochemical and biomedical industries.

Development of biomedicine is a striking example of that how Singapore became to an R&D center of MNCs in a short period of time. In 2000, after Singapore declared biomedicine as one of key industries for economic growth of the 21$^{st}$ century the country could restructure its industry in a very short time by developing the necessary capabilities. Already in 2004, turnover in this sector reached the 9.6 billion dollars having a growth of almost three times and providing 21% of value added. In fact, development of the biomedical cluster took place thanks to R&D investments of MNCs (pharmaceutical MNCs such as the companies Eli Lilly, Isis Pharmaceutical, Vanda Pharmaceuticals and Paradigm Therapeutics and world leaders in the medical equipment industry - BD, Welch Allyn, Essilor, Siemens Medical Instruments, Bracco, Applied Biosystems and Fischer Scientific).

Singapore's success main factors in the engineering sector were the following:

- Government's vision for economic development and consistent policy;
- Investments of foreign MNCs;
- First-class universities and high-skilled specialists;
- Largest network of free trade contracts with the countries of the region.

Main specialization fields currently available in Singapore's engineering services sector are engineering design and project management (for construction of industrial and infrastructural

facilities), industry processes control automation and providing of certification services (for chemical, pharmaceutical industries, electronics and IT).

***Model 2: Providing of engineering services in the outsourcing market***

Outsourcing of engineering services is being expanded followed by outsourcing of IT and business processes. Outsourcing of engineering services is being carried out mainly based on logics and model of the IT sector. Here, the main factors of success are availability of low-cost and high-qualified huge workforce, schemas for the effective project management, access to markets of main clients and formed models for providing of services. In terms of technical skills, engineering services require more advanced knowledge for the engineering sector and good command of corresponding information instruments (professional software packages). As in case of outsourcing of IT and business processes, another factor of success for this model is also the confident telecommunication infrastructure (Internet). As compared to the R&D model, outsourcing as a rule includes carrying out of standardized activities and rarely more advanced and complex engineering solutions. Hence, price, meeting the deadlines and quality control are more important for outsourcing to obtain competitive advantage in this sector. Internationally adopted certifications (ISO, CMMI, PCMMi, Spice, TUV, AS/EN etc.) serve as quality assurance and have various applications depending on economy sectors.

**India: Development of engineering services based on IT experience and capabilities**

In India, the outsourcing schema of engineering services is dominating though almost all models of service providing are available here. 60% of companies use this schema which is mainly determined by application of the model already formed and known in the field of IT and business processes outsourcing. Infosys, WIPRO, Mphasis, HCL, Tata Consultancy Services, Mahindra, Satyam and other companies like these having a leading role in outsourcing of IT and business processes and using contacts to markets as well as the formed business model have expanded their activities by including the engineering services (product lifecycle management, solutions for production processes and production systems, product design and others in various sectors of economy).

***Model 3: Sale of entire engineering services to end customers***

This model assumes presence of specialized engineering service providers offering complex solutions from creation of the service to the sale to end customer, for example building design for construction companies or design of hydropower plants or traffic facilities. In this case, except of technical capabilities also business management and marketing capabilities are important. To develop such businesses large domestic market, advanced industry as well as natural specifics of the country which can serve as basis for development of specific capabilities in certain areas of engineering services are of great importance. In terms of this, Holland is a good example where natural conditions and the geographical location of the country served as basis for development of engineering of hydraulic facilities, and Ireland where poor soils were a reason for specializing in agricultural machinery industry. Formation of specialized engineering service providers, in particular in the field of building design, was also determined by the business model available in various countries. As a rule, in Great

Britain, Denmark and Holland design activities were separate from construction companies and in France these activities were mainly integrated in one company.

This model is functioning mainly in developed industrial countries and rapidly developing new industrial countries (China, Brazil, Argentina, Mexico, Turkey, South Korea and others), which have large domestic market or where the country creates opportunities for ease access to external markets. Developing countries adopting experience of developed countries in the engineering services sector, at present, successfully compete in the international market having price advantage against engineering companies of developed countries. According to "Engineering News-Record" classification of leading engineering companies by income derived from foreign projects ("The Top 200 International Design Firms") USA is the leader by number of companies (75 from 200 international companies) followed by China with a great difference (22 companies), Japan and Italy each having 10 companies. Canada, Great Britain, Australia, Holland, Germany and France are also among top ten countries.

***Model 4: The "Opportunistic" model***

In case of the "opportunistic" model which is less used compared to previous models engineering services are provided by industrial enterprises which having own developed engineering capabilities also try to enter into engineering services sector in order to diversify their activities. This is specific for companies of emerging industrial countries like India, Brazil, Mexico and Russia. This strategy is mainly determined by vague strategic orientation and comprehensive value chain of companies, in particular rendering of complex engineering services using company's own potential and not outsourcing it to specialized engineering companies. Outsourcing does not allow to use capabilities entirely thus prompting companies to use their reserve capabilities in related sectors. Indian machinery manufacturing company "Mahindra and Mahindra" is an example for that which among its main activities provides also engineering and IT services to other companies.

***Model 5: Regional branches of global engineering companies***

Global engineering companies expand the network of their branches in various countries to more effectively carry out the servicing of customers. By globalization degree (weight of foreign orders in total income) the geography of foreign branches of world 10 leading companies embraces 36 countries on average[11].

Countries having large or faster growing domestic market or from where regional markets can be supplied more effectively are selected as destinations for branches. Nature of commercial and economic relations, language and cultural similarities with other countries of the region, competitive advantages of business environment against other countries of the region are especially important for to effectively supply the regional markets. Global companies have two main approaches when selecting regional centers.

[11] WorleyParsons (Australia), AMEC plc (UK), Fluor Corp.(USA), Jacobs (USA), AECOM Technology Corp. (USA), SNC-Lavalin International Inc.(Canada), Bechtel(USA), Foster Wheeler AG(USA), TecniPoyry (Finland), Mott MacDonald Group Ltd (UK)

In the first case, country advantages relate to availability of corresponding high-quality resources, infrastructures, ease of access to other countries of the region from that location. Such countries mainly become regional centers for other purposes (as traffic centre, financial center etc.). Moscow or Singapore are examples of that where regional centers of services of global brands are centralized. 9 out of 10 leading globalized companies have established their branches in Moscow, and 8 – in Singapore.

In the second case, countries have cost advantages against other countries of the region which can be determined mainly by low labor costs and favourable tax regime, for example favourable tax regime in Ireland compared to other EU countries and essentially low labor costs in Romania.

## MAPPING OF CAPABILITIES OF ARMENIAN ENGINEERING SERVICES SECTOR

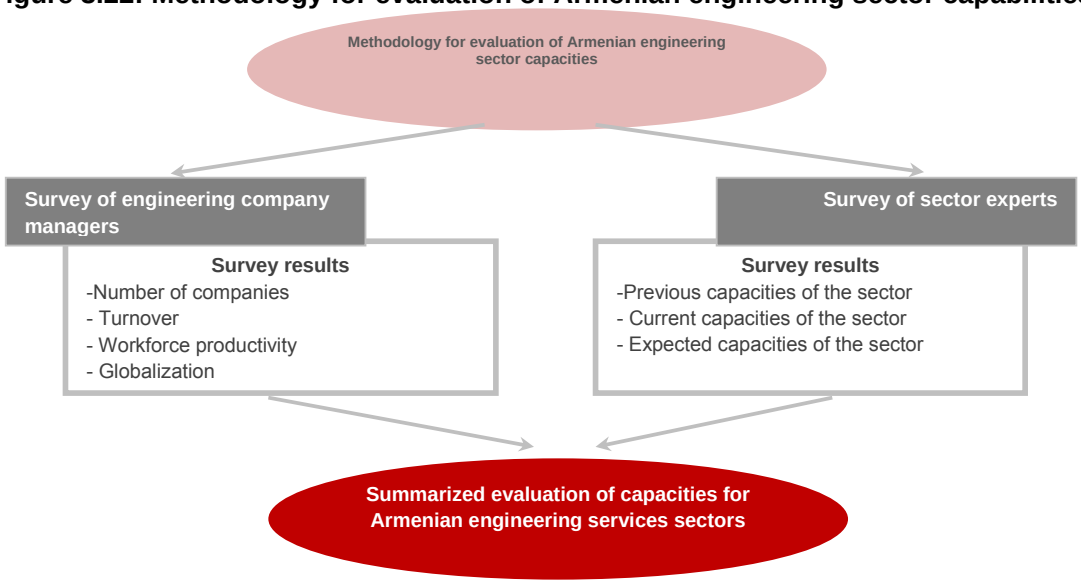
To evaluate capabilities in the Armenian engineering sector the following engineering service sectors have been studied: mechanical engineering, aerospace, high technologies (including telecommunication, semiconductors, consumer electronics, computer equipment, industry automation, medical equipment), infrastructure, construction, industrial machinery.

For the mapping of capabilities of these sectors a bilateral evaluation system (surveys of company managers and sector experts) has been applied. Based on answers of engineering service providers the most active engineering sectors have been defined by number of operating companies, turnover, workforce productivity and internationalization degree.

On the other side, based on experts evaluation, the previous, current and expected capabilities of the sector have been compared and a total index for capabilities of each sector have been calculated.

Resulted evaluation emphasizes the more promising directions of the sector and serves as a basis for development of a strategy for sector's future growth.

**Figure 3.22: Methodology for evaluation of Armenian engineering sector capabilities**

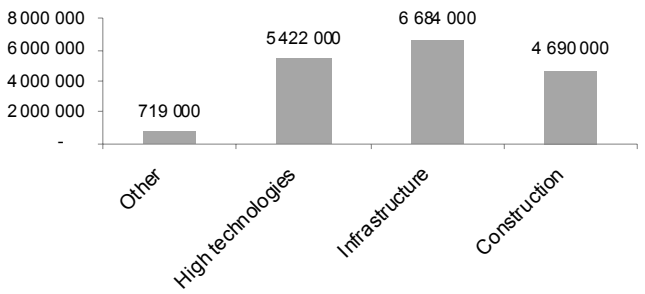


## *Evaluation of engineering company managers*

As a result of survey of Armenian engineering service providers it has been recorded that the majority, more than half of companies of this industry is currently active in the infrastructural sector, in particular in the fields of energetics, water management and traffic facilities.

In Armenian engineering services sector income derived from infrastructures has the highest ratio equaling to 60%. High technologies and construction also have big portion in formation of sector's income – 20% and 16% respectively.

**Figure 3.23: Income from engineering services sector per employee, 2009, AMD**



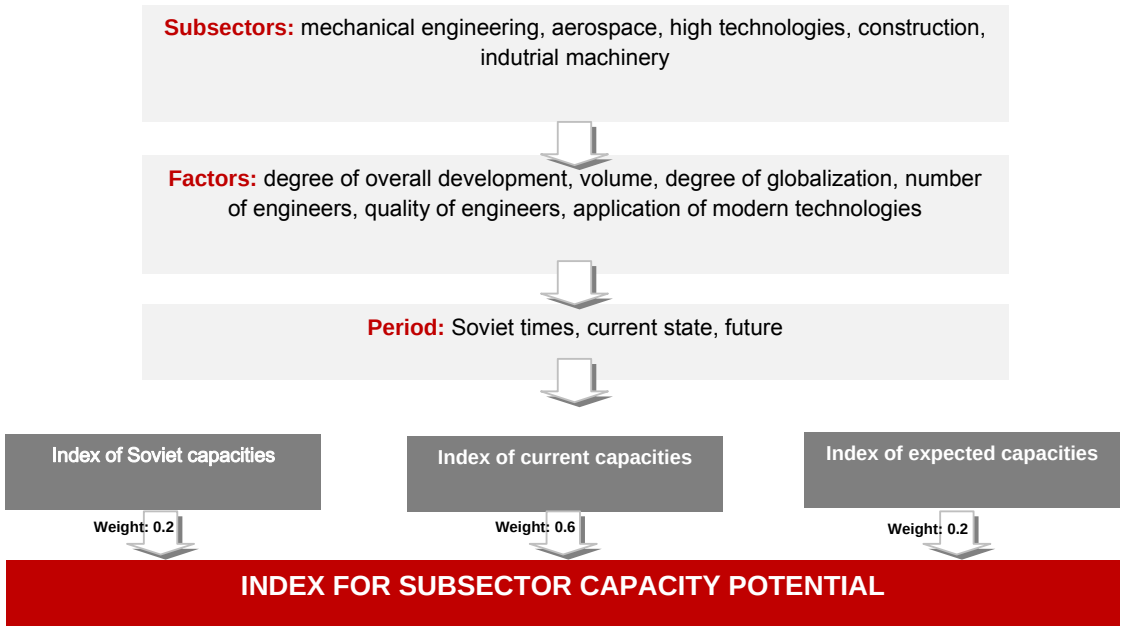

In the intersectoral comparison, sectors of infrastructures and high technologies are distinguished by quiet high efficiency of the workforce. If the income within entire engineering services amounts to 4.7 million AMD per employee, so this index for separate sectors reaches to 6.7 million AMD in infrastructures and to 5.4 million AMD in high technologies sector.

The highest exporting intensity is recorded in the sector of industry automation. Sectors of power engineering and water management are more or less active in exporting of projects and designs.

## *Evaluation of sector experts*

To collect professional opinion about sector's capabilities 7 experts have been surveyed. For each subsector of engineering services experts have evaluated the overall degree of development, volume, degree of internationalization, number and quality of available engineers as well as the application level of modern technologies by making an international comparison. Based on mentioned factors experts have assessed not only the current state of subsectors, but also their performance during Soviet times and expected possible development in the future. On averaged evaluation of experts indexes of capabilities from Soviet times, current and expected capabilities have been calculated for each sector. To calculate the total index for capabilities potential of the sectors the current, previous and expected capabilities have been considered with weights 0.6, 0.2 and 0.2 respectively.

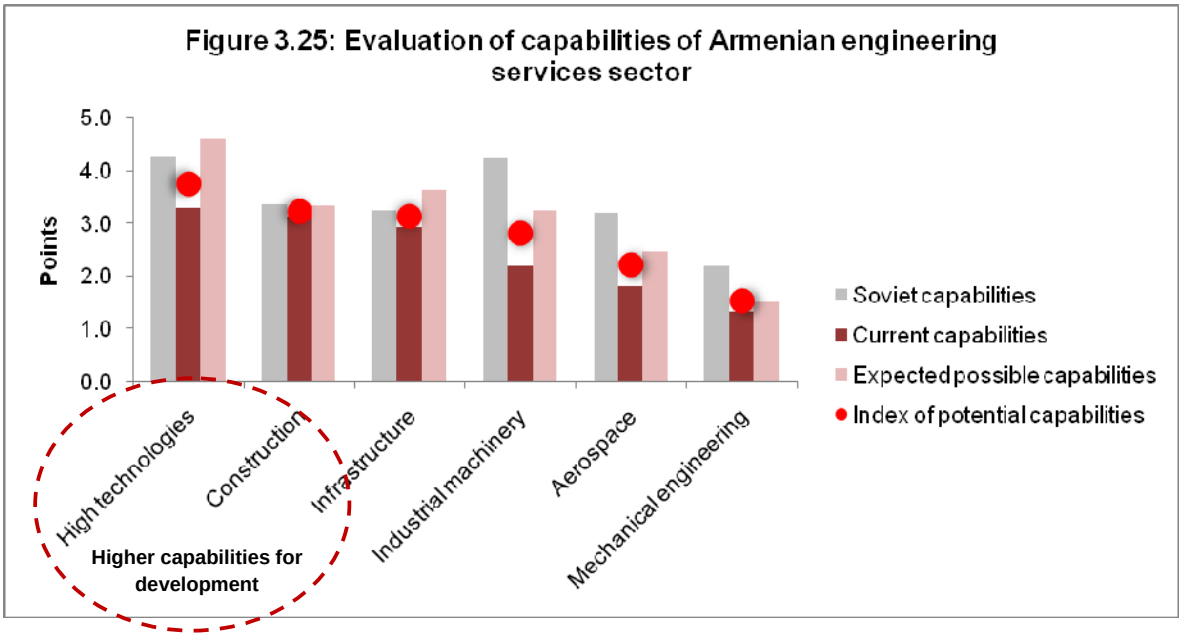
**Figure 3.24: Methodology of experts for evaluation of Armenian engineering services sector capabilities**




According to experts evaluation all sectors of engineering services in general and without exception have recorded a notable regression and lost the Soviet capabilities. Some sectors such as design of industrial machinery, aerospace and mechanical engineering experienced stagnation. If mechanical engineering was the least-developed among discussed sectors, so machine-tool construction as well as military designs with aerospace had a quiet high level of development in Armenia, not only compared to soviet countries but also worldwide. Today, both sectors are evaluated to have low capabilities.

According to experts capabilities of high technology sector (including telecommunication, semiconductors, consumer electronics, computer equipment, industrial automation, and medical equipment) can be evaluated as pretty competitive in Soviet and present times. Promising are also forecasts for different directions of this sector.

In terms of capacity potentials there are great development opportunities available for sectors of construction and infrastructural engineering where deficiency of capabilities is not essential from Soviet times. Experts see big opportunities for development of separate infrastructural directions such as power engineering, especially in export markets.

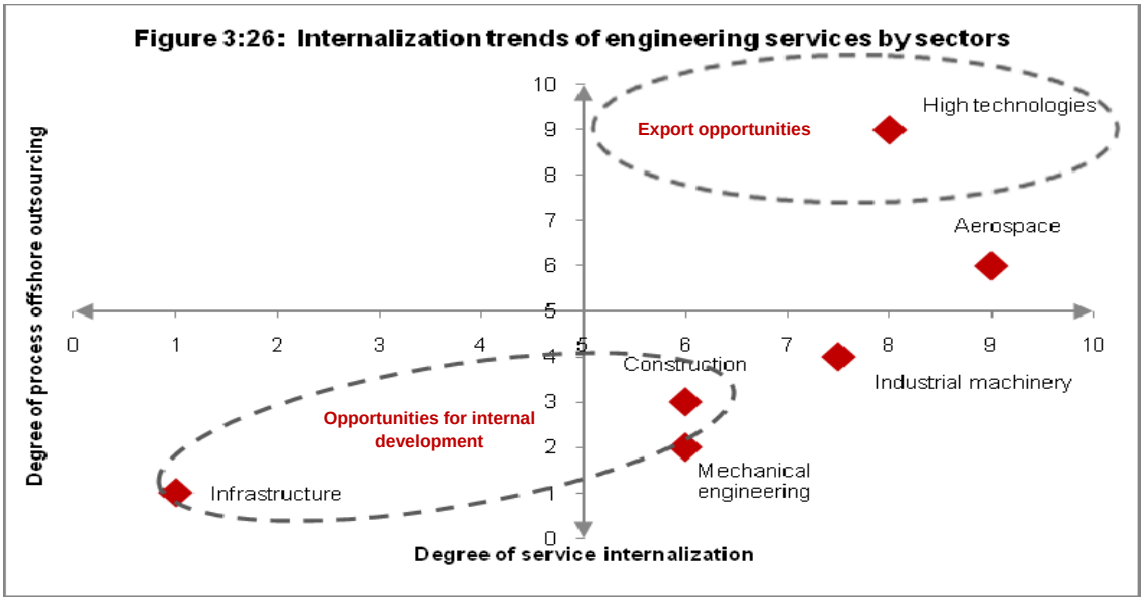



*Source: "Economy and Values" Research Center*

## MAPPING OF CAPABILITIES OF ARMENIAN ENGINEERING SERVICES SECTOR

Mapping of capabilities of Armenian engineering services sector has been carried out taking into account the most promising directions of the sector. Possible demand sources, export opportunities, factors of Armenia's attractiveness within these sectors as well as more corresponding and feasible business models have been observed for all engineering sectors.

The observed sectors strictly differ from each other by trends towards offshore outsourcing and product internalization. So, if the infrastructural sector is to be less outsourced, the high technologies including telecommunication engineering are being mainly outsourced by international companies to foreign countries. Engineering services in sectors of aerospace and industrial machinery are also being outsourced quiet frequently in foreign countries. Considering the capabilities of Armenian engineering services sector it is also possible to attract outsourcing orders especially in the sector of high technologies.




*Source: "Economy and Values" Research Center*

It should be also considered that not only sectors of engineering services but also value chain different phases within the same sector may essentially differ from each other by intensity of offshore outsourcing. The Annex describes value chains of Armenian sectors having great potential in the short-term and long-term perspectives of outsourcing opportunities for separate components.

Depending on sector's specifics demand for engineering services can have different sources. The figure below shows importance of different subjects in formation of demand for engineering services. The government can have a great share of participation in obtaining engineering services within sectors of construction and infrastructural development as well as defence. Thereby, limitation of governmental orders for last two sectors is determined by their strategic importance for each country.

The perspective that domestic industry can be as a source for demand is quiet unfortunate. In the short-term perspective, domestic industry is able to absorb engineering solutions for telecommunication and partially industrial machinery as well as can be represented in the sector of construction by its involvement. In case the demand has reached high level of advancement local manufacturers will represent growing demands also for industrial automation.

The role of transnational corporations and foreign companies is rather realistic in terms of formation of demand for high-tech sector. They can also outsource various components of industrial machinery and aerospace.

The probability to get orders for mechanical engineering services from any of observed demand sources is not realistic for Armenian companies.

**Figure 3.27: Importance of different demand sources in formation of demand**

| Transnational corporations | Foreign companies | Domestic industry | Government |
|---|---|---|---|
| Mechanical Engineering | Mechanical Engineering | Mechanical Engineering | Mechanical Engineering |
| Infrastructure | Infrastructure | Aerospace | Semiconductors |
| Construction | Construction | Semiconductors | Consumer electronics |
| Aerospace | Aerospace | Medical equipment | Computer equipment |
| Industrial machinery | Industrial machinery | Consumer electronics | Industry automation |
| Semiconductors | Semiconductors | Computer equipment | Medical equipment |
| Consumer electronics | Consumer electronics | Infrastructure | Industrial machinery |
| Computer equipment | Computer equipment | Industry automation | Telecommunication |
| Industry automation | Industry automation | Construction | Aerospace |
| Medical equipment | Medical equipment | Industrial machinery | Infrastructure |
| Telecommunication | Telecommunication | Telecommunication | Construction |

Highly important

Notably important

Less important

*Source: "Economy and Values" Research Center*

When defining the goals for development of engineering service sector factors having influence on decision for offshore outsourcing shall be considered as being specific in each sector. At present, costs minimization is a dominant factor for all sectors observed. Quality improvement possibilities, minimization of time to market as well as enhancement of capabilities are attractive for sectors being more tended to offshore outsourcing.

The present capabilities of Armenian engineering sector and perspectives of its development presume that the sector can develop considerable competitive advantages on certain factors and represent attractive outsourcing conditions to foreign companies. Possible minimization of costs, availability of specific assets and innovative capabilities are some of these realistic and important factors. It is expected that the last two factors will be the two main beneficiary cards for the sector. In the region, Armenia is quiet attractive also in terms of market management opportunities that are time to market and access to market.

**Figure 3.28: Incentives for engineering services offshore outsourcing of various sectors**

| | Costs minimization | Specific assets | Innovative capabilities | State support | Customer servicing | Entering into markets |
|---|---|---|---|---|---|---|
| Computer equipment | High | Medium | High | Medium | | |
| Consumer electronics | | Medium | High | | Medium | |
| Semiconductors | High | Medium | Medium | | | |
| Medical equipment | High | Medium | High | | | |
| Industrial automation | High | High | High | | | Medium |
| Telecommunication | High | Medium | Medium | Medium | Medium | |
| Aerospace | High | High | High | High | Medium | |
| Industrial equipment | High | High | High | | Medium | |
| Construction | High | Medium | | High | Medium | Medium |
| Mechanical engineering | High | Medium | High | High | Medium | |
| infrastructure | Medium | Medium | | Medium | Medium | Medium |

High importance
Medium importance

*Sectors are classified by descending degree of offshore outsourcing. Specific assets include workforce (head capital), row materials and other necessary investments.*
*Innovative capabilities include infrastructure components and environment promoting research and development.*
*Entering into markets means ease and speed to enter regional markets.*
*Customer servicing means necessary contact to customers during and after design works.*
*Source: "Economy and Values" Research Center*

Models of R&D center and outsourcing have more realistic perspectives to function in Armenian engineering services sector. Sector of mechanical engineering is still not for capabilities of Armenian engineering companies in case of any business model. R&D centers and foreign branches can be properly introduced in selected subsectors of high technologies. Determined by limited capabilities of the sector the model of providing complete services can only function in sectors having domestic sales such as construction and infrastructure. As the opportunistic model is for more developed industrial countries where the experience cumulated within production processes can turn into a separate service, so this model will not be widely used in Armenia too.

**Figure 3.29: Potential business models for different sectors of Armenian engineering services**

| | Complete services | R&D center | Outsourcing | Opportunistic model | Regional branches |
|---|---|---|---|---|---|
| Mechanical engineering | | Low | Medium | | |
| Aerospace | | Low | High | | |
| Telecommunication | | Medium | High | | |
| Semiconductors | | Medium | Low | | Low |
| Consumer electronics | | Medium | High | | |
| Computer equipment | Low | High | High | Low | |
| Industrial automation | Low | Medium | Medium | | Low |
| Medical equipment | High | Low | Low | Low | |
| Infrastructure | Medium | Low | Low | | |
| Construction | | High | Medium | Low | |
| Industrial equipment | | | | | |

High probability  Medium probability  Low probability

*Source: "Economy and Values" Research Center*

## GENERAL VISION OF DEVELOPMENT OF ENGINEERING SECTOR

The vision proposed for development of Armenian engineering sector is based on study results for engineering sector global development trends, best practice of their characteristics, Armenia's capabilities in the engineering services sector and development obstacles. These results are summarized in the SWOT table below.

**SWOT analysis of Armenian engineering sector**

| STRENGTHS | WEAKNESSES |
|---|---|
| • Previous industrial traditions continued in form of high-qualified specialists in a number of engineering sectors<br>• Relatively large number of companies available in the sector a part of those compete also in international markets<br>• Technical education system having good early reputation<br>• Armenia has capabilities "able to be developed" in sectors of high technologies, construction and infrastructures | • Small number of graduates having technical and engineering education<br>• Relatively strong theoretical yet very weak practical skills received by the educational system<br>• Extremely undeveloped laboratory and experimental basis<br>• Absence of industry as the main consumer of engineering services<br>• Very low local R&D investments |

| | | |
|---|---|---|
| | | • Incompatibility of local standards with international standards<br>• Low level of intra-sectoral and intersectoral cooperation<br>• Absence of international certification in Armenian companies |
| **OPPORTUNITIES** | | **THREATS** |
| • Growth of global demand for engineering services<br>• Growing globalization trends of engineering services, in particular on R&D functions creating high value added<br>• Great opportunities to use Diaspora business contacts to establish contacts with potential markets and developing capabilities lacking in the country; this opportunity is already being used by some companies of the sector<br>• Advanced IT sector and Armenia's reputation formed in the field of automation of electronic data (chip design)<br>• Armenia's specific natural characteristics, specifically seismic activity, complex relief, potential for development of renewable energetics can serve as basis for development of specific capabilities such as design of earthquake-proof buildings or development of green technologies<br>• Large-scale investments to be done in infrastructures (renewable energetics, new nuclear power plant, North-South railway etc.) | | • Growing competition in the market of engineering services caused by emerging countries<br>• Problem of alternation of generations available in the fields of research and education; if the problem will not be solved recovering of lost knowledge will require big investments and long time<br>• Not favourable regulating framework |

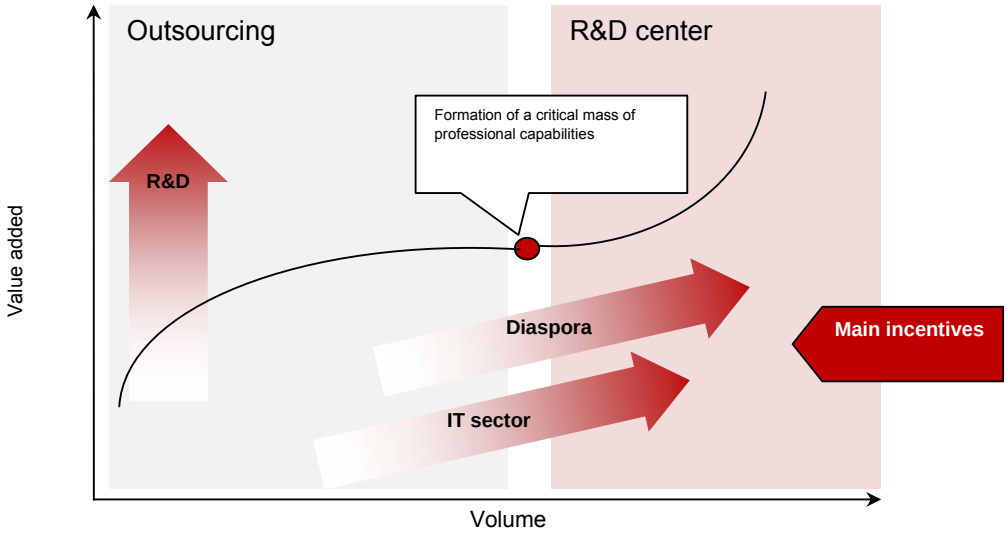
Taking into account restrictions of the domestic market and nature of engineering services the development perspective of Armenian engineering sector is definitely non-realistic if the services will not be globalized and specialized in activities creating high value added.

As a general macrolevel vision development of engineering services sector is possible to forecast in two parallel directions. The first direction emphasizes development based on local factors and the second – influence of factors arising from external markets.

**Direction 1: Development direction from external markets**

Development direction arising from external markets with its logics is similar to the model available in the sector of information technologies and presumes country's involvement in the global value chain of engineering services specializing in supplying of any function or functions.

**Figure 3.30: Engineering services sector development**
**Direction 1**




*Explanation: measuring "Volume" includes the quantitative growth of the sector and "Value added" includes the qualitative changes which means providing of services creating higher value added. Direction of main incentives arrows show which measuring they are directed to influence on.*

Based on the outsourcing model in the first development phase Armenia can develop its capabilities and pass to implementation of functions creating higher value thus becoming an R&D center of global engineering companies and MNCs. For this model, it is important to use the experience and achievements available in the IT sector. On the one side, country ranking formed in the IT sector, models of service sales and relationships in foreign markets will contribute to exporting of engineering services while on the other side information technologies are an important instrument for internalization of services. It is suspected that this direction will be accepted as a basis for development of engineering services in the high-tech sector. It is mainly determined by absence of industry domestic market. Engineering and information technology services are closely interconnected here and their parallel growth will have a great synergic effect in terms of support to development of sectors.

### Success factors and main capabilities

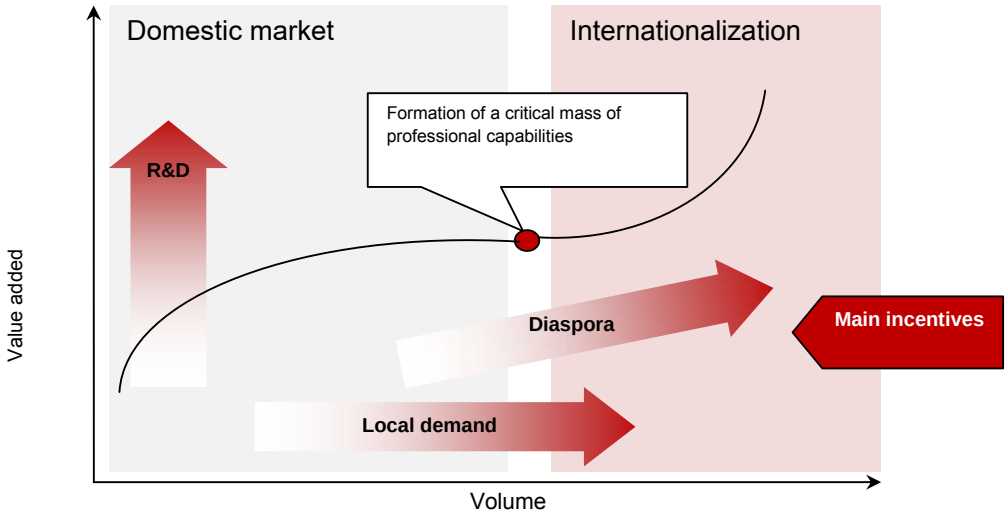
| General factors | Factors specific for the direction |
|---|---|
| • Presence of high-qualified engineers in a large number<br>• State R&D investments and promotion of private investments targeted to achieving dominancy in certain niche specialization sectors<br>• Usage of Diaspora business contacts and professional capabilities | • Usage of experience and skills available in the IT sector<br>• Availability of international certifications<br>• Project management skills<br>• Attraction of R&D centers of MNCs |

### Direction 2: Direction based on development of local factors

The second direction is based on opportunities of the local market. In this direction the local demand has to give the initial impulse which will lead to extensive growth and enlargement of the sector. On the other side, development of R&D capabilities will be important for carrying out activities which will create higher value added. The effect of the latter will be more obvious after achieving certain critical mass in the sector.

**Figure 3.31: Engineering services sector development**

**Direction 2**




*Explanation: measuring "Volume" includes the quantitative growth of the sector and "Value added" includes the qualitative changes which means providing of services creating higher value added. Direction of main incentives arrows show which measuring they are directed to influence on.*

In this direction, sectors of construction services and infrastructures will have a substantial development where Armenia, based on country specifics and consistent development of existing research capabilities, can form competitive advantages in specific sectors of the market (for example in sectors of design of facilities based on earthquake-proofing technologies and renewable energetics). It is suspected that Armenian engineering companies will internationalize their activities after a certain phase of development relying on specific value offer (professional superiority in certain technology areas).

### Success factors and main capabilities

| General factors | Factors specific for the direction |
|---|---|
| • Presence of a large number of engineers<br>• State R&D investments and promotion of private investments targeted to achieving dominancy in certain niche specialization sectors<br>• Usage of Diaspora business contacts and professional capabilities | • Development of sectors creating local demand (construction and infrastructures)<br>• State supporting policy requiring high quality standards |

# CHAPTER 4: ENGINEERING SERVICES SECTOR DEVELOPMENT STRATEGY

**Main characteristics of engineering services sector development directions**

| | Direction 1<br>High Tech R&D centre | Direction 2<br>Engineering service providers in the infrastructure sector |
|---|---|---|
| Industry/Economic sector | High technologies | Infrastructures and construction |
| Feasible business model | R&D centers of global companies | Provider of niche comprehensive services |
| Geography of potential markets | USA, EU, Japan | Stage 0: Armenia, stage 1: CIS, stage 2: Iran and developing countries from Africa |
| Main consumers of services | Industrial MNCs, global engineering companies | Governmental organizations, donor organizations, municipal and infrastructural organizations |
| Required key capabilities | • High-level educational system<br>• Large number of engineers<br>• State-of-the-art research infrastructure and capabilities<br>• Language skills (mainly English)<br>• R&D activities promotion system | • Hands-on extensive experience<br>• High-quality engineers<br>• Application of internationally adopted standards<br>• Project management skills and experience<br>• Relations to potential markets<br>• Language skills (mainly English and Russian) |

Above mentioned development directions of the Armenian engineering sector can have a parallel upgrowth while the development logic and strategy of each have essential differences.

## DIRECTION 1: HIGH-TECH RESEARCH & DEVELOPMENT CENTER

Direction 1 offers two main scenarios for the sector's development, which vary in the degree of intervention by governmental and other public bodies.

According to the first scenario sector's future growth shall rely on fundamental constructive interventions which will create an infrastructure and scientific potential to turn Armenia into an R&D center.

As per the second scenario involved minor resources can correspondingly produce only short-term and exclusively quantitative results.

Description of two scenarios under discussion and their comparative analysis follow below.

### SCENARIO 1: ACTIVE INTERVENTION

#### THE VISION

Armenia can aspire to become a high tech R&D center providing an infrastructure for development of talented individuals and contemporary R&D. Taking into account that the major part of costs carry global companies Armenia's strategy shall be focused on involving these companies in R&D activities by both establishing own R&D centers and guaranteeing of orders for local engineering companies and research teams. In the long-term perspective, improvement of environment and innovative capabilities will be accompanied with creating bases for development of Armenian high technology start-ups.

**In this model, Armenia's valuable proposal shall be based on availability of young talented individuals, scientific and technological heritage of Soviet times, contemporary R&D infrastructure as well as offering a favourable environment for R&D realization.**

In the midterm perspective, compared with developed and a number of developing industrial countries cost savings will play an essential role, but it will become less important along with the country and industry development.

**Target companies**

From the perspective of R&D activities, functional specialization is more important than the industrial (testing and measuring, studying materials durability, mechanics, electronics etc.) as the majority of engineering functional solutions are applicable in all economic sectors. To confirm the above mentioned a range of examples can be provided just from Armenia. The company «National Instruments» dealing with design of metering devices offers solutions to a number of industry sectors ranging from oil industry to aviation. The local branch of the Russian company "MikaProgresstech" deals with studying and testing materials on their durability which can be applied in any industry sector. Those, when targeting the companies it's not so important in which sector they are active, but it's important which engineering solutions these companies are ready to study and develop out of their country and in which countries.

**Based on modern globalization trends targeting of middle-size enterprises mainly tending to globalize their innovative functions and being flexible to enter new geographical sites is more reasonable for strategy of Armenia. In addition, top managements of these companies are more open as compared with large global corporations.**

### Innovation globalization trends

According to the 2007-2008 research study of the Duke university "Offshoring Research Network" innovation[12] globalization has become the strategic demand of many enterprises. The share of enterprises having clear innovation outsourcing strategy considerably increased and reached 53% (survey was conducted between 1600 large and middle-size enterprises). In spite of financial crisis the enterprises plan both to extend the current activities as well as to

[12] For the purpose of this research study "innovation" encompasses engineering, R&D and supportive activities, software development and other knowledge-based processes. Offshoring Reaches the C-Suite: 2007–2008 orn survey report, Offshoring Research Network, Duke University

undertake new projects.

The main incentives for innovation internationalization are the demand to faster get new products to the market as well as lack of scientists and engineers in their own country. Also the "A.T.Kearney" states the lack of high-skilled talented individuals to be the main reason for increased outsourcing of R&D activities.

The major part of outsourced innovations includes product design and software development.

Often, outsourcing is used by middle-sized enterprises as they can hardly compete for skilled specialists in their own country.

At the same time, compared to large transnational enterprises, such enterprises are more active and experienced in discovering and employing talents in new geographic regions (e.g. Brazil, Sri-Lanka, Egypt etc.) which widely use web-based cooperation technologies as well as prefer to work with small specialized teams.

Half of companies tending to globalize their innovation function prefer to establish own branches as a main format for entering into a new country thus, ensuring highest control of intellectual property values.

According to geographic directions of innovations outsourcing India is the leader (33%); China follows in the second place (27%). The Eastern Europe fraction amounts to 7%.

**R&D expenses**

In 2008, for R&D total costs of 430 billion euro have been invested by 2000 largest R&D investors of the world which means an average annual increase by 8.6% during past three years.

Taking into account the above mentioned a long list of all global companies which may be as target companies for Armenia was composed based on the database of 2000 largest R&D investors of the world. (The 2009 EU Industrial R&D Investment Scoreboard, European Commission) Selection of companies was carried out according to the following principles:

- 14 largest engineering R&D investment sectors with exceeding number of companies have been selected. 60% of total investments made in these sectors were for R&D activities.
- Later, companies have been filtered depending on the scope of R&D investments and based on the assumption that small R&D investors are less globalized or realize R&D activities in the most limited areas. As a result, companies not exceeding investments of 50 million euro were excluded.
- Eventually the list doesn't include first-class global companies which are leaders by sales volume (first tier companies) and the sales volume of which exceeds the sales average rate of selected companies.

The selected companies are listed in Annex 5.

A shortlist of target companies can be composed on the basis of the offered long list. For this purpose in-depth studies shall be conducted to analyze R&D activities of the companies, their strategy and behavior in this area. In particular, the study will encompass the geographic distribution of R&D centers of these companies, extension plans for their activities as well as criteria for selecting the countries. It's important also to find Armenians working in these companies or having relations to their top managements as they can help

when communicating and negotiating with the companies. More detailed description of steps hereto can be found in the chart of strategic initiatives.

Armenia has certain favourable bases which can contribute to successful development of the following model:

- Positive experience available in area of electronic data automation. Almost all leading companies of this area have established research centers in Armenia (Synopsys, Virage Logic, Mentor Graphics);
- Presence of engineering companies «National Instruments», «Progresstech» in Armenia as well as intention of the Singaporean leading engineering company «ST Engineering» to open a research center in Armenia;
- Soviet heritage (engineering university and research institutions, potential), reputation as a research center and high-skilled exceptional specialists. In Soviet times, Armenia was the "Silicon Valley" of the Union with a large number of R&D centers. Armenia also had an exceptional potential in some segments of the engineering sector.
- Extensive Diaspora contacts and its integration in middle and higher governing bodies.

***Well established experience and factors of success in the engineering R&D sector***

International leading companies are already present in Armenian IT and engineering sectors.

For leading engineering companies "PROGRESSTECH" (Russia) and "National Instruments" (USA) the following factors were crucial to choose Armenia for implementation of R&D activities:

- Reputation as a research center in Soviet times as well as presence of well-known R&D centers in Armenia
- Geographic concentration of scientific ideas and facilities in one place
- Presence of institutions of higher engineering education (Yerevan State University, State Engineering University of Armenia)
- Presence of leading global companies (Synopsys, Mentor Graphics) implementing R&D activities in the country
- Diaspora
- English and Russian language skills of engineers with certain limitations
- Cultural similarities and close relationships to Russia - the largest country in the region.

Currently, the "ST Engineering", one of the worldwide leading engineering companies with an annual turnover exceeding 6 billion US dollars also intends to open a representative office in Yerevan thanks to the two-year cooperation with Yerevan branch of "National Instruments".

It should be mentioned, that by size of R&D investments "Synopsys", "National Instruments" and "ST Engineering" are listed among 2000 largest companies of the world. Based on investments made in 2008, they were ranked respectively the 216$^{th}$, 545$^{th}$ and 1196$^{th}$ (source: The 2009 EU Industrial R&D Investment Scoreboard, European Commission).

***Expected results***

Development of this direction will have an essential influence on potential of knowledge-driven sectors of Armenia, thus creating a basis for formation of a number of higher value-added sources:

- establishment of own R&D centers by MNCs which will place R&D orders to local engineering companies or research teams;
- extension of university research activities as a result of both quantitative and qualitative changes of local and foreign research grants;
- provision of educational services for the countries of the region;
- foundation of new technology start-ups;
- creation and export of products considered as intellectual property.

**Critical weaknesses**

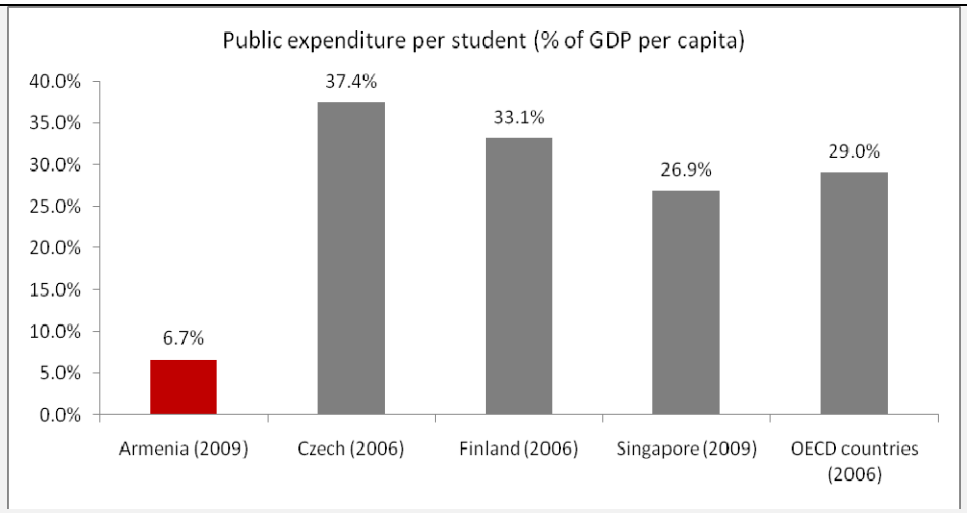
| Strategic horizon 1 | Strategic horizon 2 |
|---|---|
| • **Lack of high-skilled young specialists due to low-quality education system and the noncompliance of educational infrastructure with requirements of modern technologies** | • Lack of financing system for technology start-ups |
| • **Isolation of research and development system from the market** | • Lack of technology commercialization system |
| • **Practically no domestic demand for R&D services** | • Ineffectiveness and low protection of intellectual property rights system |
| • **Lack of favorable and supportive business environment** | |
| • **Lack of tax and financial incentives fostering specifically development of R&D activities** | |

***Engineering education and public expenditures in Armenia***

Armenia is far behind when it comes to the education quality and number of students in the engineering branch.

In Armenia, only 16% of students receive scientific and technical education and the major part of them have knowledge and skills which are not consistent with requirements of companies working with innovative technologies.

Current low levels of higher education public financing cannot afford a base for the education system improvement and this for the engineering sector which needs serious investments for establishment and regular modernization of laboratory facilities.




***Source: National Statistical Service of RA, WDI Online database***

**Armenia main competitors**

Although developed economies (USA, Germany, Japan) are still the leaders in setting up R&D activities, Armenia's main competitors in terms of price and development level of capabilities are developing and new industrial countries which the MNCs consider as main places for outsourcing of engineering services and R&D activities:

### Main countries for engineering services outsourcing

| Asia and Africa | Europe | USA |
|---|---|---|
| China | Russia | Mexico |
| India | Ukraine | Brazil |
| Egypt | Belarus | Chile |
| South Africa | Czech Republic | |
| Thailand | Poland | |
| Philippines | Hungary | |
| Vietnam | Bulgaria | |
| Turkey | Romania | |
| Singapore | | |

**DEVELOPMENT PHASES**

**Horizon 1 (1-5 years) – Improvement of education and research infrastructures**

In the first phase, strategy key point is to improve the engineering education having development of growing number of young talented engineers as its primary challenge. Among educational programs and infrastructure improvement it's necessary to form

corresponding environment which will help to increase students' motivation towards education and generate career perspectives for their main profession.

Establishment of an engineering park by the Engineering University can solve this problem. Its main goal shall be to create an environment and infrastructure ensuring extension of linkage between business, education and science. The engineering park shall provide corresponding infrastructure for implementation of R&D activities and incubation and growth of technology companies.

Establishment of a state-of-the-art lab with the public financial support can be considered as the main initiative in this sector having to key missions: contribute to education quality improvement and ensure an initial basis for research and development activities. The lab shall cover the possible largest frame of engineering directions to provide comprehensive base knowledge for the students.

Upgrade of laboratory facilities shall include training of the teaching staff and upgrading of educational programs by:

- cooperating with foreign institutions of higher education;
- providing financial support for trainings of the teaching staff abroad in cooperation with academic exchange services;
- inviting professors from foreign leading educational and research institutions (Diaspora resources should be used at maximum);
- cooperating with local and international leading companies and involving their specialists in developing of educational programs and organization of training courses.

Educational initiatives and the GoA's commitment to the R&D sector development within high technology industry will serve as a good negotiations basis for attraction of global companies for Armenia.

In this phase, attention shall be paid on expansion of activities of existing engineering service providers as well as attraction of new middle-size global companies for Armenia. In Armenia, global companies can operate mainly in following two formats:

1. placing of orders to local companies or research teams;
2. opening of own representative office.

As a rule, prior to open own representative offices, global companies place trial orders to better understand the local conditions, business development opportunities and to gain confidence for a long-term cooperation and investing. Hence, outsourcing will have a primary role in the first phase for which development of capabilities of local companies (training of employees, development of project management skills) and support in getting foreign orders are important factors. Hereto, the experience formed in the IT sector as well as sustainable infrastructure can be applied. In particular, the foreign sales force representation created by Enterprise Incubator Foundation can also assume the function to form orders for engineering services.

**Horizon 2 (5-10 years) – Innovation cluster development**

In case of success in the first phase, it will be possible to establish an engineering R&D cluster in Armenia, the main driver for which will be the MNCs gradually extending their R&D activities in Armenia. In addition, presence of one-two leading companies will foster interest of other companies for Armenia.

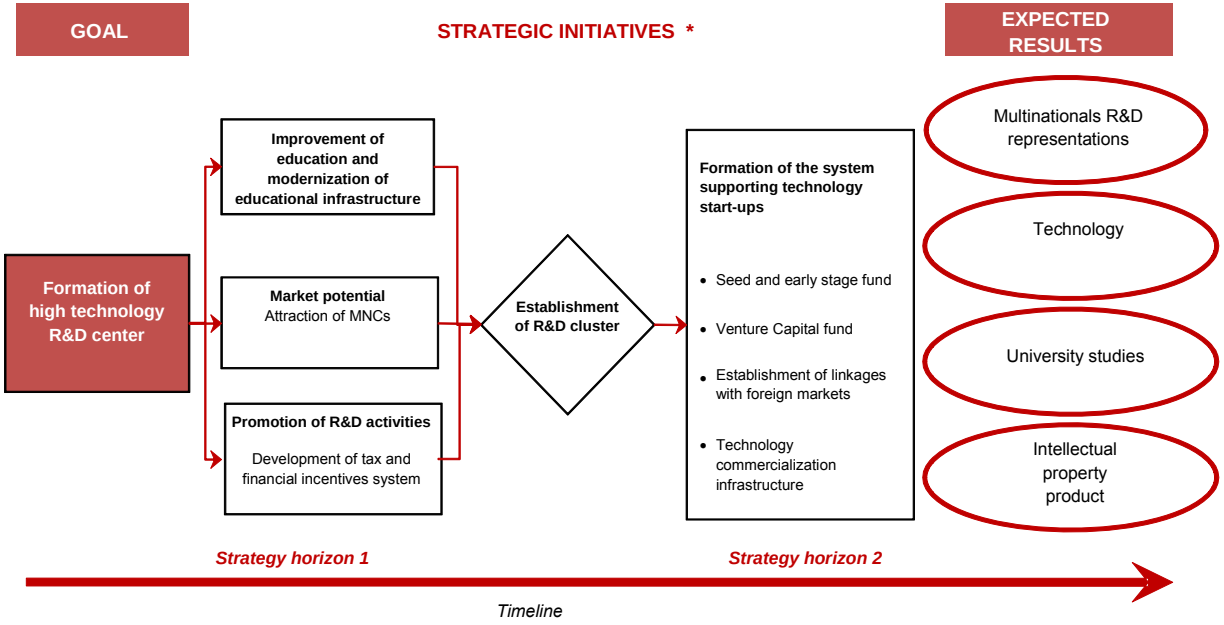
Improvements in education quality and research infrastructure as well as increase of number of skilled engineering students become important for the further development of engineering services sector. Its main goal shall be foundation of a worldwide known engineering university in Armenia.

Armenia, except of becoming an R&D centre, has modern educational capabilities and can also become an international center for engineering education.

Some research groups can establish companies based on their own design which will be able to compete in international markets. Availability of business incubation infrastructure and particularly technoparks and financing mechanisms are increasingly important for the development phase of these companies (Seed and Early Stage Venture Funds).

Development of educational and research capabilities in the engineering university will in its turn contribute to attracting more research grants.

## Direction 1. Strategy "Roadmap"




* Detailed description of strategic initiatives is shown in the following table.

## Strategic initiatives

| STRATEGIC HORIZON 1 | Required non financial strategic resources | Main initiator/ coordinator | Need for financial resources |
|---|---|---|---|
| **1. EDUCATION** | | | |
| **1.1. Professional training** | | | |
| 1.1.1. Training of the teaching staff in cooperation with foreign universities, organizations implementing existing exchange programs (i.e. CAPS, Tempus, OSI) as well as developing new programs specialized in exchange services in the engineering sector | Exchange programs | EIF[13], Engineering university, academic exchange programs | middle |
| 1.1.2. Travelling of professors selected for trainings to foreign universities and research centers, as well as master classes organized in Armenia. Foreign universities for cooperation as well as training topics will be selected through early announced tenders. Based on these tenders the most required and urgent topics will be determined. Training courses will mainly be organized for a short-term period, up to 6 months. | Establishment of cooperation with international universities, programs, courses | EIF | middle |
| 1.1.3. Organization of master classes and lectures for students' professional training. Professors from foreign outstanding universities will be invited to give the lectures. They will be involved in the learning process as "visiting professors" and will give narrow specialization courses for a short-term period, up to 3 months. The budget estimate will be smaller in case professors from Armenia are involved; it will mainly include travelling and subsistence expenses. | Professors (mainly Armenian) from outstanding universities | EIF, Engineering university | middle |
| 1.1.4. Summer courses for students organized by Armenian students studying in world leading universities, in particular by graduates of the "Luys" foundation. | Armenian students from foreign leading universities, graduates of "Luys" foundation | EIF, "Luys" foundation | low |
| 1.1.5. Courses of special software tools for students. Organization of courses for the most famous programs such as AutoCad, ArchiCad, SolidWorks, ProEngineer, LabView, widely applied by engineering companies. | Specialists, equipment, space | EIF | middle |

[13] Enterprise Incubator Foundation

| STRATEGIC HORIZON 1 | Required non financial strategic resources | Main initiator/ coordinator | Need for financial resources |
|---|---|---|---|
| 1.1.6. Support to engineers to attend local and international courses and to obtain international qualifications (e.g. CMMI) | Specialists, resources | EIF | middle |
| **1.2. Non-professional training** | | | |
| 1.2.1. Courses of foreign languages for students and professors | Specialists of foreign languages | EIF, University | low |
| 1.2.2. Development of non-professional skills of graduates. Organization of short-term courses in following directions: communication skills, team working, leadership, working culture | Specialists | EIF, University | low |
| 1.2.3. Organization of project planning and management courses for the managing staff of engineering companies | Specialists | EIF | middle |
| **1.3. Promotion of education-industry association** | | | |
| 1.3.1. Conformity of learning programs with business needs, extensive cooperation with private companies (including of special issues faced in business in master or postgraduate researches) | Skilled teaching staff<br><br>Learning programs corresponding to international standards | EIF, University and private companies | low |
| 1.3.2. Establishment of cooperation with leading industrial and engineering companies (e.g. Zangezur Copper and Molybdenum Combine, Armrusgazprom, Armenal, Ar&Ar Design) for practical training, development of programs for graduates promotion and funding according to which graduates can work in leading companies with small remuneration having the chance to be employed in the future | Cooperation with companies | EIF, University and private companies | low |
| 1.3.3. Travel and accommodation arrangements for the practice in companies out of Yerevan | | EIF, University | low |
| 1.3.4. Financing of graduates professional promotion enabling graduates who have no work experience to work in leading companies | | EIF, donor organizations | low |
| **1.4. Modernization of educational infrastructure** | | | |

| STRATEGIC HORIZON 1 | Required non financial strategic resources | Main initiator/ coordinator | Need for financial resources |
|---|---|---|---|
| 1.4.1. Establishment of modern complex labs in Yerevan State Engineering University.<br>1.4.2. Establishment of public-private cooperation with various industrial and engineering companies. At present, the faculties of Engineering University enhance their labs with the help of private companies, for example ArmRusGasProm has completely upgraded the engineering university gas lab. | Specialist/organization experienced in labs designing | University, EIF, RA Ministry of Economy, global companies | high |
| 1.4.3. Create co-financing mechanisms and a target fund to support establishment of university labs by private companies | | RA Ministry of Economy, EIF, donor organizations | middle |
| **2. FORMATION OF MARKET/DEMAND** | | | |
| **2.1. Orders for Armenian Engineering companies** | | | |
| 2.1.1. Attracting of orders with the help of foreign sales representations | | EIF, in cooperation with foreign sales representation | middle |
| **2.2. Targeting of global companies** | | | |
| 2.2.1. Identification of middle-size outsourcing companies which may operate in Armenia (e.g. create a database of companies currently providing outsourcing of innovation or having such plans. As sources for this information can serve organizations performing global outsourcing research in the engineering sector, such as the Offshoring Research Network of Duke University. It's also possible to order them to conduct surveys among companies from their database whether these companies intend to work in Armenia and what are their needs/demands). | Research institutions | Armenian development agency, EIF | middle |
| **2.3. Target communication** | | | |
| 2.3.1. Presentation of Armenia's capabilities by participating in business forums and organizing of "road-shows".<br>Organization of a business forum in target markets once a year, after that organization of individual meetings between Armenian and foreign companies. | Materials representing the sector, investment guides | Armenian development agency with support of EIF foreign sales office | middle |

| STRATEGIC HORIZON 1 | Required non financial strategic resources | Main initiator/ coordinator | Need for financial resources |
|---|---|---|---|
| 2.3.2. Cooperation with the global consulting company AT Kearney to include Armenia in the "Global Service Locations Index" report. | | Armenian Development Agency, EIF | low |
| 2.3.3. Negotiations with selected companies to render R&D services in Armenia using Diaspora contacts and potential. Companies having Armenians in their central and top management can have the priority when being targeted. | Diaspora representatives | RA Ministry of Economy, Armenian Development Agency, EIF | middle |
| 2.3.4. Establishment of contacts and creation of a comprehensive database by using resources of the Ministry of Diaspora, Armenian communities in various countries, professional networks (LinkedIn, Hoover) to find similar companies and staffs. | Databases, contacts | RA Ministry of Diaspora | middle |
| **2.4. Support to MNCs attraction** | | | |
| 2.4.1. Determination and usage of tax and financial incentives and MNCs for R&D activities in Armenia. The mechanism of tax incentives will assume a case-by-case usage and providing of certain benefits to only selected multinationals meeting the requirements. Profit tax exemption can be as a tax benefit which will not require essential financial costs from the state, but it will have significant positive effect on investing attractiveness of the country. Almost all countries intending to promote investments of technology companies always include tax benefit packages in their instruments. | | RA Ministry of Economy in cooperation with the RA Ministry of Finance | middle |
| 2.4.2. Co-financing of new employee training costs. | | EIF in cooperation with donor organizations | high |
| **3. DEVELOPMENT OF BUSINESS CAPABILITIES IN EXISTING ENGINEERING COMPANIES** | | | |
| 3.1.1. Organization of training courses for employees. Training courses for programs widely-used by engineering companies, such as AutoCad, ArchiCad, SolidWorks, ProEngineer, LabView.<br>3.1.2. Development of project management skills | | EIF in cooperation with sector association and donor organizations | middle |
| **4. IMPROVEMENT OF BUSINESS ENVIRONMENT** | | | |

| STRATEGIC HORIZON 1 | Required non financial strategic resources | Main initiator/ coordinator | Need for financial resources |
|---|---|---|---|
| 4.1.1. Along the activities directed to general improvement of business environment also issues directly related to engineering activities shall be addressed, in particular concerning dual-use goods import and export procedures, product certification requirements, lowest level of travelling and living allowances and other similar issues. | | RA Ministry of Economy,<br>RA Ministry of Finance | low |

| STRATEGIC HORIZON 2 | Required non critical financial resources | Main initiator/coordinator | Need for financial resources |
|---|---|---|---|
| **1. EDUCATION** | | | |
| 1.1. Inclusion of Armenian State Engineering University in international lists of best technology universities | High-qualified professors and educational infrastructure | University, RA Ministry of education and science | middle |
| **2. COUNTRY BRANDING AND ATTRACTION OF INVESTMENTS** | | | |
| 2.1. Promotion of Armenian technology cluster through country branding | | Armenian Development Agency, EIF | high |
| 2.2. Negotiations to attract new MNCs for Armenia | Diaspora | RA Ministry of Economy, Armenian Development Agency, EIF | middle |
| **3. PROMOTION OF ARMENIAN TECHNOLOGY COMPANIES** | | | |
| 3.1. Business incubation (development of business skills, support to find markets and establish contacts with partners) | | EIF, donor organizations | middle |
| 3.2. Start-up capital (in form of shareholders' investments or grants) | | RA Ministry of Economy, EIF, donor organizations | high |
| **4. TECHNOLOGY COMMERCIALIZATION INFRASTRUCTURE** | | | |
| 1.1. Strengthening of technology commercialization infrastructure and capabilities | | RA Ministry of Economy, EIF | middle |
| 1.2. Assuring effective functioning of intellectual property protection system | | RA Ministry of Economy, Intellectual Property Agency | low |

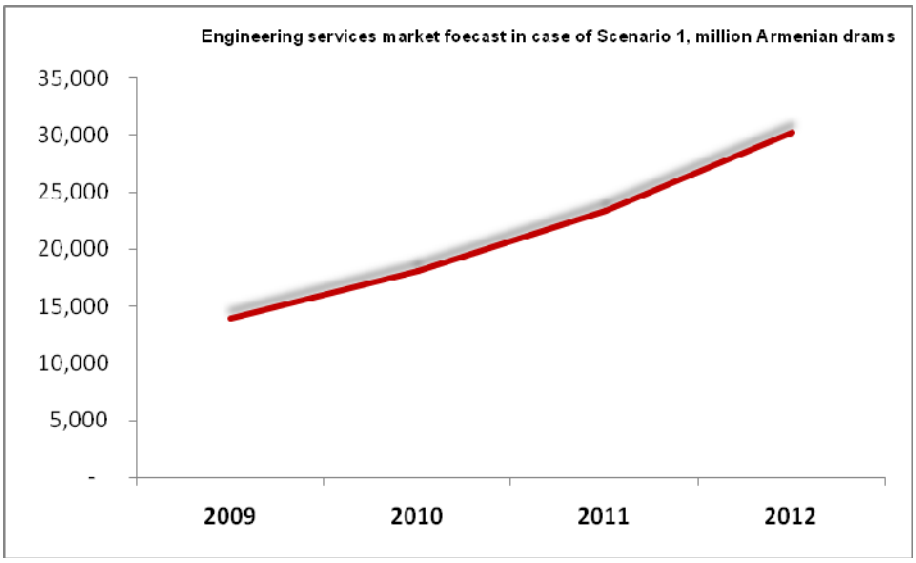
**SCENARIO 2: TRIVIAL INTERVENTION**

The second scenario of Armenian engineering sector development assumes trivial external intervention in the engineering sector or entire absence of the latter.

In case of absence of intensive intervention it is expected that the sector will show natural growth as a result of planned activities of main companies active in the sector.

The market development forecasts are quiet positive for a short-term period, though they are not sustainable and promising in a broader perspective as there are no fundamental bases and improvements for the development and there is only a quantitative growth due to development of certain consumer industries.

Below is description of development without interventions according to the scenario 1.




Actions according to scenario 2 can be carried out requiring modest financing compared to scenario 1. In this case, list of actions to be carried out mainly include:

***- Courses for preparation of specialists***

These courses will mainly include teaching of most commonly used software packages for a limited number of students. AutoCad, ArchiCad, SolidWorks, ProEngineer, LabView are software mostly used in companies participated in the survey. EIF can take on organization of the courses in cooperation with universities and individual specialists.

***- Preparation of managers***

It's expected that courses for preparation of specialists will create groups of specialists ready to implement small-sized outsourcing orders. Development of leadership and project management skills through courses and practical experience will be of high importance for such workgroups.

***- Strengthening of cooperation between sector participants***

The role of EIF, professional associations and other similar institutions is highly important in this field. Their involvement can be shown in creating of a cooperation platform in form of meetings, discussions and organization of events like these. Engineering companies' step to cooperation can create serious strategic coalitions allowing availability for large-scale projects.

It's also extremely important to strengthen cooperation between engineering companies and other interested parties of the sector: state, universities, specialists as well as consuming sectors. In this context, supportive efforts shall be directed to purposeful activities of universities arising from companies' requirements and which will help students and specialists to establish direct contact with companies as well as to lobby for sector's importance in governmental bodies.

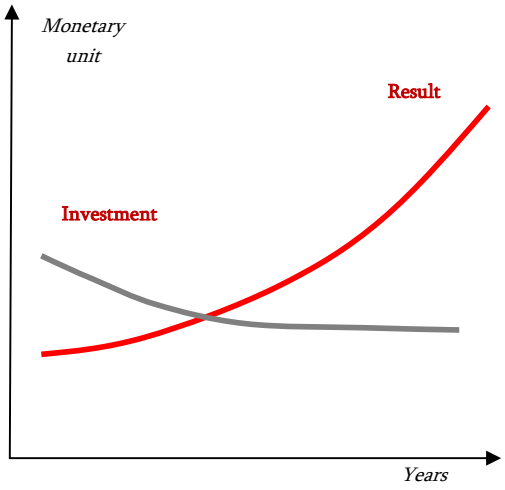
***- Sales offices in target countries***

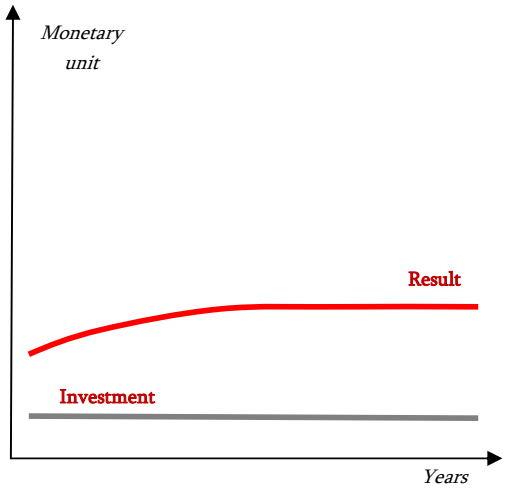
In case of intervention according to the second scenario of direction 1 Armenia can, in the best case, be introduced in the engineering services global market with a minor share of outsourcing of simple solutions. In the outsourcing segment mainly a small number of foreign companies' representations as well as domestic workgroups will work. Though, the latter will not have sufficient resources to attract orders from foreign countries. That is why the main function of a sales office in this case shall be oriented to the "sale" of engineer-specialists.

Below is the comparative analysis of two different scenarios of direction 1 in respect to required actions and expected results.

| | Required investment | Expected result | Position in the market | Additional opportunities |
|---|---|---|---|---|
| Scenario 1 | Professional trainings, short-term, not advanced courses<br>Establishment of Sales Offices | Formation of separate groups of educated specialists having certain project management skills | Outsourcing market of simple engineering functions | This scenario is itself limited to the extent that it cannot even maintain its own growth pace and be spread on the factors which will lead to development of other sectors |
| Scenario 2 | Creation of infrastructure, practical labs<br>Improvement of base higher education<br>Negotiations with foreign companies to establish R&D centers in Armenia | Establishment of own R&D centers by multinationals<br>Enhancement of university research activities<br>Providing of educational services for countries of the region<br>Establishment of technology start-ups | R&D center for multinationals<br>High-qualified specialists<br>Complex engineering solutions | Development after scenario 2 promises to have a multiplier effect and to be expanded in many sectors of economy thus contributing to development |

Below is the comparative correlation of invested efforts and obtained results for two different scenarios of Direction 1.




As the graphic shows engineering sector development according to Scenario 1 is an absolutely pretentious initiative. Difference between investments and intervention levels requested by two various scenarios is significant though extremely critical. So, if in the short-term perspective, the result index regardless of investments level can be just similar for both of scenarios, there is a quite different picture in the long-term perspective. This reasoning is proved by the argument that in case of Scenario 1 development of R&D centers can increase the sector's productivity up to more than ten times compared to Scenario 2.

## DIRECTION 2: ENGINEERING SERVICE PROVIDERS IN THE INFRASTRUCTURES' SECTOR

### THE VISION

To create internationally competitive companies providing engineering services in Armenia which will provide entire engineering services in target markets. Taking into account the capabilities potential to be developed it will mainly encompass design of civil, hydroengineering, energy facilities.

### Main challenges

Due to limited size of local market the future enlargement of this sector is directly linked with development of capabilities of Armenian companies to supply foreign markets. In the first development phase, the mentioned capabilities will be improved by creating corresponding demand and environment in domestic market.

There is a drastic competition in international markets where engineering companies from developed countries are still dominant (USA, Japan, Germany, France, Canada, Holland, Australia etc.), though companies from developing countries (China, India, Egypt, Turkey etc.) capture the market at a fast pace. For the latter, large domestic market and enormous infrastructure investments contributed to development of capabilities of local companies.

Important requirements to compete in foreign markets of engineering companies are the following:

- Financial prosperity of companies which will guarantee prefinancing of costs;
- available experience in international market;
- local certification and licensing in the target market or strategic partnership with local companies;
- application of internationally adopted standards;
- availability of unique technologies which will be considered as competitiveness advantage source.

**Expected results**

Formation of two or three large companies providing competitive engineering services in the international market.

**Critical weaknesses**

| Strategic horizon 1 | Strategic horizon 2 |
|---|---|
| • **Low level of young specialists theoretical and practical skills as a result of low quality education** | • Absence of mechanisms for risk insurance in foreign markets |
| • **Usage of old, soviet construction norms and absence of knowing internationally adopted norms (British Standards, ASSHTO (USA), Eurocodes)** | • Small size of companies, in particular limited financial and human resources |
| • **Absence of domestic demand for innovation** | • Absence of capabilities and experience in exporting services |
| • **Disuse of technologies providing competitive advantage** | |

**Development phases**

**Horizon 1 (1-5 years) – development of competitive capabilities in domestic market**

In this phase, the key point shall be creation of sources for competitive advantage of engineering companies by ensuring availability of corresponding demand and environment in the domestic market. It shall be based on mastering unique technologies and obtaining advanced experience. Due to limited resources it's necessary to concentrate efforts on selected at least two or three sectors where a great demand potential in the Armenian market is available (in particular, they can be solar or hydrotechnical sectors, sectors of seismically safe facility).

The main incentive of the sector can be formation of a local demand promoting innovation and mastering of technologies in selected sectors. It can be reached by creation of own technologies as well as import and adaptation of new technologies and knowledge. This means radical reviewing of principles and processes of construction and design work tenders conducting. Application of new technologies in evaluation of tender results shall be as a mandatory requirement. The large scale of these programs also plays an essential role

in cumulating skills and experience. The larger the programs the greater the opportunity and probability are for formation of advanced capabilities.

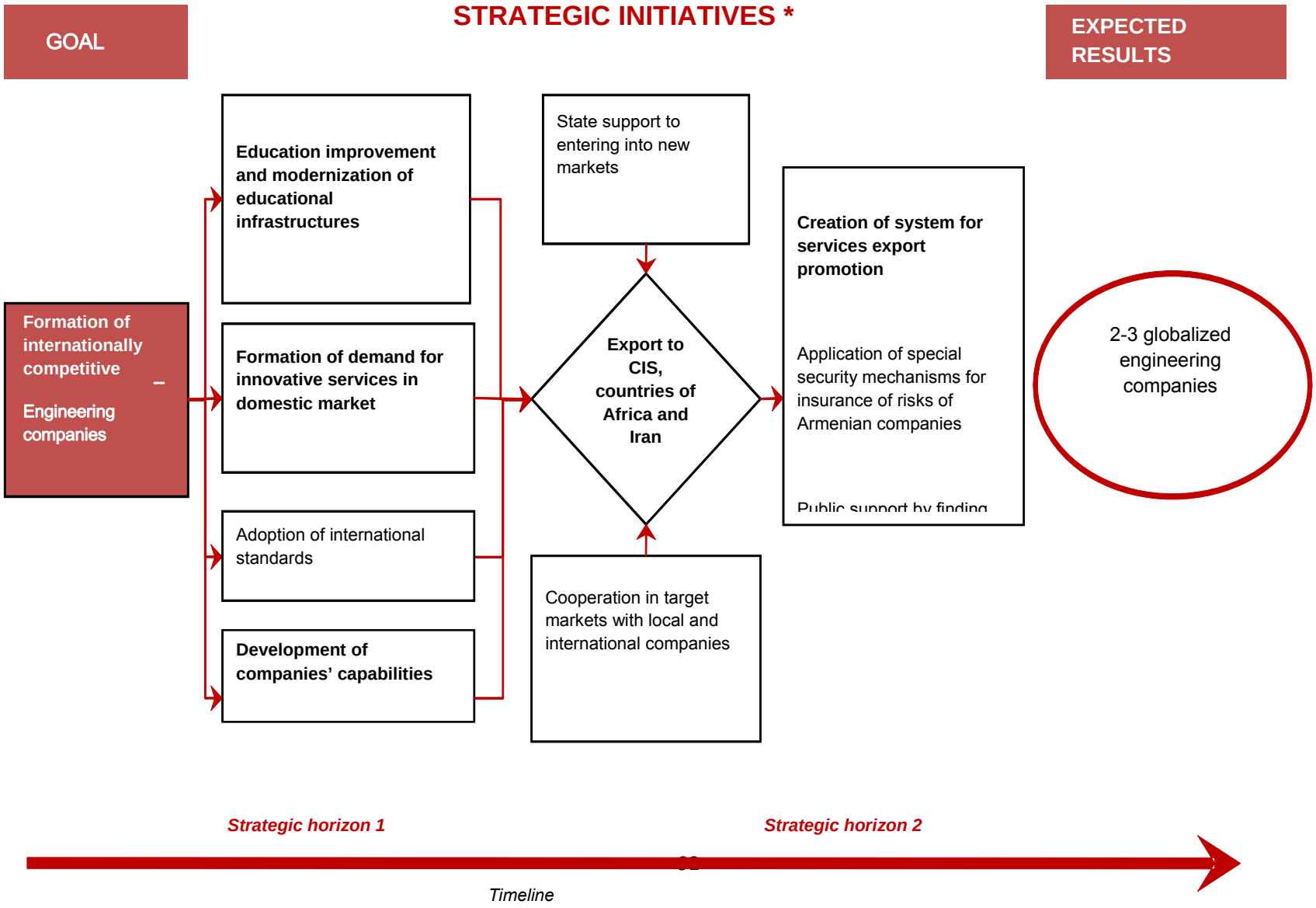
In parallel, adoption and use of internationally known standards in Armenia shall be commenced. The education system shall be the first which will also include training of the teaching staff, upgrade of educational programs and laboratory base.

**Horizon 2 (5-10 years) – Penetration in foreign markets**

Obtaining of sufficient experience and technological superiority in the domestic market will create bases for companies to appear in foreign markets.

The most possible markets for Armenian engineering companies are CIS countries, Iran and developing countries of Africa. The CIS countries can be the primary goal as the soviet previous construction norms are still valid in these countries. Russian is used as common communication language here, too. Partnership with engineering companies from developed countries can help to enter into markets of Iran and countries of Africa. In general, western companies avoid to have such partnerships, but in some markets, cost reducing factor (Armenian engineers have a quiet smaller salary compared to engineers from Europe and America), non-willingness of own employees to travel to developing countries as well as inaccessible markets such as Iran are serious motives for implementation of joint projects.

## Direction 2: Strategy “Roadmap”




* Detailed description of strategic initiatives is shown in the next table.

## Strategic initiatives

| Strategic horizon 1 | Required non-financial critical resources | Main initiator/coordinator | Need of financial resources |
|---|---|---|---|
| **1. EDUCATION** | | | |
| 1.2. Educational initiatives described in Direction 1 | | | |
| 1.3. Including of international engineering and construction norms in educational programs | Skilled professors<br>Professional literature | University | middle |
| **2. STANDARDS** | | | |
| 2.1. Transfer to internationally adopted norms and standards | Experienced specialists | Government represented by sector ministries | high |
| **3. MARKET AND DEMAND** | | | |
| 3.1. Selection of sectors to be developed in Armenia and directing of investments towards these sectors (e.g. promotion for development of solar energy technologies by fixing prices for energy bought from solar stations, developing special credit mechanisms) | Public and private cooperation institutions | GoA and sector ministries | high |
| 3.2. Creation of incentives for development of capabilities within public purchases section (requirement to apply international standards and innovative approaches, promotion of consortiums with international leading companies) | | Government, system of public purchases | high |
| **4. INTERSECTORAL COOPERATION** | | | |
| 4.1. Establishment of a competent association within the sector which will have the mission to promote increase of companies' competitiveness by joining the efforts of sector's participants (promotion for adoption of international standards, training for employees, cooperation with universities and other areas) | Active initiating companies | Engineering companies | low |

| Strategic horizon 2 | Required non-financial critical resources | Main initiator/coordinator | Need of financial resources |
|---|---|---|---|
| **1. DEVELOPMENT OF EXPORTING CAPABILITIES** | | | |
| 1.1. Obtain small market niche players in target markets | Financial resources | Engineering companies | high |
| 1.2. Establish strategic partnership with local or international companies in target markets | Diaspora | Engineering companies | middle |
| **2. PUBLIC SUPPORT TO EXPORT** | | | |
| 2.1. Public support within intergovernmental cooperation | | Government | low |
| 2.2. Support to companies by creating an export institution for mitigation of risks arising from activities in foreign countries (Eximbank)<br>(main functions of this institution shall include export insurance and crediting). | Support of international specialists | RA Ministry of Economy and RA Ministry of Finance | high |

## POSSIBLE HUGE RISKS ANALYSIS

### Direction 1 (Scenario 1): High Tech R&D center

| Risk | Consequences | Possible mitigation |
|---|---|---|
| Skilled specialists leave for abroad – "outflow of heads" | Shortage of Armenia's innovation capabilities and human resources | At the beginning "outflow of heads" may be an active process which will slow down when global companies will be involved and higher remunerated jobs will be available. This will even contribute to "inflow of heads". At the same time, it should be considered that move of high-quality specialists also can be of positive benefit for the country's long-term development. It will contribute to exchange of experience and knowledge and establishment of new business relationships |
| Sector's dependence on one-two large transnational companies which can engage the major part of qualified workforce | Insufficient qualified specialists in other sectors of economy Termination of activities of just one company can result in crucial unemployment | In a long-term perspective high-quality specialists and research teams will establish own technology companies providing new jobs. That means availability of infrastructures for promotion of technology start-ups |
| Incompatibility of created valued offer with requirements of MNCs from the quantitative and qualitative point of view | Small volumes of multinationals' investments | Research capabilities being developed to be in more conformity with requirements of multinationals whereby the needs of them shall be studied as early as possible |

### Direction 1 (Scenario 2): Outsourcing center

| Risk | Consequences | Possible mitigation |
|---|---|---|
| Small number of specialists having fragmentary skills | Decentralization of professional skills whereby creation or preservation of an academic base and scientific infrastructure will fail | Mass organization of professional courses |
| Possibilities of trivial risks facing different sectors (low level of risks is associated with low level of intervention) | Very low effectiveness of resources used for intervention which associated with insufficient level of results | |

### Direction 2: Infrastructure engineering services provider

| Risk | Consequences | Possible mitigation |
|---|---|---|
| Counteraction against in-depth system changes associated with transfer to international standards and implementation of innovations | Lack of capabilities development which will hinder formation of competitive advantages | Thorough policy to be implemented by the government |
| Lack of leadership and cooperation in the sector | Hindering to make changes | Establishment of sector association which will try to join private companies around the general vision and to more effectively implement development of capabilities |

| Risk | Consequences | Possible mitigation |
|---|---|---|
| | | with joint efforts |
| Other competitors have more favourable conditions for capabilities development associated with size of their domestic markets and higher level of improvement | Armenian companies will not be able to compete in foreign markets | As narrow as possible specialization area shall be chosen where large scales are not of critical importance. |
| Political risks associated with entering in markets of developing countries | Limitation of export opportunities for Armenian companies | The GoA shall try to create political and trade and economic ties in target markets and deepen them with governments |
| Change of market needs and technologies prior to development of capabilities | Market needs and technologies can change faster as a result of which capabilities formed in Armenia will become out-of-date and not competitive | Continuous upgrade of educational programs and technologies |

## CONCLUSION

Regardless of development direction and models the further growth of engineering sector and its direction depend on three key factors:

1. Fundamental improvement of educational system;
2. Active and direct public intervention;
3. Globalization.

### Education

The basis for any of engineering services sector development directions is improvement of education quality through basic reforms. The further development of the sector calls for establishment of an engineering university according to international standards which should become one of the main strategic goals.

### State

Regardless of the direction being applied the state shall undertake the role of the main initiator in both cases and contribute to sector's development by direct intervention. In one case it shall support the demand formation for high-quality infrastructure engineering services. In the other case, the state shall make public investments to create an attractive infrastructure to engage global companies R&D services for Armenia. For the latter, support of the state and even its direct participation in negotiations with MNCs is critical.

Moreover, the state shall have an active participation in improvement of educational system quality. The state shall act as the initiator for modernization of lab facilities, one of the primary issues of this sector and it shall also bear the major part of costs.

### Globalization

Due to limitations of the Armenian domestic market there is no other way as to direct the sector to foreign markets. This assumes development of internationally competitive capabilities and providing of an environment and infrastructure for their usage.

### Complex and entire approach

Strategic goals cannot be achieved if any of components of strategic initiatives (education, market, infrastructure and environment) is ignored or their development is failed. Complex approach towards problems and involving of all interested parties are the main guarantees for achieving expected results.

# ANNEXES

## ANNEX 1
## ENGINEERING SECTOR DEFINITIONS

### NACE revision 2.0

71 Architectural and engineering activities; technical testing and analysis
71.1 Architectural and engineering activities and related technical consultancy
71.11 Architectural activities
71.12 Engineering activities and related technical consultancy
71.2 Technical testing and analysis
71.20 Technical testing and analysis

### NAICS-North American Industry Classification System (Code: 541330)

This industry comprises establishments primarily engaged in applying physical laws and principles of engineering in the design, development, and utilization of machines, materials, instruments, structures, processes, and systems. The assignments undertaken by these establishments may involve any of the following activities: provision of advice, preparation of feasibility studies, preparation of preliminary and final plans and designs, provision of technical services during the construction or installation phase, inspection and evaluation of engineering projects, and related services.
Subcategories:

| | |
|---|---|
| Acoustical system engineering design services<br>Boat engineering design services<br>Chemical engineering services<br>Civil engineering services<br>Combustion engineering consulting services<br>Construction engineering services<br>Consulting engineers' offices<br>Consulting engineers' private practices<br>Electrical engineering services<br>Engineering consulting services<br>Engineering design services<br>Engineering services<br>Engineers' offices | Engineers' private practices<br>Environmental engineering services<br>Erosion control engineering services<br>Geological engineering services<br>Geophysical engineering services<br>Heating engineering consulting services<br>Industrial engineering services<br>Logging engineering services<br>Marine engineering services<br>Mechanical engineering services<br>Mining engineering services<br>Petroleum engineering services<br>Traffic engineering consulting services |

**ISIC Rev.3 code 7421**

- Tabulation Category: K - Real estate, renting and business activities
- Division: 74 - Other business activities
- Group: 742 - Architectural, engineering and other technical activities
- **Class: 7421 - Architectural and engineering activities and related technical consultancy**

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**Explanatory note**

This class includes consulting architectural and engineering activities, surveying, geological exploration and prospecting activities and engineering. Architectural activities concern building design and drafting and often supervision of construction, town and city planning and landscape architecture.

Engineering and technical activities concern specialized activities related to civil engineering, hydraulic engineering, traffic engineering including project management for constructions, electrical and electronic engineering, mining engineering, chemical engineering, mechanical, industrial and systems engineering, air-conditioning, refrigerating, sanitary and pollution control engineering, acoustical engineering, etc. Geological and prospecting activities utilize surface measurements and observation designed to yield information on subsurface structure and the location of petroleum, natural gas and mineral deposits and of ground water. This may involve airborne geophysical surveys, hydrological surveys, etc. Also included are map making and related land surveying activities.

Exclusions: Test drilling and testhole boring in connection with petroleum and gas extraction is classified in class 1120 (Service activities incidental to oil and gas extraction excluding surveying).

Research and development activities are classified in division 73.

Technical testing is classified in class 7422.

**Other definitions**

**Engineeringoutcourcing.com portal of engineering services**

Engineering services are those service functions that deal with or related to core engineering processes.

Examples are:

- CAD / CAM (computer aided manufacturing / design)
- Auto design
- Failure analysis of structural steel

The distinction that needs to be drawn here is between engineering functions and engineering service functions. An engineering function could be auto engine manufacturing. A related engineering service function would be designing the engine. It is similar to the distinction between manufacturing and manufacturing support services.

**Canada Statistics Report**

The engineering services industry is comprised of firms primarily engaged in applying principles of engineering in the design, development and utilization of machines, materials, structures, processes and systems. It offers services ranging from feasibility studies to design and commissioning or the start-up of the operation of projects. Most firms are pure engineering services firms.

**ThomasNet - Engineering service portal**

Firms provide engineering services for virtually every industry, product and system. They range in scope from massive **civic planning projects to microchip design**, and can be employed at any stage in a production project, whether prototype generation or package engineering.

Typically, the best method of locating engineering services for a project is to first define the associated industry and potential production services needed, then to investigate companies specializing in one or both of those fields. Many custom manufacturers also offer extensive engineering services, including design assistance, and those specializing in the pertinent areas are the most likely to offer the fastest turnaround at the lowest cost. Certain firms offer planning and design services for a wide range of industries rather than one specific field, although many of these can still be found by searching within a specified area, rather than through a broader search for engineering services.

**NASSCOM and Booz Allen Hamilton Engineering outsourcing potential in India**

A joint study for the potential of outsourcing engineering services to India was conducted by NASSCOM and Booz Allen Hamilton. The report is focused on ‘core’ engineering service outside software engineering, PLM and other IT enabled services. The framework used examined demand-side, supply-side and competitive dynamics. The core engineering services included are:

1. Aerospace, Automotive, Construction & Industrial machinery, Telecom and Utilities
2. Product and component design, Plant design, Process engineering and Plant maintenance & operations

# ANNEX 2
## LIST OF ENGINEERING COMPANIES

| | COMPANY NAME | PARTICIPATION IN SURVEY | SPECIALISATION AREA |
|---|---|---|---|
| 1 | INSTITUTE OF GEOPHYSICS AND ENGINEERING SEISMOLOGY NAMED AFTER A.NAZAROV | Participated | Geophysics, seismology |
| 2 | A-2 | Participated | Natural gas industry |
| 3 | ALPHA SYSTEM TECHNOLOGIES | Participated | Energetics |
| 4 | ASHNVIKS | Participated | Urban development |
| 5 | AR & AR DESIGN CONSTRUCTION | Participated | Energetics, hydraulic engineering |
| 6 | ARMILDESIGNPROJECT | Participated | Urban development, product design |
| 7 | AROSA | Participated | Transportation facilities |
| 8 | ARTRANS | Participated | Transportation facilities |
| 9 | ARPA-SEVAN | Participated | Energetics, water industry, transportation facilities, geophysics |
| 10 | GENAGRO | Participated | Water industry, urban development |
| 11 | "GEORISK" SCIENTIFIC RESEARCH COMPANY | Participated | Geophysics |
| 12 | YERANG | Participated | Urban development |
| 13 | YEREVAN TELECOM SOLUTIONS | Participated | Telecommunication |
| 14 | YEREVAN TELECOMMUNICATION RESEARCH INSTITUTE | Participated | Telecommunication |
| 15 | ELLIPS GA | Participated | Security systems |
| 16 | AE CONSULTING | Participated | Engineering consultancy |
| 17 | SCIENTIFIC RESEARCH INSTITUTE OF ENERGY | Participated | Energetics |
| 18 | EPYGIARM | Participated | Telecommunication |
| 19 | INDUSTRIAL TECHNOLOGIES CO | Participated | Robotics, automation |
| 20 | INTERSTANOK SCIENTIFIC PRODUCTION ASSOCIATION | Participated | Stone working, urban development |
| 21 | LOGISTIC GROUP | Participated | Logistics |
| 22 | LT-PYRKAL | Participated | Crystal growth, laser engineering |
| 23 | KHORDA | Participated | Energetics, water industry |
| 24 | KAMURJSHIN | Participated | Transportation facilities |
| 25 | "ARMATOM" ARMENIAN SCIENTIFIC RESEARCH INSTITUTE FOR NUCLEAR PLANT OPERATION | Participated | Energetics |
| 26 | ARMHYDROENERGYPROJECT | Participated | Water industry |
| 27 | ARMPROJECT | Participated | Urban development |
| 28 | REPINDUSTRYPROJECT | Participated | Urban development |
| 29 | HGSN (HAYGYUGHSHINNAKHAGITS) | Participated | Urban development |

| | | | |
|---|---|---|---|
| 30 | HYDROENERGETICA | Participated | Energetics |
| 31 | HORATANTSK | Participated | Geophysics |
| 32 | MIKAPROGRESSTECH | Participated | Aviation |
| 33 | CENTRE OF MICROBIOLOGY AND MICROBIAL DEPOSITORY (CMMD) | Participated | Biological engineering |
| 34 | NATIONAL INSTRUMENTS | Participated | Automation, metrology |
| 35 | JINJ | Participated | Water industry |
| 36 | JRTUQ | Participated | Water industry |
| 37 | RAKE | Participated | Urban development, geophysics |
| 38 | SADE | Participated | Urban development, water industry |
| 39 | SYMOTEC | Participated | Mechanics, automation |
| 40 | STEP LOGIC YUG | Participated | Telecommunication |
| 41 | VANARKH | Participated | Design estimates |
| 42 | TECHNOKOM | Participated | Heat engineering, electrical engineering, mechanical engineering, energetics |
| 43 | TECHPROJECT | Participated | Industry, construction |
| 44 | TRANSPROJECT | Participated | Transportation facilities |
| 45 | CAMBRIC ARMENIA | Participated | Mechanics |
| 46 | KMC | Participated | Energetics, telecommunication |
| 47 | QVE NAKHAGIC | Participated | Urban development |
| 48 | SCIENTIFIC TECHNOLOGICAL CENTER OF ORGANIC AND PHARMACEUTICAL CHEMISTRY (STCOPHCH) | Participated | Pharmaceutics |
| 49 | FABLOG CONSULTING | Participated | Logistics |
| 50 | ELECTROSEVKAVMONTAG | Participated, field of activity does not correspond | |
| 51 | ELECTROPROJECT | Participated, field of activity does not correspond | |
| 52 | HAEK SHINARARUTYUN | Participated, field of activity does not correspond | |
| 53 | HARWAL MACHINERY | Participated, field of activity does not correspond | |
| 54 | SG DESIGN ELECTRONICS | Participated, field of activity does not correspond | |
| 55 | SNART | Participated, field of activity does not correspond | |
| 56 | YERREPAIRPROJECT | Activity terminated | |
| 57 | SOLAREN | Activity terminated | |
| 58 | NATIONAL INSTITUTE OF METROLOGY | Field of activity does not correspond | |
| 59 | AAB CONCERN | Not participated | |
| 60 | INTEGRAL DESIGN EV ENGINEERING | Not participated | |
| 61 | INTRACOM ARMENIA | Not participated | |
| 62 | LERNAMETALURGIAI INSTITUTE | Not participated | |
| 63 | MEKUSICH | Not participated | |
| 64 | “MATERIALS SCIENCE” RESEARCH AND PRODUCTION ENTERPRISE | Not participated | |
| 65 | TSK-SVYAZSTROYKOM | Not participated | |

# ANNEX 3

## SURVEY QUESTIONNAIRE FOR MANAGERS OF ENGINEERING SERVICE COMPANIES

*Research Center "Economy and Values" contracted by Enterprise Incubator foundation and the World Bank conducts a research study of Armenian engineering services sector with the purpose to analyze development perspectives of the sector and design strategy to support the sector development. To evaluate the current state and support needs of the sector survey of managers of active companies is being conducted.*

### *I. General description of the company*

1. Company full name_____

2. Position of company executive_____

3. Name of company executive_____

4. Year of establishment _____

5. Form of restructuring (privatization, buying or integration etc.) (please check only one)

   ☐ 1. Privatization
   ☐ 2. Buying or integration
   ☐ 3. Other (describe)_____

6. Year of restructuring _____

7. Legal form (please check only one)

   ☐ 1. LLC
   ☐ 2. CJSC
   ☐ 3. OJSC
   ☐ 4. Private entrepreneur
   ☐ 5. Other (describe)_____

8. Is your company with foreign capital (please check only one).

   ☐ 1. Yes
   ☐ 2. No, go to position 11
   ☐ 3. Refuse to answer

9. If yes, indicate share of foreign capital (%) in your company's share structure ----------

10. If yes, indicate the origin of foreign owner (country where the company is registered). ----------

11. Description of services of the company by main and secondary activities

| | |
|---|---|
| 11.1. Main activities | 11.1.1. _____<br>11.1.2. _____<br>11.1.3. _____ |

| | |
|---|---|
| | 11.1.4. _____<br>11.1.5. _____ |
| 11.2. Secondary activity | 11.2.1. _____<br>11.2.2. _____<br>11.2.3. _____<br>11.2.4. _____<br>11.2.5. _____ |

12. For which sectors of economy or which companies does your company provide services?

    12.1. _____

    12.2. _____

    12.3. _____

13. Does your company have a quality control system (or do you have quality certificates) (please check only one).

    ☐ 4. Yes

    ☐ 5. No, go to position 11

    ☐ 6. Refuse to answer

14. If yes, please indicate the certificate and the issuer.

| Certificate | Issued by: |
|---|---|
| 14.1.1. | 14.2.1. |
| 14.1.2. | 14.2.2. |
| 14.1.3. | 14.2.3. |

***II. Human resources of company***

15. Indicate number of permanent employees in your company: ----------

16. Indicate number of non-permanent employees (to be engaged for certain projects): _____

17. Indicate number of permanent employees in the company by functional directions:

| Functional directions | Number |
|---|---|
| 17.1. Technical staff (engineers) | |
| 17.2. Managing staff | |
| 17.3. Sales and marketing | |
| 17.4. Finances and accounting | |
| 17.5. Other servicing assistance staff | |

18. Indicate average salaries of permanent employees in your company by functional directions:

| Functional directions | Monthly average salary in AMD |
|---|---|
| 18.1. Technical staff (engineers) | |
| 18.2. Managing staff | |
| 18.3. Sales and marketing | |
| 18.4. Finances and accounting | |
| 18.5. Other servicing assistance staff | |

19. Qualitative characteristic of your company staff (excluded the servicing and assistance staff)

| | % in total |
|---|---|
| 19.1. Specialists with foreign educated/trained abroad | |
| 19.2. Specialists with international experience | |
| 19.3. Specialists with English knowledge | |
| 19.4. Specialists with Russian knowledge | |
| 19.5. Specialists possessing international certificates for professional skills | |

20. Please indicate which software packages do you use?

| Software package | Number of specialists familiar with the software package |
|---|---|
| 20.1. AutoCAD | |
| 20.2. Autodesk Inventor | |
| 20.3. PRO/Engineer | |
| 20.4. UGS NX | |
| 20.5. Solid Works | |
| 20.6. ANSYS | |
| 20.7. Abaqus (Simulia) | |
| 20.8. Solid Works Simulation | |
| 20.9. MSC Nastran | |
| 20.10. Surf CAM | |
| 20.11. Labview | |
| 20.12. Archi CAD | |
| 20.13. Other (indicate)_____ | |

21. Please indicate the educational level of your professional/technical staff members.

| | % in total technical staff members |
|---|---|
| 21.1. Technical education | |
| 21.2. Higher education (Bachelor, Master's, Diploma) | |
| 21.3. Candidate of science | |
| 21.4. Doctor of Science | |

22. How would you evaluate the system of higher education in Armenia in terms of preparing high-qualified specialists (please check only one).

☐ 1. High-qualified specialists corresponding to international standards.

☐ 2. Specialists having good theoretical knowledge but weak practical skills.

☐ 3. Both the theoretical and practical knowledge of graduates is at the lowest level.

☐ 4. Other _____

23. Describe ease of hiring required specialists in the labor market (please check only one).

☐ 1. Easy

☐ 2. Difficult

☐ 3. There are no specialists on the labor market.

24. Does your company need to hire new employees now? If yes, please indicate the number by specialization.

| 24.1. Specialization | 24.2. Number |
|---|---|
| 24.1.1. | 24.2.1. |
| 24.1.2. | 24.2.2. |
| 24.1.3. | 24.2.3. |

25. Indicate reasons for being unable to find necessary specialists.

☐ 25.1. Incompatibility of professional skills

☐ 25.2. Incompatibility of practical skills

☐ 25.3. Not attractive salaries offered by your company

☐ 25.4. Other (please indicate)_____

### *III. Company sales*

26. Please indicate approximate income of your company for 2009 (please check only one).

☐ 1. Up to 20 million AMD
☐ 2. 20-50 million AMD
☐ 3. 50-100 million AMD
☐ 4. 100-300 million AMD
☐ 5. 300-500 million AMD
☐ 6. More than 500 million AMD

27. Please indicate share of income derived from engineering services (%) in total for 2009: ----------

28. Describe sales dynamics in your company over last three years (please check only one).

| | 28.1. Change | 28.2. Average annual increase/decrease, in % |
|---|---|---|
| ☐ | 1. Decreased | |
| ☐ | 2. Increased | |
| ☐ | 3. Remain the same | |

29. What are your expectations in sales for coming three years (please check only one).

| | 29.1. Change | 29.2. Average annual increase/decrease, in % |
|---|---|---|
| ☐ | 1. Will decrease | |
| ☐ | 2. Will increase | |
| ☐ | 3. Will remain the same | |

30. Indicate the main sales markets for products and services of your company (including Armenia) (classify countries by descending share of sales)

| 30.1. Country | 30.2. Share in total sales (%) |
|---|---|
| 30.1.1. | 30.2.1. |
| 30.1.2. | 30.2.2. |
| 30.1.3. | 30.2.3. |

*Note for interviewer: positions from 31 to 35 relate only to companies having also export activities, i.e. in the position 30 also foreign countries shall be indicated.*

31. What are the engineering solutions being exported (if products/services of the company are being completely exported, i.e. "Armenia" has not been indicated in position 30, pass to position 32).
    31.1. _____
    31.2. _____
    31.3. _____

32. What are the main channels of sales?

| | |
|---|---|
| ☐ | 32.1. Directs sale to the end customer |
| ☐ | 32.2. Sale through sales agents |
| ☐ | 32.3. Sale through company's foreign representation |

33. How has your company established contacts to foreign customers?

| | |
|---|---|
| ☐ | 33.1. Participation in international exhibitions |
| ☐ | 33.2. Searching for customers via internet |
| ☐ | 33.3. Using Diaspora contacts |
| ☐ | 33.4. Foreign partner has found us through our website or yellow pages |
| ☐ | 33.5. Establishing of personal contacts by business trips and visiting target markets |
| ☐ | 33.6. Through foreign representations |
| ☐ | 33.7. Implementation of a joint project in Armenia |
| ☐ | 33.8. Other _____ |

34. Please indicate which of mentioned positions better describe the exporting experience of your company (please check only one)?

| | |
|---|---|
| ☐ | 1. We work only with one client. |
| ☐ | 2. We work several clients in the same exporting markets. |
| ☐ | 3. We export our products and services to several countries and work with various clients. |

35. Exporting intensity of your company (please check only one).

| | |
|---|---|
| ☐ | 1. Rarely |
| ☐ | 2. 1-2 deals per year |
| ☐ | 3. Regularly |

*Note for the interviewer: position 36 relates only to companies having no export activities, i.e. in position 30 only "Armenia" is indicated.*

36. Please indicate reasons for not having export activities.

36.1. _____

36.2. _____

36.3. _____

37. Which of below mentioned means are being used by your company?

| | | |
|---|---|---|
| ☐ | 37.1. | Advertisement |
| ☐ | 37.2. | Availability of printed advertisement materials |
| ☐ | 37.3. | Participation in local exhibitions |
| ☐ | 37.4. | Participation in international exhibitions |
| ☐ | 37.5. | Diaspora partners |
| ☐ | 37.6. | Website of the company |
| ☐ | 37.7. | Other instruments of e-marketing |
| ☐ | 37.8. | Other (please indicate)_____ |

***IV. Demand***

38. Please indicate which factors are important for your local clients when deciding to cooperate?

| | 1= not important; 5= very important | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 38.1. Price | ☐ | ☐ | ☐ | ☐ | ☐ |
| 38.2. Quality | ☐ | ☐ | ☐ | ☐ | ☐ |
| 38.3. Servicing | ☐ | ☐ | ☐ | ☐ | ☐ |
| 38.4. Number of projects implemented by company | ☐ | ☐ | ☐ | ☐ | ☐ |
| 38.5. Other clients of the company | ☐ | ☐ | ☐ | ☐ | ☐ |
| 38.6. Advice/recommendation of partners | ☐ | ☐ | ☐ | ☐ | ☐ |
| 38.7. Other (please indicate)_____ | ☐ | ☐ | ☐ | ☐ | ☐ |

39. Please indicate which factors are important for your foreign clients when deciding to cooperate (if the company has no export, go to position 40)?

| | 1= not important; 5= very important | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 39.1. Price | ☐ | ☐ | ☐ | ☐ | ☐ |
| 39.2. Quality | ☐ | ☐ | ☐ | ☐ | ☐ |
| 39.3. Servicing | ☐ | ☐ | ☐ | ☐ | ☐ |
| 39.4. Number of projects implemented by company | ☐ | ☐ | ☐ | ☐ | ☐ |
| 39.5. Other clients of the company | ☐ | ☐ | ☐ | ☐ | ☐ |
| 39.6. General information of the country (image) | ☐ | ☐ | ☐ | ☐ | ☐ |
| 39.7. Advice/recommendation of partners | ☐ | ☐ | ☐ | ☐ | ☐ |
| 39.8. Other (please indicate)_____ | ☐ | ☐ | ☐ | ☐ | ☐ |

### *V. Sector competition framework and cooperation, company's strategy*

40. How would you evaluate competition among Armenian companies within your specialization field?:

| 1= no competition; 5= intensive competition | | | | |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |
| ☐ | ☐ | ☐ | ☐ | ☐ |

41. How would you evaluate cooperation among companies within sector you are operating in (please check only one)?

| | |
|---|---|
| ☐ | 1. Companies intensively cooperate with each other (exchange of experience, implementation of joint projects) |
| ☐ | 2. Companies generally know each other and partly cooperate (exchange of general information) |
| ☐ | 3. Companies are isolated and have no contact to each other. |

42. Please indicate relation of your company to business/professional entities mentioned below.

| | Not aware | Aware | Cooperation | Membership |
|---|---|---|---|---|
| 42.1. Union of Information Technology Enterprises (UITE) | ☐ | ☐ | ☐ | ☐ |
| 42.2. Union of 3D Modeling Designers | ☐ | ☐ | ☐ | ☐ |
| 42.3. Union of Architects of Armenia | ☐ | ☐ | ☐ | ☐ |
| 42.4. Union of Manufacturers and Businessmen of Armenia (UMBA) | ☐ | ☐ | ☐ | ☐ |
| 42.5. RA Chamber of Commerce and Trade | ☐ | ☐ | ☐ | ☐ |
| 42.6. Other (please indicate)_____ | ☐ | ☐ | ☐ | ☐ |

43. Indicate level of usage of business support services by your company.

| | 1= no usage; 5= intensive | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 43.1. Financial services (banks and other financial institutions) | ☐ | ☐ | ☐ | ☐ | ☐ |
| 43.2. Contractual sales agents | ☐ | ☐ | ☐ | ☐ | ☐ |
| 43.3. Business consultancy (consultancy on investing and marketing) | ☐ | ☐ | ☐ | ☐ | ☐ |
| 43.4. Training services | ☐ | ☐ | ☐ | ☐ | ☐ |
| 43.5. Legal consultancy | ☐ | ☐ | ☐ | ☐ | ☐ |
| 43.6. Tax and accounting consultancy | ☐ | ☐ | ☐ | ☐ | ☐ |
| 43.7. Other (please indicate)_____ | ☐ | ☐ | ☐ | ☐ | ☐ |

44. Indicate orientation of your company strategy for coming 3 years (please check only one):

| | |
|---|---|
| ☐ | 1. Increase in sales in the domestic market and volume of offered services |
| ☐ | 2. Enter new markets with offered services |
| ☐ | 3. Expansion of products/services in the current market |
| ☐ | 4. Enter new markets with new products |
| ☐ | 5. Other (please indicate)_____ |

### *VI. Obstacles hindering the sector development and needed support*

45. What are the main obstacles hindering development of Armenian engineering services sector (classify by degree of importance, 5 indicates the highest degree of importance).

| | 1= not important; 5= very important | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 45.1. Limited domestic demand | ☐ | ☐ | ☐ | ☐ | ☐ |
| 45.2. Incompatibility of Armenian standards with international standards | ☐ | ☐ | ☐ | ☐ | ☐ |
| 45.3. Limited application of new technologies | ☐ | ☐ | ☐ | ☐ | ☐ |
| 45.4. Limited access to international markets | ☐ | ☐ | ☐ | ☐ | ☐ |
| 45.5. Absence of financial sources | ☐ | ☐ | ☐ | ☐ | ☐ |
| 45.6. Availability of human resources | ☐ | ☐ | ☐ | ☐ | ☐ |
| 45.7. Low-qualified graduates with technical education | ☐ | ☐ | ☐ | ☐ | ☐ |
| 45.8. Legal framework | ☐ | ☐ | ☐ | ☐ | ☐ |
| 45.9. Limited marketing capabilities | ☐ | ☐ | ☐ | ☐ | ☐ |
| 45.10. Absence of development agencies, entities, associations or limited activities of those | ☐ | ☐ | ☐ | ☐ | ☐ |
| 45.11. State support and absence of strategy for sector development | ☐ | ☐ | ☐ | ☐ | ☐ |
| 45.12. Export-import-regulations | ☐ | ☐ | ☐ | ☐ | ☐ |
| 45.13. Tax regime in the sector | ☐ | ☐ | ☐ | ☐ | ☐ |
| 45.14. Other (please indicate)_____ | ☐ | ☐ | ☐ | ☐ | ☐ |

46. Please indicate what kind of support would you receive for further development of your company (classify by degree of importance, 5 indicates the highest degree of importance).

| | 1= not important; 5= very important | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 46.1. Attraction of financial resources | ☐ | ☐ | ☐ | ☐ | ☐ |
| 46.2. Attraction and training of human resources | ☐ | ☐ | ☐ | ☐ | ☐ |
| 46.3. Support to export | ☐ | ☐ | ☐ | ☐ | ☐ |
| 46.4. Integration of system for business processes management | ☐ | ☐ | ☐ | ☐ | ☐ |
| 46.5. International certification | ☐ | ☐ | ☐ | ☐ | ☐ |
| 46.6. Marketing support, getting new orders | ☐ | ☐ | ☐ | ☐ | ☐ |
| 46.7. Other (please indicate)_____ | ☐ | ☐ | ☐ | ☐ | ☐ |

47. Please indicate what are the main specific activities and intervention you would receive from the state to satisfy development needs of the company/sector.

| |
|---|
| 47.1. |
| 47.2. |
| 47.3. |

48. Please describe below any additional information you would to mention.

| |
|---|
| 48.1. |
| 48.2. |
| 48.3. |

Please provide additional information – printed materials, booklets, if any, about products and services offered by your company.

Hope you will not mind if we will call you for any questions that might arise.

**THANK YOU FOR PARTICIPATIN IN THE SURVEY**

# ANNEX 4

## VALUE CHAIN ELEMENTS ACCORDING TO OUTSOURCING OPPORTUNITIES IN SHORT-TERM AND LONG-TERM PERSPECTIVES IN SELECTED SECTORS OF ENGINEERING SERVICES

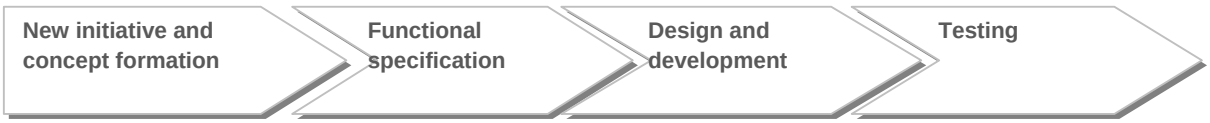
### Outsourcing of engineering services in the telecommunication sector

| Concept formation | Functional specification | Design and development | Testing |
|---|---|---|---|
| Study | Design specification | Computer system design | Coding and unit testing |
| Concept design | Preparation of specifications | Algorithm implementation through hardware/software packages | Functionality and compatibility test |
| Design assessment | | Modeling and development analysis | Application test |
| Feasibility study | | Components adaptation | Regulatory testing |
| Main design | | Program package integration | Product quality assurance |
| Architecture | | Sample design | Test automation |
| Modeling | | | |
| Algorithm assessment/implementation | | | |

Outsourcing opportunities for a short-term period

Outsourcing opportunities for a long-term period

## Outsourcing of engineering services in the industry automation sector




| | | | |
|---|---|---|---|
| Product concept design | Design specification | Modeling | System integration and network fit |
| Porting to new hardware | Preparation of specifications | Algorithm assessment/implementation | Field tests |
| Design assessment | | System design | Product quality assurance |
| Feasibility study | | Architectural design | Test systems development |
| Main design | | Design of system-on-chip/ASIC | Security systems check |
| Architecture | | Development of electronic hardware | Test automation |
| Modeling | | Real-time software | |
| Algorithm assessment/implementation | | HMI/GUI software development | |
| | | FDT-DTM design | |
| | | Client application software | |
| | | Sost application software development | |
| | | Simulation software development for optimization | |
| | | Mechanical design | |
| | | Product documentation and maintenance | |
| | | Modify for volume production | |

Outsourcing opportunities for a short-term period

Outsourcing opportunities for a long-term period

## Outsourcing of engineering services in the sector of semiconductors


| | | | | |
|---|---|---|---|---|
| Product concept design | Design specification | Functional design | Sample study | Testing |
| Porting to new hardware | Preparation of specifications | Logic synthesis | Sample modeling | Substrate testing |
| Design assessment | | Test synthesis | Sample testing | ATPG testing |
| Feasibility study | | Functional testing | Sample analysis | Productive test |
| Main design | | Pre-layout verification | | Functionality test |
| Architecture | | Post-layout verification | | Safety test |
| Modeling | | Development of parallel board/system | | Qualification |
| Algorithm assessment/implementation | | Substrate design | | Application test |
| | | Software package design and development | | Field testing |
| | | | | QA package |

Outsourcing opportunities for a short-term period

Outsourcing opportunities for a long-term period

## Outsourcing of engineering services in the sector of consumer electronics


| | | | |
|---|---|---|---|
| Study | Design specification | Analysis and modeling | Design check |
| Product concept design | Preparation of specifications | Computer design | Risk analysis |
| Design assessment | | Analog and digital circuit engineering | Design approval |
| Feasibility study | | Printed circuit design | Design and coding review |
| Main design | | Software system structure design | Software package testing |
| Modeling | | Embedded software development | Design for testability |
| Algorithm assessment/usage | | Concept exploration | Risk management |
| | | Product styling | Operational reliability assurance |
| | | Human factors engineering | Hazard analysis |
| | | Molded part design | |
| | | Mechanism design | |

Outsourcing opportunities for a short-term period

Outsourcing opportunities for a long-term period

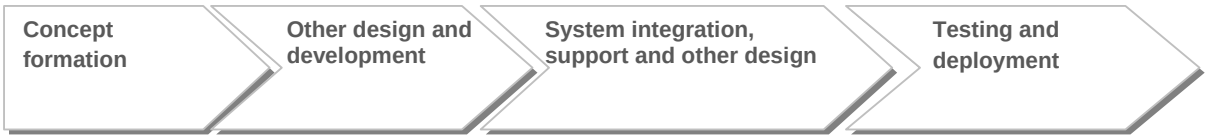
## Outsourcing of engineering services in the sector of medical devices


| | | | | |
|---|---|---|---|---|
| Study | Design specification | Analysis and modeling | FDA regulatory documents | Design check |
| Product concept design | Preparation of specifications | Software design | Design conformity with FDA, IEC and UL requirements | Risk analysis |
| Design assessment | | Analog and digital circuit engineering | FDA conformity with design requirements | Design approval |
| Feasibility study | | Printed circuit engineering | Electromagnetic compliant designs | Design and coding review |
| Main design | | Software package structure design | Regulatory conformity and certification | V&V testing |
| Modeling | | Embedded software development | | |
| Algorithm assessment/implementation | | Concept exploration | | Design for testability |
| System structure engineering | | Product styling | | Test fixtures |
| | | Human factors engineering | | Risk management |
| | | Molded part design | | Risk analysis |
| | | Mechanism design | | Clinical testing |
| | | | | Product data management 21 CFR according to part 11 |

Outsourcing opportunities for a short-term period

Outsourcing opportunities for a long-term period

## Outsourcing of engineering services in hardware sector




| | | | |
|---|---|---|---|
| Study | Computer-based design | System integration | Development/technical support testing |
| Product concept design | Mechanical engineering | System testing | System testing |
| Design assessment | Computer hardware development | Product support | Executive testing |
| Feasibility study | Mechanical engineering | Derivative product hardware design and development of | Hardware, mechanical devices |
| Main design | System software design | Derivative product mechanical design and development | System software sustenance |
| System structure design | System software development | | |

Outsourcing opportunities for a short-term period

Outsourcing opportunities for a long-term period

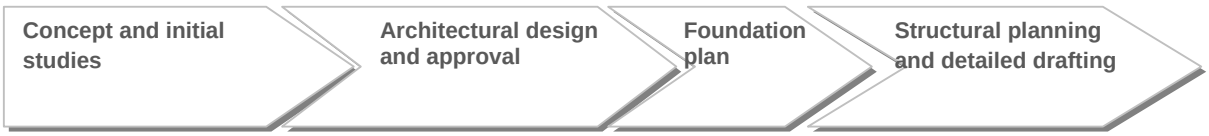
## Outsourcing of engineering services in infrastructures sector


| | | | | |
|---|---|---|---|---|
| Concept | Analysis | Structural layouts | Automation systems engineering | Field commissioning |
| Design Assessment | Design approval | Layouts for earthworks, lighting, cable networks | Optimizing solutions | Commissioning tools |
| Detailed formulation of design requirements | Design automation | Planning of air conditioning, fire fighting and other systems | Information integration | Commission facility |
| Drafting of functional specification and technical characteristics | Layout arrangements | | Panel building | System tuning |
| | Plans and isometric views | | S/w development | Plant operation |
| | Detailed layouts containing calculations | | BOM+ procurement | Support |
| | P&ID | | Processes control | Remote monitoring and diagnostics |
| | | | Processes optimization | Quality control/assurance |
| | | | Manufacturing execution systems | |
| | | | Plant-wide integration of information | |

Outsourcing opportunities for a short-term period

Outsourcing opportunities for a long-term period

## Outsourcing of engineering services in the sector of construction




| | | | |
|---|---|---|---|
| Geological investigations | Architectural specification | Foundation plans | Structural specification |
| Landscape design | Architectural plans | Foundation estimates | Structural plans |
| Analysis | Erection plan | Erection drawings | Structural calculations |
| Territory investigation | Initial design and quantitative evaluation | Shop drawings | Mechanical design (HVAC) |
| Landscape specification | | Piece details | Electrical design |
| Landscape planning | | Soil test | Mechanical specifications |
| | | Civil drawings | Mechanical plans |
| | | Precast calculations | Mechanical calculations |
| | | Connections design | Electrical specifications |
| | | Member designs | Electrical plans |
| | | Column design | Electrical calculations |
| | | Detailing | |
| | | Lateral analysis | |
| | | Glazing and façade calculations | |
| | | Formwork design | |

Outsourcing opportunities for a short-term period

Outsourcing opportunities for a long-term period

## ANNEX 5
## LONG-LIST OF GLOBAL COMPANIES AS POSSIBLE TARGETS FOR ARMENIAN HIGH TECHNLOGY INDUSTRY

### 1. Sector: Automobiles & parts

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 1 | Aisin Seiki | Japan | 915.33 | 21,432 | 73,509 |
| 2 | Mitsubishi Motors | Japan | 274.50 | 21,287 | 33,202 |
| 3 | Michelin | France | 499.00 | 16,408 | 120,067 |
| 4 | Toyota Industries | Japan | 291.67 | 15,878 | 39,528 |
| 5 | Delphi | USA | 1,366.92 | 14,664 | 146,600 |
| 6 | Goodyear | USA | 263.31 | 14,020 | 74,700 |
| 7 | Yamaha Motor | Japan | 675.33 | 12,729 | 49,761 |
| 8 | ZF | Germany | 670.00 | 12,501 | 61,156 |
| 9 | Fuji Heavy Industries | Japan | 412.87 | 12,479 | 26,404 |
| 10 | TRW Automotive | USA | 148.20 | 10,788 | 65,200 |
| 11 | Tata Motors | India | 218.05 | 10,476 | 23,638 |
| 12 | Toyota Boshoku | Japan | 251.73 | 9,792 | 26,942 |
| 13 | Lear | USA | 81.30 | 9,763 | 80,000 |
| 14 | Valeo | France | 786.00 | 8,664 | 51,200 |
| 15 | Hyundai Mobis | South Korea | 69.30 | 7,910 | N/A |
| 16 | Porsche Automobile | Germany | 899.64 | 7,466 | 12,011 |
| 17 | Dongfeng Motor | Hong Kong | 152.90 | 7,441 | 92,783 |
| 18 | Visteon | USA | 312.23 | 6,866 | 33,500 |
| 19 | Calsonic Kansei | Japan | 221.70 | 6,615 | 14,881 |
| 20 | Dana | USA | 151.47 | 5,764 | 29,000 |
| 21 | ArvinMeritor | USA | 97.84 | 5,161 | 19,800 |
| 22 | MAHLE | Germany | 285.89 | 5,014 | 48,847 |
| 23 | Federal-Mogul | USA | 124.68 | 4,939 | 43,400 |
| 24 | Pirelli | Italy | 156.00 | 4,894 | 31,500 |
| 25 | Sumitomo Rubber Industries | Japan | 153.58 | 4,801 | 20,369 |
| 26 | Toyoda Gosei | Japan | 193.04 | 4,710 | 23,925 |
| 27 | Autoliv | USA | 264.18 | 4,657 | 34,000 |
| 28 | GKN | UK | 100.34 | 4,527 | 38,147 |
| 29 | Yokohama Rubber | Japan | 121.34 | 4,377 | 16,099 |
| 30 | Tenneco | USA | 51.80 | 4,256 | 21,000 |
| 31 | Nok | Japan | 72.61 | 4,177 | 33,588 |
| 32 | Takata | Japan | 179.71 | 4,094 | 34,994 |
| 33 | Harley-Davidson | USA | 117.63 | 4,025 | 9,300 |
| 34 | Hella | Germany | 356.68 | 3,940 | 24,736 |
| 35 | Rheinmetall | Germany | 199.00 | 3,869 | 19,910 |
| 36 | BorgWarner | USA | 147.99 | 3,787 | 13,800 |
| 37 | Koito Manufacturing | Japan | 165.08 | 3,735 | 15,315 |
| 38 | Tokai Rika | Japan | 145.43 | 3,492 | 14,776 |

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 39 | Behr | Germany | 241.00 | 3,383 | 19,448 |
| 40 | Tognum | Germany | 144.00 | 3,133 | 8,681 |
| 41 | Toyo Tire | Japan | 76.34 | 2,835 | 7,248 |
| 42 | Burelle | France | 112.16 | 2,745 | 13,106 |
| 43 | NGK Spark Plug | Japan | 138.46 | 2,743 | 11,599 |
| 44 | ZF Lenksysteme | Germany | 117.70 | 2,594 | 10,610 |
| 45 | Hankook Tire | South Korea | 54.14 | 2,548 | N/A |
| 46 | Showa | Japan | 56.48 | 2,249 | 10,921 |
| 47 | Eberspaecher | Germany | 82.60 | 2,240 | 5,575 |
| 48 | Sanden | Japan | 54.49 | 2,093 | 8,494 |
| 49 | Wabco | USA | 66.84 | 1,862 | 7,200 |
| 50 | Ssangyong Motor | South Korea | 73.04 | 1,782 | |
| 51 | IMMSI | Italy | 74.22 | 1,737 | 7,810 |
| 52 | Nissin Kogyo | Japan | 58.04 | 1,607 | 7,415 |
| 53 | American Axle & Manufacturing | USA | 61.15 | 1,517 | 7,250 |
| 54 | Modine Manufacturing | USA | 58.00 | 1,138 | 6,953 |

## 2. Sector: Aerospace & defence

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 1 | Dassault Aviation | France | 272.73 | 3,748 | 12,391 |
| 2 | Rockwell Collins | USA | 284.18 | 3,431 | 20,300 |
| 3 | MTU Aero Engines | Germany | 138.20 | 2,724 | 7,263 |
| 4 | SAAB | Sweden | 130.92 | 2,165 | 13,199 |
| 5 | Zodiac | France | 134.65 | 2,014 | 17,824 |
| 6 | Elbit Systems | Israel | 133.08 | 1,898 | 10,876 |
| 7 | BE Aerospace | USA | 94.53 | 1,518 | 6,485 |
| 8 | Moog | USA | 78.85 | 1,369 | 8,844 |
| 9 | Japan Aviation Electronics Industry | Japan | 67.39 | 1,239 | 5,672 |
| 10 | Meggitt | UK | 61.44 | 1,203 | 8,211 |
| 11 | Esterline Technologies | USA | 62.45 | 1,067 | 9,699 |
| 12 | Ruag | Switzerland | 83.41 | 1,039 | 6,310 |
| 13 | FLIR Systems | USA | 64.72 | 775 | 1,943 |
| 14 | Industria de Turbo Propulsores | Spain | 50.00 | 483 | 2,774 |

## 3. Sector: Commercial vehicles & trucks

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 1 | Paccar | USA | 245.90 | 10,772 | 18,700 |
| 2 | Navistar International | USA | 273.38 | 10,593 | 17,800 |
| 3 | Cummins | USA | 303.60 | 10,318 | 39,800 |
| 4 | Liebherr | Switzerland | 330.00 | 7,491 | 29,660 |
| 5 | Terex | USA | 51.22 | 7,115 | 20,000 |
| 6 | AGCO | USA | 139.93 | 6,061 | 15,600 |
| 7 | Oshkosh | USA | 66.19 | 5,136 | 14,000 |
| 8 | Wartsila | Finland | 121.00 | 4,612 | 17,623 |
| 9 | China South Locomotive | China | 105.99 | 3,700 | |
| 10 | Claas | Germany | 113.78 | 3,236 | 8,749 |

| | | | | | |
|---|---|---|---|---|---|
| 11 | Bucher Industries | Switzerland | 52.79 | 1,885 | 8,176 |

## 4. Sector: Computer hardware

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 1 | Lexmark | USA | 304.54 | 3,258 | 14,000 |
| 2 | NetApp | USA | 358.63 | 2,451 | 7,976 |
| 3 | Xyratex | Bermuda | 62.83 | 755 | 1,880 |
| 4 | VeriFone | USA | 57.64 | 663 | 2,362 |
| 5 | Quantum | USA | 50.75 | 582 | 1,870 |
| 6 | Palm | USA | 127.49 | 529 | 939 |
| 7 | Avocent | USA | 69.59 | 473 | 1,971 |
| 8 | Electronics For Imaging | USA | 101.04 | 403 | 2,021 |
| 9 | Emulex | USA | 92.97 | 351 | 853 |

## 5. Sector: Computer services

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 1 | Fujitsu Siemens Computers | Netherlands | 134.10 | 6,614 | 10,643 |
| 2 | SunGard Data Systems | USA | 233.82 | 4,026 | 20,000 |
| 3 | Unisys | USA | 92.81 | 3,765 | 28,000 |
| 4 | Indra Sistemas | Spain | 166.34 | 2,380 | 24,430 |
| 5 | Wincor Nixdorf | Germany | 104.53 | 2,319 | 8,989 |
| 6 | TietoEnator (now Tieto) | Finland | 57.90 | 1,866 | 16,397 |
| 7 | DST Systems | USA | 111.58 | 1,644 | 10,900 |
| 8 | Teradata | USA | 115.11 | 1,268 | 6,400 |
| 9 | Sopra | France | 50.10 | 1,129 | 12,080 |
| 10 | Gsi Commerce | USA | 74.81 | 696 | 4,470 |
| 11 | Prithvi Information Solutions | India | 117.35 | 166 | 2,751 |
| 12 | Kpit Cummins Infosystems | India | 65.97 | 117 | 4,576 |

## 6. Sector: Electrical components & equipment

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 1 | Tyco Electronics | Bermuda | 381.30 | 10,672 | 96,000 |
| 2 | Kyocera | Japan | 488.94 | 10,242 | 66,496 |
| 3 | Fuji Electric | Japan | 248.10 | 7,319 | 25,634 |
| 4 | Chi Mei Optoelectronic | Taiwan | 152.11 | 6,974 | 37,623 |
| 5 | Nexans | France | 63.00 | 6,799 | 23,480 |
| 6 | Nidec | Japan | 238.89 | 5,890 | 96,897 |
| 7 | Alps Electric | Japan | 335.37 | 5,497 | 41,224 |
| 8 | Fujikura | Japan | 111.03 | 5,234 | 49,448 |
| 9 | Cooper Industries | USA | 102.02 | 4,692 | 31,202 |
| 10 | Legrand | France | 182.90 | 4,202 | 34,830 |
| 11 | Tatung | Taiwan | 128.91 | 4,105 | |

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 12 | Ibiden | Japan | 85.61 | 3,282 | 12,695 |
| 13 | Elpida Memory | Japan | 237.65 | 3,218 | 3,477 |
| 14 | Energizer | USA | 65.97 | 3,116 | 16,410 |
| 15 | Leoni | Germany | 87.02 | 2,912 | 52,444 |
| 16 | CommScope | USA | 96.96 | 2,890 | 15,000 |
| 17 | Techtronic Industries | Hong Kong | 83.20 | 2,471 | 19,354 |
| 18 | Samsung Electro-Mechanics | South Korea | 165.19 | 1,537 | |
| 19 | Spectris | UK | 58.96 | 814 | 5,717 |
| 20 | TPO Displays | Taiwan | 69.51 | 730 | |
| 21 | Powerwave Technologies | USA | 55.87 | 640 | 2,346 |

## 7. Sector: Electronic equipment

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 1 | Pioneer | Japan | 471.40 | 6,147 | 42,775 |
| 2 | Omron | Japan | 408.90 | 6,056 | 35,426 |
| 3 | Agilent Technologies | USA | 506.48 | 4,154 | 19,600 |
| 4 | Rockwell Automation | USA | 137.63 | 4,099 | 21,000 |
| 5 | Hoya | Japan | 138.20 | 3,823 | 35,545 |
| 6 | Fanuc | Japan | 148.65 | 3,718 | 4,894 |
| 7 | Yokogawa Electric | Japan | 324.42 | 3,472 | 20,266 |
| 8 | HTC | Taiwan | 205.01 | 3,340 | 9,353 |
| 9 | Delta Electronics | Taiwan | 141.33 | 3,100 | |
| 10 | Yaskawa Electric | Japan | 77.30 | 3,034 | 8,347 |
| 11 | Agfa-Gevaert | Belgium | 179.00 | 3,032 | 12,486 |
| 12 | BYD | China | 106.31 | 2,825 | 130,000 |
| 13 | Citizen | Japan | 85.72 | 2,672 | 22,127 |
| 14 | Chunghwa Picture Tubes | Taiwan | 95.42 | 2,597 | |
| 15 | Molex | USA | 117.99 | 2,395 | 32,160 |
| 16 | Shimadzu | Japan | 69.80 | 2,301 | |
| 17 | Funai Electric | Japan | 117.38 | 2,200 | 2,628 |
| 18 | Yamatake | Japan | 78.13 | 1,973 | 8,315 |
| 19 | Ulvac | Japan | 68.14 | 1,914 | 6,872 |
| 20 | TomTom | Netherlands | 143.35 | 1,674 | 2,703 |
| 21 | Roper Industries | USA | 62.88 | 1,659 | 7,900 |
| 22 | Gemalto | Netherlands | 98.36 | 1,659 | 10,000 |
| 23 | Keyence | Japan | 64.90 | 1,593 | 2,925 |
| 24 | Hitachi KokUSAi Electric | Japan | 141.42 | 1,571 | 4,895 |
| 25 | EPCOS | Germany | 77.65 | 1,478 | 21,195 |
| 26 | MiTAC International | Taiwan | 55.56 | 1,412 | |
| 27 | PerkinElmer | USA | 77.74 | 1,394 | 7,900 |
| 28 | Itron | USA | 86.84 | 1,374 | 8,700 |
| 29 | Endress & Hauser | Switzerland | 88.79 | 1,211 | 8,434 |
| 30 | HORIBA | Japan | 84.62 | 1,065 | 5,146 |
| 31 | Japan Radio | Japan | 66.91 | 1,046 | 3,751 |
| 32 | Trimble Navigation | USA | 106.67 | 956 | 3,940 |
| 33 | Anritsu | Japan | 112.03 | 798 | 3,963 |

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 34 | Hamamatsu Photonics | Japan | 80.64 | 784 | 3,762 |
| 35 | Barco | Belgium | 77.96 | 778 | 3,644 |
| 36 | JEOL | Japan | 51.48 | 745 | 3,047 |
| 37 | Sick | Germany | 72.09 | 737 | 5,031 |
| 38 | Ingenico | France | 67.55 | 728 | 2,507 |
| 39 | Zebra Technologies | USA | 61.24 | 703 | 3,200 |
| 40 | Kudelski | Switzerland | 149.75 | 695 | 2,651 |
| 41 | National Instruments | USA | 109.81 | 590 | 5,157 |
| 42 | Novatek Microelectronics | Taiwan | 62.55 | 574 | |
| 43 | Coherent | USA | 53.44 | 431 | 2,149 |
| 44 | Orbotech | Israel | 55.11 | 309 | 1,693 |

## 8. Sector: General industrials

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 1 | Israel | Israel | 64.03 | 14,246 | |
| 2 | Kawasaki Heavy Industries | Japan | 287.53 | 11,914 | 30,563 |
| 3 | Eaton | USA | 300.00 | 11,062 | 75,000 |
| 4 | Furukawa Electric | Japan | 157.06 | 9,320 | 37,669 |
| 5 | Kubota | Japan | 196.70 | 9,163 | 24,464 |
| 6 | ITT | USA | 175.76 | 8,419 | 40,800 |
| 7 | Benteler | Germany | 123.30 | 6,327 | 24,281 |
| 8 | Dover | USA | 136.12 | 5,506 | 32,300 |
| 9 | Hyosung | South Korea | 56.83 | 5,484 | |
| 10 | Freudenberg | Germany | 160.50 | 5,050 | 33,569 |
| 11 | Voith | Germany | 267.02 | 4,934 | 41,384 |
| 12 | Tomkins | UK | 66.69 | 3,968 | 32,424 |
| 13 | Sealed Air | USA | 61.58 | 3,485 | 17,000 |
| 14 | OC Oerlikon | Switzerland | 229.15 | 3,353 | 19,142 |
| 15 | NGK Insulators | Japan | 96.56 | 2,896 | 11,551 |
| 16 | Trelleborg | Sweden | 55.13 | 2,844 | 24,347 |
| 17 | Smiths | UK | 74.99 | 2,401 | 22,600 |
| 18 | Diehl Stiftung | Germany | 157.50 | 2,217 | 10,982 |
| 19 | Trumpf | Germany | 150.60 | 2,144 | 7,716 |
| 20 | Korber | Germany | 91.00 | 1,749 | 9,227 |
| 21 | Meidensha | Japan | 51.83 | 1,615 | 6,825 |

## 9. Sector: Health care equipment & services

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 1 | Smith & Nephew | UK | 109.35 | 2,735 | 9,757 |
| 2 | Carl Zeiss | Germany | 321.00 | 2,731 | 13,041 |
| 3 | Terumo | Japan | 125.03 | 2,432 | 12,322 |

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 4 | Synthes | Switzerland | 122.20 | 2,297 | 9,509 |
| 5 | Beckman Coulter | USA | 201.51 | 2,229 | 11,000 |
| 6 | Dragerwerk | Germany | 135.08 | 1,925 | 10,720 |
| 7 | CR Bard | USA | 143.24 | 1,764 | 11,000 |
| 8 | Getinge | Sweden | 81.34 | 1,753 | 11,623 |
| 9 | Biomet | USA | 59.14 | 1,536 | 7,220 |
| 10 | Varian Medical Systems | USA | 97.55 | 1,489 | 4,900 |
| 11 | Kinetic Concepts | USA | 54.56 | 1,351 | 6,900 |
| 12 | Bio-Rad Laboratories | USA | 114.76 | 1,269 | 6,600 |
| 13 | Hologic | USA | 58.58 | 1,205 | 3,933 |
| 14 | Inverness Medical Innovations | USA | 80.45 | 1,202 | 8,300 |
| 15 | Millipore | USA | 73.82 | 1,153 | 5,900 |
| 16 | Coloplast | Denmark | 51.86 | 1,137 | 7,420 |
| 17 | Waters | USA | 58.70 | 1,133 | 5,000 |
| 18 | BioMerieux | France | 132.70 | 1,111 | 5,863 |
| 19 | Edwards Lifesciences | USA | 100.15 | 890 | 6,200 |
| 20 | Topcon | Japan | 80.78 | 880 | 3,172 |
| 21 | Sysmex | Japan | 73.18 | 879 | 3,916 |
| 22 | Advanced Medical Optics (now Abbott Medical Optics) (now part of Abbott Laboratories) | USA | 54.63 | 853 | 3,711 |
| 23 | Sonova | Switzerland | 52.30 | 844 | 5,108 |
| 24 | Bruker | USA | 94.17 | 796 | 4,400 |
| 25 | Sorin | Italy | 62.16 | 757 | 4,162 |
| 26 | IDEXX Laboratories | USA | 50.84 | 737 | 4,700 |
| 27 | Varian | USA | 51.66 | 728 | 3,900 |
| 28 | William Demant | Denmark | 66.91 | 722 | 5,383 |
| 29 | Intuitive Surgical | USA | 57.10 | 629 | 1,049 |

## 10. Sector: Household goods & home construction

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 1 | Electrolux | Sweden | 190.33 | 9,534 | 55,177 |
| 2 | BSH Bosch und Siemens Hausgerate | Germany | 262.00 | 8,758 | 40,708 |
| 3 | Sekisui Chemical | Japan | 204.28 | 7,609 | 18,907 |
| 4 | Reckitt Benckiser | UK | 108.61 | 6,789 | 24,300 |
| 5 | Newell Rubbermaid | USA | 85.97 | 4,655 | 20,400 |
| 6 | Black & Decker | USA | 105.04 | 4,379 | 22,100 |
| 7 | Clorox | USA | 79.86 | 3,794 | 8,300 |
| 8 | Rinnai | Japan | 51.96 | 1,864 | 3,199 |
| 9 | Fagor Electrodomesticos | Spain | 56.00 | 1,603 | 9,861 |
| 10 | Dyson James | UK | 54.15 | 632 | 2,203 |

## 11. Sector: Industrial machinery

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 1 | NHK Spring | Japan | 70.39 | 3,848 | 17,324 |
| 2 | Danfoss | Denmark | 159.35 | 3,645 | 27,386 |

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 3 | Andritz | Austria | 51.24 | 3,610 | 13,707 |
| 4 | Knorr-Bremse | Germany | 171.34 | 3,384 | 14,765 |
| 5 | Georg Fischer | Switzerland | 96.66 | 3,018 | 14,326 |
| 6 | Heidelberger Druckmaschinen | Germany | 186.00 | 2,999 | 19,519 |
| 7 | Husqvarna | Sweden | 52.40 | 2,942 | 15,720 |
| 8 | Dongfang Electric | China | 51.95 | 2,865 | 18,469 |
| 9 | Bharat Heavy Electricals | India | 68.48 | 2,851 | 43,636 |
| 10 | SMC | Japan | 132.11 | 2,841 | 14,756 |
| 11 | Minebea | Japan | 78.97 | 2,654 | 50,549 |
| 12 | Grundfos | Denmark | 149.12 | 2,555 | 17,482 |
| 13 | Alfa Laval | Sweden | 59.50 | 2,534 | 11,821 |
| 14 | Doosan Infracore | South Korea | 53.59 | 2,445 | |
| 15 | Krones | Germany | 116.38 | 2,381 | 9,834 |
| 16 | Amada | Japan | 54.89 | 2,256 | 5,747 |
| 17 | Rieter | Switzerland | 82.67 | 2,124 | 14,183 |
| 18 | Crane | USA | 99.21 | 1,874 | 12,000 |
| 19 | Pall | USA | 51.55 | 1,850 | 10,600 |
| 20 | Daifuku | Japan | 55.27 | 1,838 | 5,663 |
| 21 | Koenig & Bauer | Germany | 54.20 | 1,532 | 8,052 |
| 22 | Sauer-Danfoss | USA | 59.65 | 1,504 | 9,600 |
| 23 | DEUTZ | Germany | 73.40 | 1,495 | 4,862 |
| 24 | Glory | Japan | 76.32 | 1,470 | 5,346 |
| 25 | Mettler-Toledo International | Switzerland | 73.59 | 1,420 | 10,000 |
| 26 | Hexagon | Sweden | 141.65 | 1,317 | 9,062 |
| 27 | Buhler | Switzerland | 55.63 | 1,280 | 7,660 |
| 28 | Bobst | Switzerland | 65.30 | 1,104 | 5,939 |
| 29 | Juki | Japan | 62.44 | 1,035 | 7,264 |
| 30 | Woodward Governor | USA | 52.82 | 905 | 5,823 |
| 31 | STX Engine | South Korea | 59.06 | 861 | |

## 12. Sector: Leisure goods

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 1 | Olympus | Japan | 523.25 | 8,959 | 35,772 |
| 2 | Nikon | Japan | 463.29 | 7,586 | 25,342 |
| 3 | Eastman Kodak | USA | 360.44 | 6,774 | 24,400 |
| 4 | Casio Computer | Japan | 117.07 | 4,945 | 13,202 |
| 5 | Yamaha | Japan | 197.35 | 4,355 | 26,517 |
| 6 | Mattel | USA | 136.84 | 4,258 | 29,000 |
| 7 | Namco Bandai | Japan | 139.55 | 3,655 | |
| 8 | Brunswick | USA | 87.92 | 3,388 | 19,760 |
| 9 | Electronic Arts | USA | 977.71 | 3,030 | 9,100 |
| 10 | Harman International Industries | USA | 284.82 | 2,959 | 11,694 |
| 11 | Activision Blizzard | USA | 567.87 | 2,903 | 7,000 |
| 12 | Hasbro | USA | 137.72 | 2,893 | 5,900 |
| 13 | Garmin | Cayman Islands | 148.28 | 2,514 | 8,919 |
| 14 | Inventec Appliances | Taiwan | 52.34 | 2,031 | 18,566 |
| 15 | Samsung Techwin | South Korea | 66.25 | 1,960 | |
| 16 | Shimano | Japan | 74.24 | 1,866 | 9,610 |
| 17 | Amer Sports | Finland | 54.00 | 1,577 | 6,285 |
| 18 | Polaris Industries | USA | 55.74 | 1,402 | 3,300 |

| | | | | | |
|---|---|---|---|---|---|
| 19 | Roland | Japan | 53.50 | 862 | 2,528 |
| 20 | THQ | USA | 78.56 | 597 | 2,000 |
| 21 | Bang & Olufsen | Denmark | 71.20 | 550 | 2,541 |
| 22 | Midway Games | USA | 68.62 | 158 | 540 |
| 23 | SCI Entertainment (now Eidos) | UK | 74.68 | 138 | 1,080 |

## 13. Sector: Semiconductors

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 1 | Analog Devices | USA | 392.90 | 1,941 | 9,000 |
| 2 | LSI | USA | 483.83 | 1,926 | 5,488 |
| 3 | Taiyo Yuden | Japan | 70.54 | 1,891 | 20,117 |
| 4 | Kla-Tencor | USA | 294.95 | 1,814 | 6,000 |
| 5 | Lam Research | USA | 232.92 | 1,781 | 3,800 |
| 6 | Spansion | USA | 310.66 | 1,642 | 8,700 |
| 7 | ON Semiconductor | USA | 168.28 | 1,478 | 14,172 |
| 8 | Maxim Integrated Products | USA | 415.65 | 1,477 | 9,810 |
| 9 | Sanken Electric | Japan | 108.51 | 1,463 | 10,379 |
| 10 | Advantest | Japan | 242.12 | 1,451 | 3,666 |
| 11 | Xilinx | USA | 255.68 | 1,313 | 3,145 |
| 12 | Cypress Semiconductor | USA | 139.23 | 1,297 | 4,100 |
| 13 | Avago Technologies | Singapore | 190.65 | 1,225 | 3,600 |
| 14 | Powerchip Semiconductor | Taiwan | 72.05 | 1,198 | |
| 15 | Chartered Semiconductor | Singapore | 127.96 | 1,195 | 6,004 |
| 16 | Fairchild Semiconductor | USA | 81.22 | 1,133 | 9,771 |
| 17 | Atmel | USA | 187.28 | 1,127 | 6,400 |
| 18 | National Semiconductor | USA | 220.15 | 1,051 | 5,800 |
| 19 | Altera | USA | 185.41 | 984 | 2,760 |
| 20 | Semiconductor Manufacturing | China | 73.56 | 974 | 10,598 |
| 21 | Linear Technology | USA | 141.79 | 845 | 4,173 |
| 22 | Nanya Technology | Taiwan | 140.23 | 807 | |
| 23 | Teradyne | USA | 155.73 | 796 | 3,800 |
| 24 | ASM International | Netherlands | 75.01 | 747 | 12,022 |
| 25 | Tokyo Seimitsu | Japan | 60.79 | 729 | 1,318 |
| 26 | Novellus Systems | USA | 158.03 | 727 | 3,048 |
| 27 | Disco | Japan | 66.13 | 727 | 2,260 |
| 28 | International Rectifier | USA | 76.13 | 709 | 5,100 |
| 29 | ProMOS Technologies | Taiwan | 66.87 | 675 | 6,800 |
| 30 | Microchip Technology | USA | 83.11 | 650 | 4,895 |
| 31 | RF Micro Devices | USA | 122.86 | 638 | 4,095 |
| 32 | Skyworks Solutions | USA | 105.05 | 619 | 3,300 |
| 33 | Varian Semiconductor Equipment | USA | 80.03 | 600 | 1,545 |
| 34 | Himax Technologies | Cayman Islands | 63.00 | 599 | 1,214 |
| 35 | Winbond Electronics | Taiwan | 78.29 | 562 | |
| 36 | Intersil | USA | 103.30 | 554 | 1,531 |
| 37 | Macronix International | Taiwan | 70.76 | 537 | |
| 38 | CSR | UK | 109.89 | 500 | 1,049 |
| 39 | Verigy | Singapore | 74.10 | 497 | 1,650 |
| 40 | Integrated Device Technology | USA | 115.97 | 477 | 2,112 |
| 41 | MKS Instruments | USA | 56.50 | 465 | 2,631 |
| 42 | QLogic | USA | 95.87 | 456 | 1,031 |
| 43 | FEI | USA | 50.63 | 431 | 1,830 |

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 44 | TriQuint Semiconductor | USA | 65.81 | 413 | 2,297 |
| 45 | Micronas Semiconductor | Switzerland | 82.83 | 404 | 1,880 |
| 46 | PMC-Sierra | USA | 113.41 | 378 | 1,064 |
| 47 | Infinera | USA | 57.86 | 374 | 937 |
| 48 | Realtek Semiconductor | Taiwan | 130.12 | 368 | |
| 49 | OmniVision Technologies | USA | 61.07 | 365 | 1,328 |
| 50 | Conexant Systems | USA | 90.05 | 362 | 1,279 |
| 51 | Sunplus Technology | Taiwan | 101.61 | 355 | |
| 52 | Atheros Communications | USA | 87.46 | 340 | 1,079 |
| 53 | Credence Systems (now part of LTX-Credence) | USA | 55.51 | 332 | 1,324 |
| 54 | Cymer | USA | 69.40 | 330 | 994 |
| 55 | Zoran | USA | 80.98 | 316 | 1,411 |
| 56 | ARM | UK | 79.37 | 309 | 1,711 |
| 57 | Silicon Laboratories | USA | 72.81 | 299 | 727 |
| 58 | Standard Microsystems | USA | 53.36 | 234 | 946 |
| 59 | DSP | USA | 53.13 | 220 | 446 |
| 60 | Silicon Image | USA | 61.02 | 197 | 610 |
| 61 | Interdigital | USA | 72.85 | 164 | 379 |
| 62 | Applied Micro Circuits | USA | 60.93 | 154 | 551 |
| 63 | Rambus | USA | 54.84 | 103 | 330 |

## 14. Sector: Telecommunications equipment

| # | Company | Country | R&D investment, in million euro, 2008 | Sales in million euro, 2008 | Number of employees |
|---|---|---|---|---|---|
| 1 | ZTE | China | 450.52 | 4,671 | 61,350 |
| 2 | Corning | USA | 451.08 | 4,279 | 27,000 |
| 3 | Harris | USA | 197.84 | 3,821 | 16,500 |
| 4 | Juniper Networks | USA | 526.01 | 2,570 | 7,014 |
| 5 | Tellabs | USA | 219.57 | 1,244 | 3,228 |
| 6 | UTStarcom | USA | 103.23 | 1,180 | 4,400 |
| 7 | JDS Uniphase | USA | 135.33 | 1,101 | 7,100 |
| 8 | ADC Telecommunications | USA | 60.07 | 1,075 | 10,600 |
| 9 | Brocade Communications | USA | 183.87 | 1,055 | 2,834 |
| 10 | 3Com | USA | 129.48 | 947 | 5,868 |
| 11 | Arris | USA | 80.97 | 823 | 1,838 |
| 12 | Pace | UK | 61.63 | 771 | 762 |
| 13 | Polycom | USA | 97.33 | 769 | 2,648 |
| 14 | GN Store Nord | Denmark | 71.35 | 756 | 4,786 |
| 15 | Ciena | USA | 125.92 | 649 | 2,203 |
| 16 | Plantronics | USA | 51.84 | 551 | 3,600 |
| 17 | Aastra Technologies | Canada | 57.10 | 485 | 2,200 |
| 18 | Italtel | Italy | 93.93 | 468 | 2,319 |
| 19 | F5 Networks | USA | 75.61 | 468 | 1,694 |
| 20 | Foundry Networks (now part of Brocade Communications) | USA | 55.43 | 437 | 981 |
| 21 | Finisar | USA | 66.23 | 389 | 5,004 |
| 22 | ADTRAN | USA | 58.86 | 360 | 1,644 |
| 23 | Tekelec | USA | 72.38 | 331 | 1,085 |
| 24 | Sonus Networks | USA | 51.96 | 226 | 991 |
| 25 | Sirf Technology (now part of CSR, UK) | USA | 78.21 | 167 | 571 |

| | | | | | |
|---|---|---|---|---|---|
| **26** | Airvana | USA | 53.83 | 99 | 555 |
| **27** | Nextwave Wireless | USA | 103.81 | 90 | 688 |