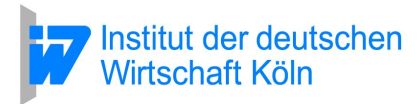




In cooperation with



European Engineering Report

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Preface

The European Community is developing an economic renewal strategy, which replaces the Lisbon Agenda. The “Europe 2020 strategy” aims at turning Europe into a smart, sustainable and inclusive economy. Whether these objectives can be achieved will not least depend on the ability of the European countries to ensure that there is a sufficient number of well-qualified engineers to tackle important challenges.

The new Europe 2020 strategy, as proposed by the Commission, focuses on three priorities: One is to create smart growth, generated by an economy that is based on knowledge and innovation. Another key priority is to make economic growth sustainable by fostering a resource efficient, greener and more competitive economy. The third key priority is inclusive growth created by a high-employment economy delivering social and territorial cohesion.

Engineers’ contribution to technological innovation applied in the market place is indispensable for achieving higher economic growth as well as for creating new jobs, securing clean energy supply, sustaining natural resources and tackling the challenges associated with climate change. Thus, they will play an important role in putting into practice all three priorities set out in the Europe 2020 Strategy.

Ensuring the availability of a sufficient number of well-qualified engineers across all countries must be a policy priority for the years to come. One of the challenges associated with the design and implementation of adequate EU-wide policies, is to correctly assess the starting point, i.e. the present labour market situation for engineers and their level of qualification.

The European Engineering Report commissioned by VDI (The Association of German Engineers) and developed by the Cologne Institute for Economic Research IW Köln, aims at providing a comprehensive overview of the most important indicators with respect to the European labour market for engineers and their education. The data allow a comparison across 31 European countries and relevant conditions that engineers face there.

The objective of the study is to contribute to a better informed policy discussion aimed at promoting qualified engineers who are crucial for technological, social and economic development as well as the success of the Europe 2020 strategy.



Dr.-Ing. Willi Fuchs
Managing Director
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Key Findings

Engineers play an important role in the innovative performance and the competitiveness of European countries. The aim of this report is therefore to provide a comprehensive overview of the most important indicators with respect to the European labour market for engineers and to their education. The report covers the 27 European Union member states, the EU applicants Croatia and Iceland as well as Norway and Switzerland. Generally, the indicators show a great heterogeneity between the countries. The extent to which engineers are appreciated appears to differ widely across Europe. The main findings of this report are as follows:

- The **number of employed engineering workers**, that is persons working in the engineering profession regardless of their degree, ranges from more than 1.2 million in Germany to only 1,700 in Malta.
- Finland and Germany, at more than 3 per cent, have the highest **shares of employed engineering workers among all employees**. In contrast, in countries like the Slovak Republic and Austria the proportion is less than half of the average.
- **Female engineering workers** are most common in Eastern European countries like Latvia and Bulgaria, where they account for around 30 per cent of the total. At about 9 per cent, the share of female engineering workers is lowest in the UK. On average, every 6th engineer in Europe is female.
- The Netherlands and Switzerland have the highest proportions of **engineering workers employed part-time** at around 23 and 15 per cent respectively. Less than 5 per cent of the employed engineering workers in the Czech Republic, Poland and Spain work part-time.
- The **average weekly working hours** of engineering workers vary between 37 hours 6 minutes and 45 hours 18 minutes. Engineering workers in Austria, Iceland and France work the longest, whereas their counterparts in the Netherlands, Norway and Finland work the shortest hours.
- Due to the fact that they have a large share of engineering workers below the age of 35, Ireland and Spain are not likely to encounter replacement problems when their older engineering workers leave the workforce. The **age structure of employed engineering workers** in Germany, Bulgaria and Norway, however, indicates that these countries will face such problems.
- In Europe, engineering workers do not necessarily hold an engineering degree. Nor do all **graduate engineers**, that is people holding an engineering degree, work in the engineering profession. On average, at least 28 per cent of graduate engineers work in a profession other than engineering, indicating their great labour market flexibility.
- The **number of graduations in engineering** varies between more than 55,000 a year in France and less than 50 in Cyprus.
- At 20 per cent, Finland has the highest **share of graduations in engineering** among all graduations. At only about 4 per cent, Cyprus has the lowest share. On average, the proportion of graduations in engineering is about 12 per cent.
- In view of their **PISA score in science** and the proportion reaching the highest **PISA level in science**, Finnish 15-year-olds seem to be exceptionally well prepared for further education and a career in engineering. This is in contrast to Romanian teenagers, who lag far behind, with the consequence that Romania will most likely face a dearth of young engineers in the future.

1 Introduction

Engineers are particularly important for the economies of the countries of Europe. They develop innovations that contribute to economic growth in two ways: On the one hand, innovations are responsible for technical progress, which is a precondition of economic growth and prosperity. On the other hand, innovations improve a country's competitiveness in the global market, which also fosters growth. Despite their prominent role in innovation and progress, the labour market for engineers in Europe is far from homogeneous. This heterogeneity creates different conditions for engineers in the respective labour markets that show the importance of engineers for the industry and the economy of a country as a whole. The aim of this report is therefore to provide a comprehensive overview of the most important indicators with respect to the European labour market for engineers and their education. The data allow a comparison of the European countries and the conditions that engineers face there.

For the purposes of this report an engineering worker is defined as a person working in the engineering profession based on the International Standard Classification of Occupations (ISCO-88).¹ Table 1 lists the different areas of engineering included in this definition. According to the definition, an engineering worker does not necessarily have a degree in engineering. This issue is dealt with and explained in more detail in chapter 2.7.

Table 1: Engineering workers according to ISCO-88

Architects, town and traffic planners
Civil engineers
Electrical engineers
Electronics and telecommunications engineers
Mechanical engineers
Chemical engineers
Mining engineers, metallurgists and related professionals
Cartographers and surveyors
Architects, engineers and related professionals not elsewhere classified

Source: ILO, 2004

In the following chapters, ten indicators are presented. Indicators 2.1 to 2.7 deal with the labour market for engineers. Besides the number of engineering workers, data on the proportions of female and part-time engineering workers are presented. An overview of the tertiary qualifications in engineering and consequently the education of engineers is provided by indicators 2.8 and 2.9. Finally, indicator 2.10 presents data on the ability of 15-year-olds in science revealing the different countries' potential with respect to engineering skills in the near future.

The data used in this report originate from either the European Labour Force Survey (LFS) or the statistical database of the Organisation for Economic Co-operation and Development (OECD). Although these sources offer the most comprehensive dataset available on the subject, not all data are readily available for the 31 countries of interest listed in Table 2. The 27 European Union member states, the EU-applicants Croatia and Iceland, as well as Norway and

¹ People are classified with respect to their occupations by their home countries' statistical authority which in some cases could lead to demarcation problems (cf. chapter 2.7).

Switzerland are the subjects of this study. Both the LFS and the OECD data offer the best possible comparability for these countries. All but the data on PISA (indicator 2.10), which date from 2006, are for 2007. The averages calculated for most of the indicators are weighted to minimise the influence of factors which would otherwise distort the comparison.

Table 2 – Countries included in the analysis

Abbreviation	Country	Indicator									
		2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	2.10
AT	Austria	X	X	(X)		X	(X)	X	X	X	X
BE	Belgium	X	X	X	(X)	X	X	X	X	X	X
BG	Bulgaria	X	X	(X)		X	(X)	X	X	X	X
CH	Switzerland	X	X	X	X	X	X	X	X	X	X
CY	Cyprus	X	X	X		X	(X)	X	X	X	
CZ	Czech Republic	X	X	X	(X)	X	X	X	X	X	X
DE	Germany	X	X	X	X	X	X	X	X	X	X
DK	Denmark	X	X	X		X	X	X	X	X	X
EE	Estonia	(X)	(X)			(X)		(X)	X	X	X
ES	Spain	X	X	X	X	X	X	X	X	X	X
FI	Finland	X	X	X	X	X	X	X	X	X	X
FR	France	X	X	X	X	X	X	X	X	X	X
GR	Greece	X	X	X		X	X	X	X	X	X
HR	Croatia	(X)	(X)	(X)		(X)		(X)	X	X	X
HU	Hungary	X	X	X		X	X	X	X	X	X
IE	Ireland	X	X	X		X	X		X	X	X
IS	Iceland	X	X			X			X	X	X
IT	Italy	X	X	X	X	X	X	X	X	X	X
LT	Lithuania	X	X	(X)		X	(X)	X	X	X	X
LU	Luxembourg	X	X			X		X			X
LV	Latvia	X	X	(X)		X		X	X	X	X
MT	Malta	(X)	(X)			(X)		(X)	X	X	
NL	Netherlands	X	X	X	X	X	X	X	X	X	X
NO	Norway	X	X	X		X	X	X	X	X	X
PL	Poland	X	X	X	(X)	X	X	X	X	X	X
PT	Portugal	X	X	X		X		X	X	X	X
RO	Romania	X	X	X		X	X	X	X	X	X
SE	Sweden	X	X	X	X	X	X	X	X	X	X
SI	Slovenia	X	X	(X)		X	(X)	X	X	X	X
SK	Slovak Republic	X	X	(X)		X	X	X	X	X	X
UK	United Kingdom	X	X	X	X	X	X	X	X	X	X

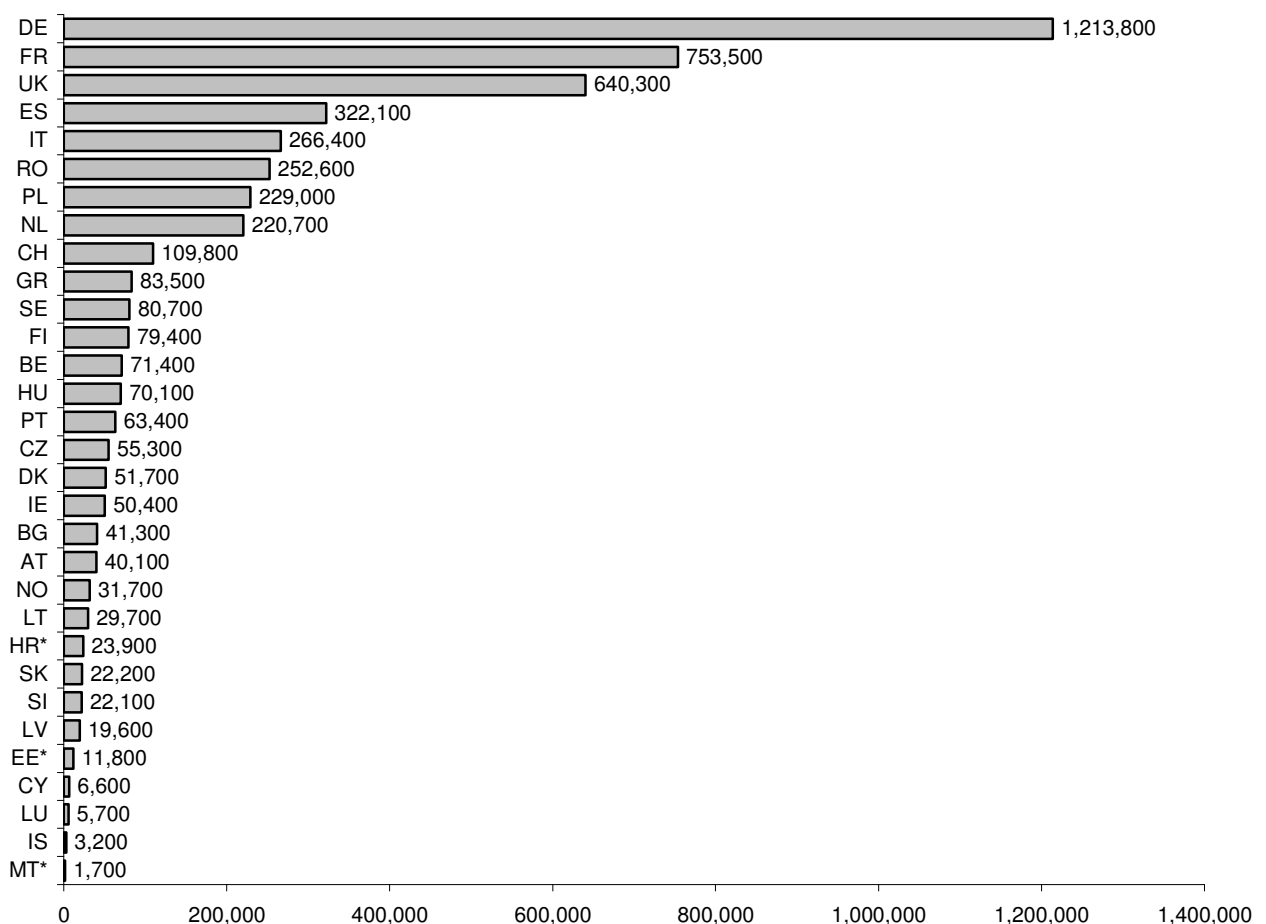
(X) Reliability limited due to small sample size.

2 Indicators

2.1 Employed Engineering Workers

In the European Labour Force Survey, an employee is a person aged 15 years or more who, during the reference week, performed paid work for at least one hour. People who had a job or a business but were absent during the reference week due to illness, holidays or similar issues are also included in this definition. Employed engineering workers are defined as employees who work in the engineering profession, regardless of the degree they hold. Fig. 1 shows the number of engineering workers employed in the 27 European Union member states as well as Croatia, Iceland, Norway, and Switzerland.

Fig. 1 – Employed engineering workers in 2007



* Data reliability limited due to small sample size.

Numbers rounded.

Source: Eurostat, 2009a

Germany, the largest economy in Europe, also had, at 1.2 million, the highest number of employed engineering workers in 2007. Companies in France, ranking second, employed only 753,500 engineering workers, a difference of more than 60 per cent. For the UK, the country with the third highest number of engineering workers, the difference is even higher at 90 per

cent. Together, the three largest employers of engineering workers, Germany, France and the UK, accounted for more than half of Europe's engineering workers in 2007.

The number of engineering workers in the 31 countries listed in Fig. 1 differs greatly from country to country. In 2007, companies in small European countries such as Malta, Iceland, Luxembourg and Cyprus employed fewer than 10,000 engineering workers per country. At the same time, companies in countries ranking in the top eight had more than 200,000 engineering workers per country on their payroll; that is, 20 times as many.

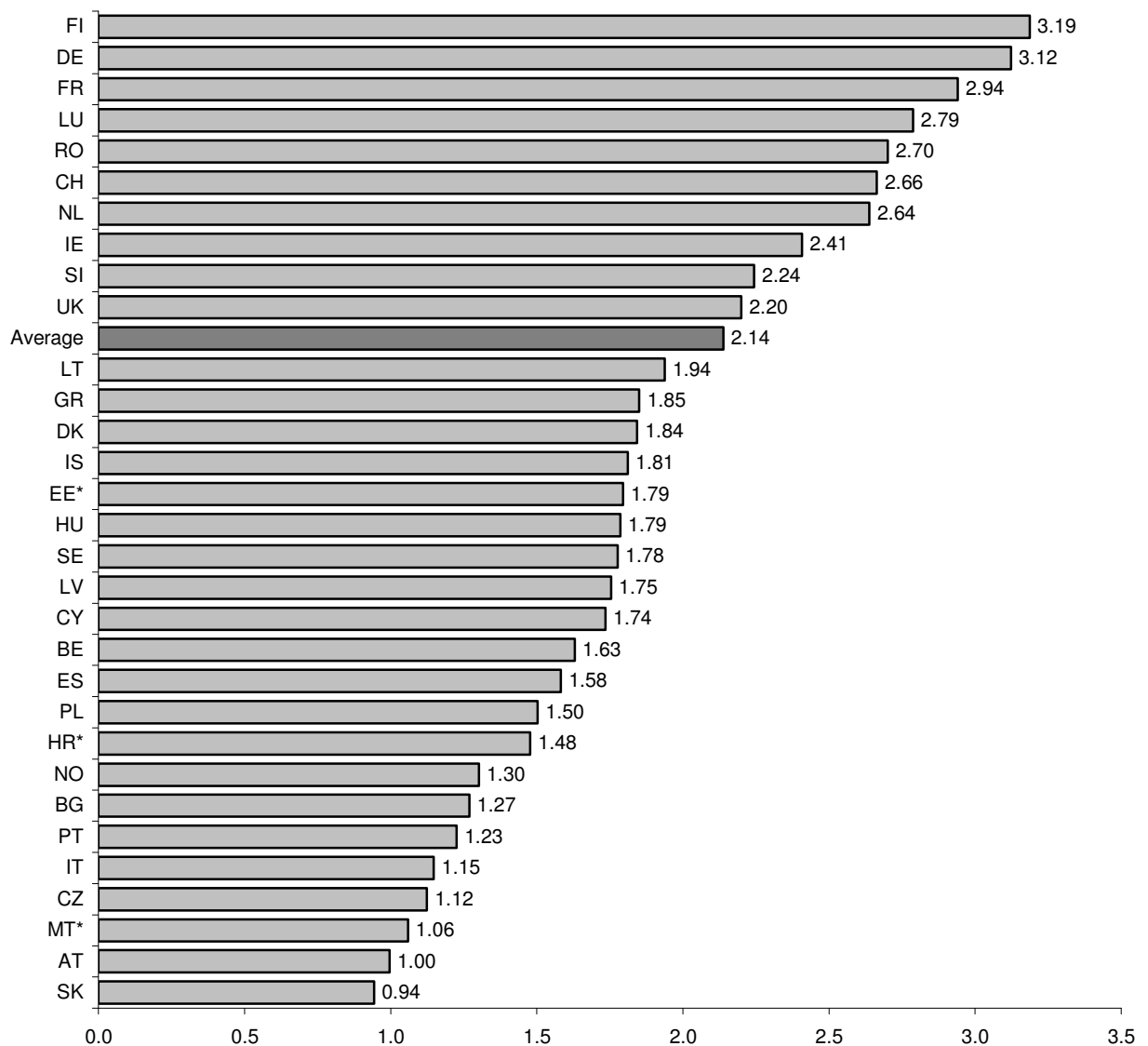
Generally, the greater a country's population, the more likely it is to have a large number of engineering workers. The eight countries in Fig. 1 with the largest number of engineering workers – Germany, France, the UK, Spain, Italy, Romania, Poland and the Netherlands – were also the eight most populous European countries in 2007 (cf. Eurostat, 2009b), while the seven smallest countries, Malta, Iceland, Luxembourg, Cyprus, Estonia, Latvia and Slovenia also had the fewest engineering workers. Overall, the European countries are ranked very similarly with respect to their population and to the number of employed engineering workers.

To sum up, in 2007 the number of engineering workers varied greatly among the 31 European countries included in the analysis. Germany, with more than 1.2 million, had by far the largest number of engineering workers, whereas Malta only employed 1,700, more than 700 times less. The size of a country influences the number of its engineering workers significantly.

2.2 Engineer Density

Using the absolute number of employed engineering workers in a country as the sole indicator of their importance can be misleading, as it does not take into account the country's size or industrial structure. In contrast, the number of employed engineering workers as a share of all employed persons in a country permits a more useful comparison of the data. The higher this share is, the higher the significance of the profession in any given country. Fig. 2 shows the number of employed engineering workers relative to all employed persons for all 31 countries included in this report in 2007.

Fig. 2 – Share of employed engineering workers among all employees in 2007



* Data reliability limited due to small sample size.

Numbers rounded.

Source: Eurostat, 2009a

In 2007, the average share of employed engineering workers among all employees in Europe was 2.14 per cent. However, the range of values for the 31 different countries surveyed was large: The difference between the highest share, 3.19 per cent in Finland, and the lowest, just 0.94 per cent in the Slovak Republic, was 2.25 percentage points. Hence, the highest share was more than three times the lowest.

With more than 3 per cent of their employees being engineering workers, Finland and Germany had the highest shares of all countries in 2007. These two countries place a particularly strong emphasis on science and technology: For instance, both spent a comparatively high amount on research and development (R&D) during the reference year: Finland's expenditure represented 3.47 per cent of its gross domestic product (GDP), whereas Germany had an R&D expenditure of 2.54 per cent in 2007. In contrast, the Slovak Republic, the country with the lowest share of engineering workers, spent a mere 0.46 per cent of its GDP on developing new products or processes (cf. Eurostat, 2009g). Engineering workers typically perform R&D-related tasks and are thus a valuable asset for their countries. This connection is reflected in the exceptionally high proportions of companies in high-tech industries engaging in innovation in both Finland and Germany in 2006: more than half of such companies in Finland and nearly two thirds in Germany (cf. Eurostat, 2009h).

Comparing the results presented in Figs. 1 and 2, four groups of countries can be distinguished, based on the absolute number of engineering workers and the ratio of engineering workers to other workers:

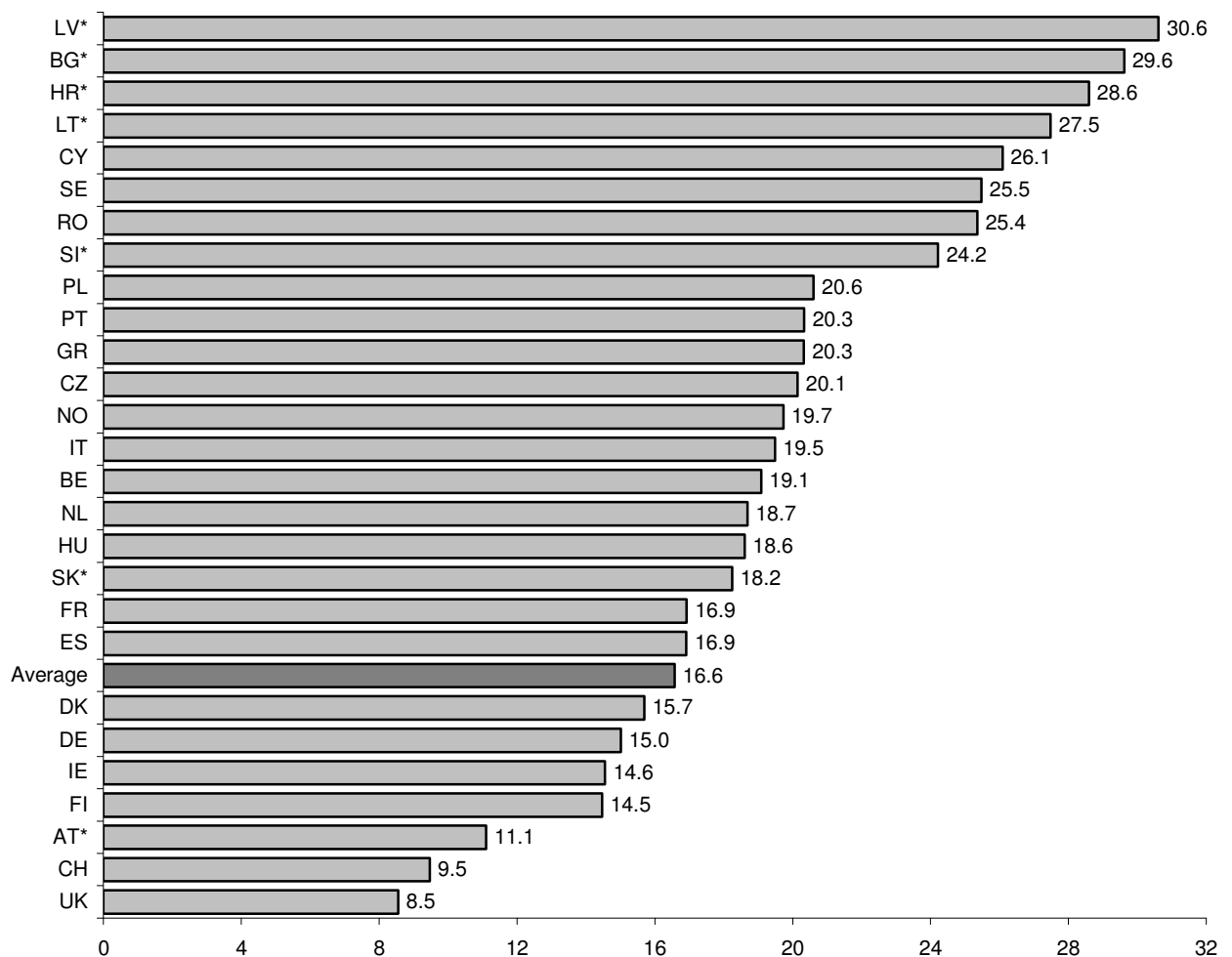
1. **High number and high share of engineering workers:** Countries such as Germany and France had both a high number and a high share of engineering workers in 2007. The high number stemmed from the size of the country and the high share indicated a strong focus on science and technology.
2. **Low number and high share of engineering workers:** Finland, Luxembourg and Ireland are examples of countries that are comparatively small but focus on industries where engineers are needed.
3. **High number and low share of engineering workers:** Although countries such as Spain, Italy and Poland employed a large number of engineering workers in 2007, the share of engineering workers in these countries was comparatively low. It can be inferred from this that the focus in these countries lay on other industries than those needing engineers.
4. **Low number and low share of engineering workers:** Small European countries such as Malta, Austria and the Slovak Republic neither employed a high number of engineering workers in 2007 nor did engineering workers play an important role in the total workforce.

Overall, there was a wide span in the proportions of engineering workers among all employees in 2007 in Europe. Finland and Germany had ratios that were considerably higher than the average share of 2.14, whereas countries such as the Slovak Republic and Austria had shares that were less than half the average.

2.3 Female Participation in Engineering

Engineering has traditionally been a typically male domain. In recent years, numerous initiatives have been launched and associations founded to promote engineering studies for girls and to support female engineers in the workplace.² While there is a serious shortage of science and technology experts in many vital business areas, women are a largely unused potential in the engineering profession. Fig. 3 demonstrates the share of female employed engineering workers in 27 European countries in 2007. Estonia, Iceland, Luxembourg and Malta are not covered.

Fig. 3 – Female employed engineering workers as a share of the total in 2007



* Data reliability limited due to small sample size.

Numbers rounded.

Source: Eurostat, 2009a

² Examples are the “Women’s Engineering Society” in the UK (www.wes.org.uk) and the “Shadowing initiative” organized by the European Commission (http://ec.europa.eu/information_society/activities/itgirls/shadowing/index_en.htm).

At 16.6 per cent on average in 2007, the proportion of women in the engineering profession in Europe was relatively low. Comparing the different European countries, the variety in the share of female engineering workers is quite striking. In 2007 there was a gap of more than 22 percentage points between the largest and the smallest shares, 30.6 per cent and 8.5 respectively. However, even the largest share still fell well short of 48.5 per cent, the average share of women with tertiary education among all employees.

In 2007, the countries with the highest percentage of female engineering workers were formerly communist Eastern European countries such as Latvia (30.6 per cent), Bulgaria (29.6 per cent), Croatia (28.6 per cent) and Lithuania (27.5 per cent). Between a quarter and a third of the employed engineering workers in these countries were female in the reference period. This is due to the historical development of their educational systems and the structure of their labour markets. In pre-communist times, women had far easier access to education in these countries than women in Western European countries. This then changed little under communism as gender equality was seen as a by-product of egalitarianism and women were encouraged to study technical subjects (cf. European Commission, 2004; Simard, 2007). Eastern European countries still profit from this fact today. In 2007, the Western European country with the highest proportion of women in the engineering profession was Sweden with 25.5 per cent.

By contrast, the United Kingdom, with 8.5 per cent, employed very few female engineering workers. Switzerland and Austria had similarly low shares of below 12 per cent. Activating the potential of female engineering workers will be a challenge for these countries in the years to come. Overall, in 2007 the majority of European countries had shares of female engineering workers well above the average of 16.3 per cent. Large countries with relatively low shares such as Germany (15.0 per cent) and the UK (8.5 per cent) brought the average down.

In 2007, 44.6 per cent of all employees in the 27 European Union member states (EU27) were women (cf. Eurostat, 2009e). Compared to the whole female population, women were slightly underrepresented in the labour market: 50.6 per cent of the population of the EU27 was female in 2007 (cf. Eurostat, 2009b). The low participation rate of women in the labour market indicates that more women than men stayed home. 60.7 per cent of the so-called inactive people in the EU27 who stated in 2007 that they did not want to work were women (cf. Eurostat, 2009f).³ Mostly, they stay at home to take care of children or incapacitated adult family members. Education also has an impact on labour market participation, however: The share of female university or college graduates among all employees in Europe exceeded the share of all female employees in 2007 by several percentage points. In the 27 countries shown in Fig. 3, female university or college graduates made up 48.5 per cent of all employed graduates of tertiary programmes (cf. Eurostat, 2009e). The average share of female engineering workers in these countries was only a third of this.

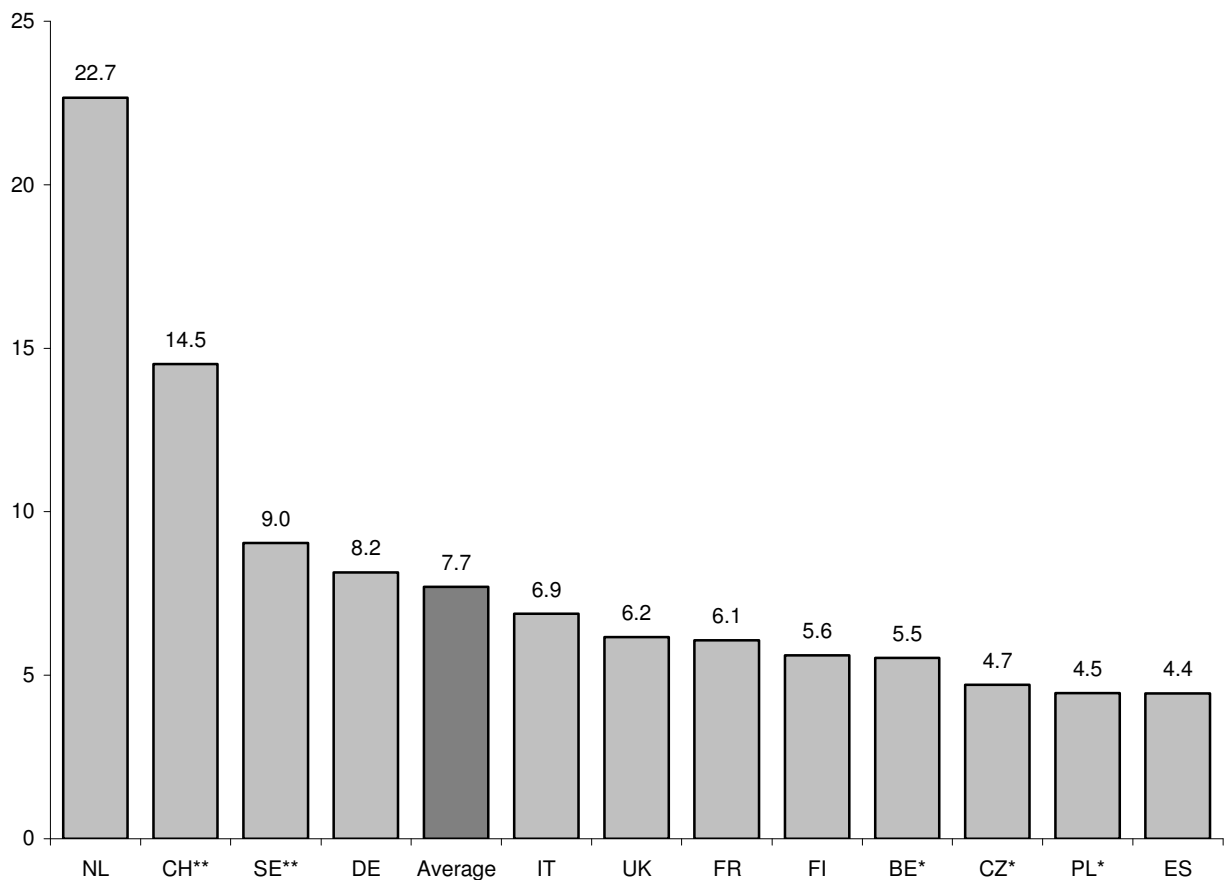
To conclude, female engineering workers were far from common in Europe in 2007. On average, only every 6th engineer was female. Eastern European countries such as Latvia and Bulgaria had the highest shares of female engineering workers, whereas the UK had the lowest.

³ Inactive people are neither employed nor unemployed and typically include stay-at-home parents and people in training.

2.4 Part-time Engineers

The extent of part-time work within a profession is a sign of the flexibility of the workplace. Among European countries, working hours differ considerably. Part-time work within the framework of the European Labour Force Survey is defined as all employment with less than 35 usual working hours, however. Data on the extent of part-time work among employed engineering workers are generally scarce, which is why only 12 countries are covered by the indicator. Fig. 4 shows the proportion of employed engineering workers working part-time. The indicator encompasses both male and female employed engineering workers.

Fig. 4 – Share of engineering workers employed part-time in 2007



* Data reliability limited due to small sample size.

** Based on smaller population than displayed in Fig. 1 due to incomplete answers.

Numbers rounded.

Source: Eurostat, 2009a

Fig. 4 shows that, on average, 7.7 per cent of the employed engineering workers in the 12 countries providing data worked part-time in 2007. That was about every 13th engineering worker in the Netherlands, Switzerland, Sweden, Germany, Italy, the UK, France, Finland, Belgium, the Czech Republic, Poland and Spain. Overall, around 18.2 per cent of university or college graduates in these 12 countries worked reduced hours in 2007 (cf. Eurostat, 2009c). This demonstrates that the average share of employed engineering workers working part-time in

2007 was, in fact, comparatively low: On average in the 12 countries included here, less than half as many engineering workers as other university or college graduates worked part-time. One reason for this could be the relatively low participation of women in the profession, as shown by indicator 2.3.

More than one in five employed engineering workers in the Netherlands worked part-time in 2007, giving the country the highest share of part-time engineering workers of all countries included. This result is particularly surprising in view of the share of Dutch women in engineering which – at 18.7 per cent – was significantly lower than the share of part-timers at 22.7 per cent. This means that in 2007 a significant number of the engineering workers working part-time in the Netherlands were male. Part-time work has a long tradition in the Netherlands. Started as a collective way to reduce the high unemployment rate in the 1980s, it has become widely accepted among employers and employees (cf. van Doorne-Huiskes, 2004). These days, the Netherlands is often referred to as a “part-time economy” because such a large share of the labour force prefers to work reduced hours (cf. Bosch et al., 2008).

Switzerland also had a relatively high share of part-time engineering workers in 2007. At 14.5 per cent, similar to that in the Netherlands, this proportion was greater than the share of female engineering workers in the country (cf. 2.3). Hence, in Switzerland, male engineering workers often hold part-time jobs, too.

Most of the 12 European countries that data were available for showed a different pattern, however: Generally, all countries except the Netherlands and Switzerland exhibited shares of part-time engineering workers of less than 10 per cent. That is, less than one in ten engineering workers worked part-time in the reference period. The share of part-time engineering workers employed in the Netherlands was five times as high as in Spain, the country with the smallest percentage of part-timers in the engineering profession. The Czech Republic, Poland and Spain all had exceptionally low shares of engineering workers in part-time jobs with less than 5 per cent of all employed engineering workers.

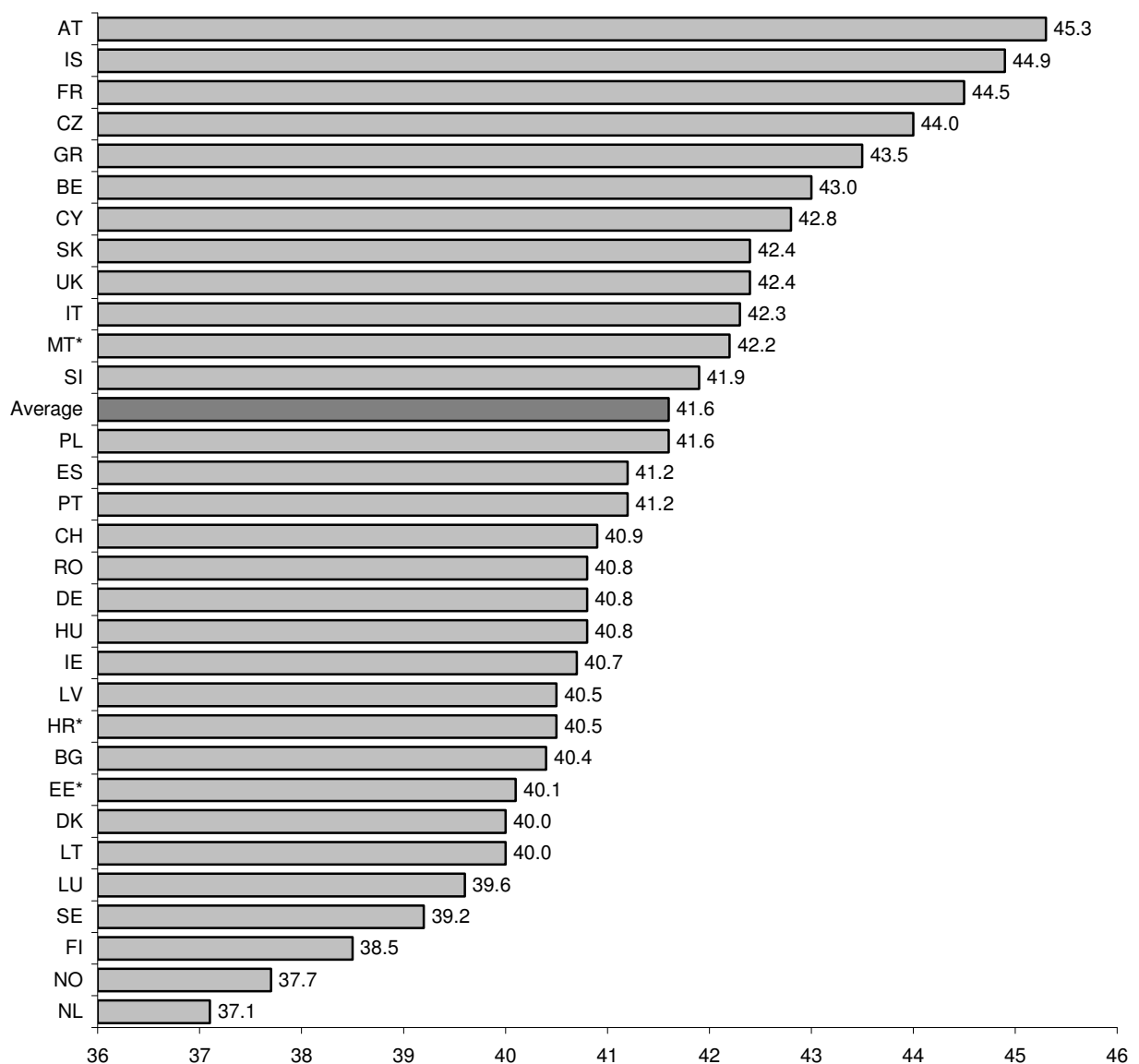
In general, a high share of people working part-time is positively correlated with a high share of female employees. In 2007, women in the European Union were four times as likely to work part-time as men. Even among workers with a tertiary degree, nearly 3.5 times as many women worked part-time as men (cf. Eurostat, 2009c). Starting a family is the most common reason for reducing one’s working hours (cf. Eurostat, 2009d); and traditionally, this role still falls to women. Whereas in 2007 nearly a third of all women working part-time in the 27 European Union member states did so to look after children or incapacitated adults, less than 4 per cent of the men working part-time gave this reason for their reduced working hours (cf. Eurostat, 2009d).

Summing up, part-time work was not common among employed engineering workers in 2007 with only 7.7 per cent of them working less than a full working week. Among the 12 countries covered by this indicator, the Netherlands and Switzerland had the highest shares of part-timers.

2.5 Weekly Working Hours of Engineers

Working hours are one means of comparing the working conditions for employees in different countries. The average weekly working hours of employed engineering workers in 2007 are shown in Fig. 5. All 31 countries included in this report are covered by this indicator. In the European Labour Force Survey, the “usual working hours” comprise all hours which an employee usually worked in one week. They include overtime but exclude commuting time and the main meal break. No distinction between full-time and part-time employees is made; the average weekly working hours cover all employees.

Fig. 5 – Average weekly working hours of employed engineering workers in 2007



* Data reliability limited due to small sample size.

Numbers rounded.

Source: Eurostat, 2009a

At 45 hours 18 minutes a week, the average working hours of Austrian engineering workers are the longest in Europe. A full-time professional in Austria worked 44 hours 12 minutes per week in 2007 (cf. Eurostat, 2009j). Thus, Austrian engineering workers worked an average 1 hour 6 minutes per week more, even though part-timers were included in their average working time. Compared to the average working hours of the 31 countries listed in Fig. 5, the average Austrian engineering worker worked 3 hours 42 minutes a week longer. Other European countries with above-average working hours in 2007 were Iceland, France and the Czech Republic. Engineering workers worked 44 or more hours a week in these countries. Generally, long working hours may indicate over-time due to factors such as the demands of the job, project-based work or a general shortage of skilled employees.

Compared to the other European countries, engineering workers in the Netherlands had short working hours in 2007. The average of just 37 hours 6 minutes is more than 8 hours per week less than the working time of engineering workers in Austria, the country with the longest working hours. The reason for the comparatively few hours Dutch engineering workers put in on average lay in the high share of part-timers in the country. As indicator 2.4 shows, 22.7 per cent of the Dutch engineering workers worked part-time. This high share decreases the average weekly working hours, as they cover both part-time and full-time employees.

Switzerland, the other country with an exceptionally high share of part-time engineering workers in 2007 (14.5 per cent), had average weekly working hours of 40 hours 54 minutes. Despite similarly high shares of part-timers, Swiss engineering workers worked significantly longer hours than Dutch engineering workers. The difference amounted to 3 hours 48 minutes. On the one hand, this difference is due to the fact that the share of engineering workers working part-time is 8.2 percentage points higher in the Netherlands than in Switzerland, resulting in a bigger distortion of the average weekly working hours. On the other hand, in 2007 Swiss professionals employed full-time worked 3 hours 6 minutes more than their Dutch counterparts (cf. Eurostat, 2009j). This could have caused an upward bias with respect to Swiss engineering workers' weekly working hours.

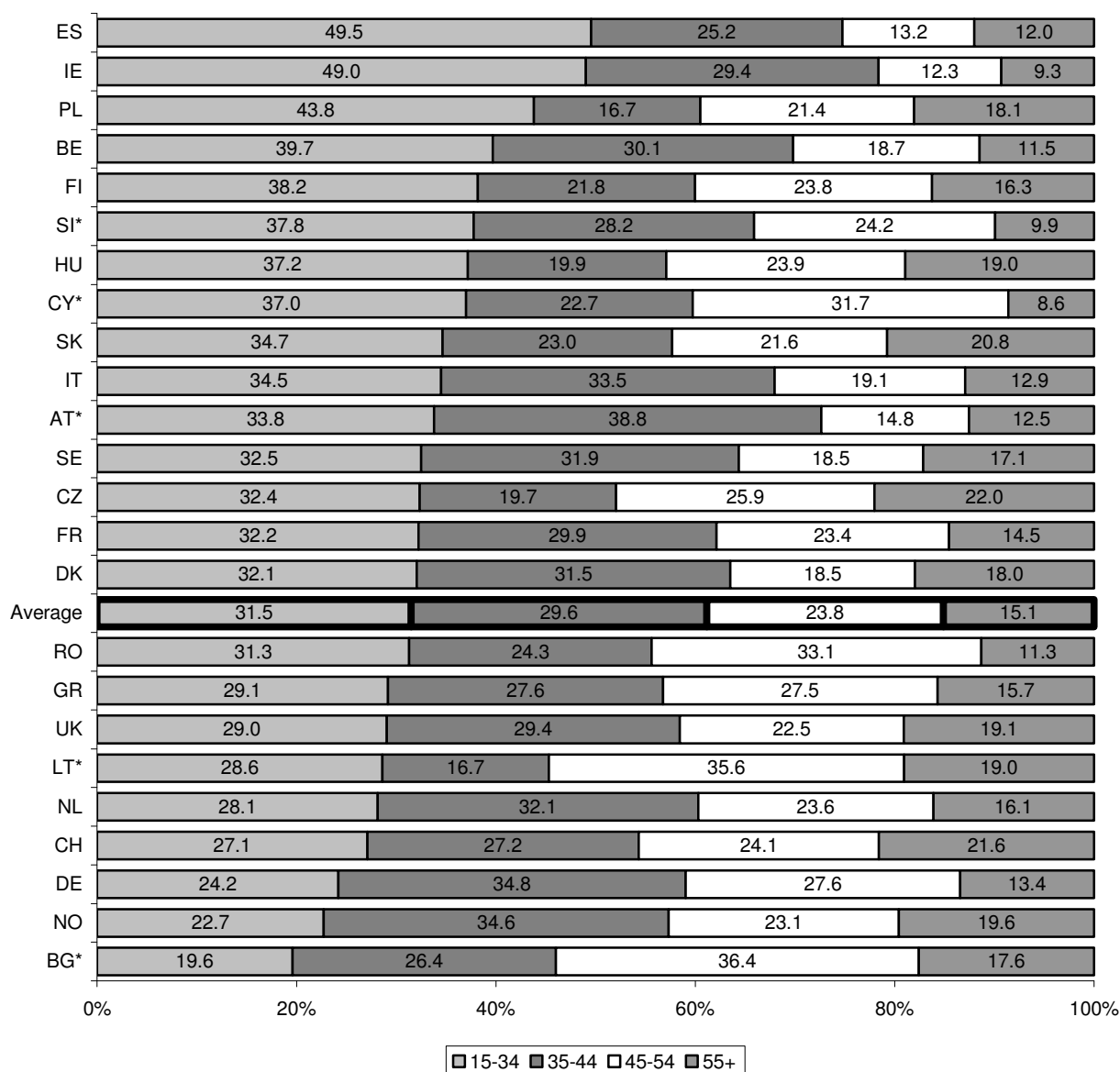
In the International Standard Classification of Occupations (ISCO-88), engineers count as professionals. In the 31 European countries included in this report, professionals as classified by ISCO-88 worked 37 hours 30 minutes on average (cf. Eurostat, 2009j). However, the working time of engineering workers in 2007 exceeded the working time of all professionals taken together. On average, an engineering worker in the 31 European countries displayed in Fig. 5 worked 41 hours 36 minutes. That is 4 hours 6 minutes more than the average professional in these countries and 3 hours 48 minutes more than the average employee there.

Over all 31 countries, the average weekly working hours of engineering workers varied between 37 hours 6 minutes and 45 hours 18 minutes in 2007. Besides the Netherlands, Norway, Finland and Sweden also had fewer working hours, whereas engineering workers in Austria, Iceland, France and the Czech Republic worked a relatively high number.

2.6 The Age Structure of Engineers

Demographic change and the accompanying problems will continue to influence the European labour market in the years to come. The current age structure of engineering workers is an indicator of the impact that aging will have on the engineering profession in the future: Engineering workers aged 55 years or older today will most likely leave the workforce within the next ten years. Young engineers will then be required to fill the void and ensure the competitiveness of companies employing engineers. A low share of young engineering workers – usually going hand in hand with a comparatively low number of engineering graduates – is one of the major determinants of imminent engineer shortages in the labour market. Fig. 6 shows the age structure of employed engineering workers in 26 European countries in 2007.

Fig. 6 – Age structure of employed engineering workers in 2007



* Data reliability limited due to small sample size.

Numbers rounded.

Source: Eurostat, 2009a

Fig. 6 demonstrates that 31.5 per cent of the employed engineering workers in the 26 European countries were younger than 35 and 15.1 per cent were aged 55 or older. At the same time, 35.3 per cent of all employees with a tertiary degree were younger than 35 years, whereas 12.6 per cent were 55 years old or older in the EU27 (cf. Eurostat, 2009e). Given both the substantially smaller share of young employees and the higher share of experienced employees, the EU27 labour market for engineers is far more susceptible to the influence of demographic change than the overall academic labour market.

With respect to their proportion of engineering workers younger than 35, two countries stick out: Nearly half of the employed engineering workers in Spain and Ireland belonged to this age group in 2007. Both countries also showed relatively low shares of engineering workers 55 years old or older. It can be concluded that these two countries are unlikely to encounter severe problems replacing retiring engineering workers in the future.

Bulgaria, Norway and Germany exhibited comparatively low shares of engineering workers younger than 35. In the latter two countries, less than 25 per cent, in the first fewer than 20 per cent of the employed engineering workers were younger than 35. On top of the small proportion of young engineering workers, Bulgaria and Norway also exhibited an above-average share of engineering workers aged 55 or older. Hence, these countries in particular face problems with regard to replacing retiring engineering workers. At 13.4 per cent, the German proportion of engineering workers aged 55 or older was relatively low, but even today German companies face severe recruiting problems with respect to engineers (cf. Erdmann/Koppel, 2009).

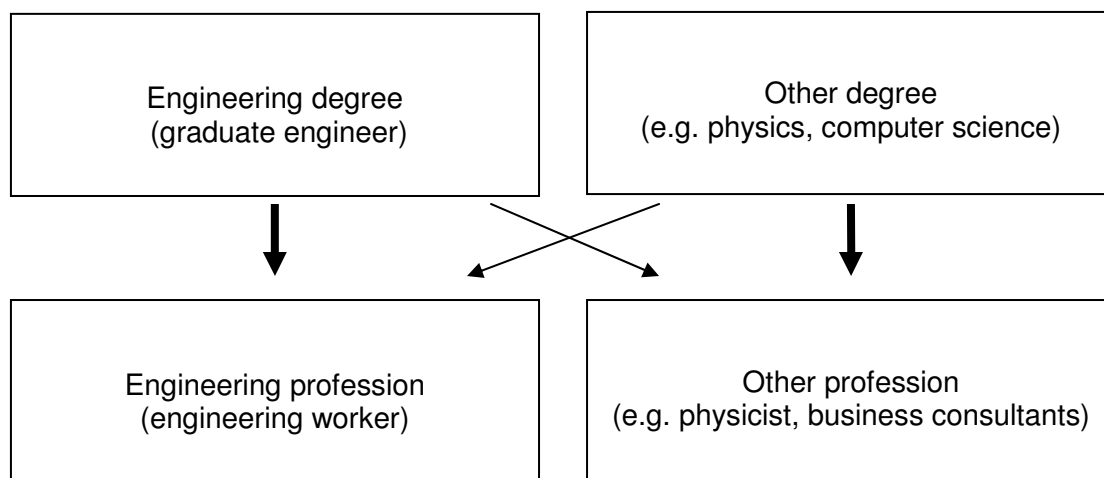
Most Eastern European countries showed relatively high shares of older engineering workers. Around one fifth of the employed engineering workers in the Czech Republic, the Slovak Republic and Hungary were 55 years old or older. This is because in communist times, the promotion of science and engineering was a focus of the governments in Eastern Europe and students were encouraged to study engineering (cf. Simard, 2007; The Library of Congress, n. d). However, the share of younger engineering workers in these countries also exceeded the average, implying that a sufficient number of replacements should be at hand in the future. A brain drain towards western countries, though, might undermine this trend.

To sum up, countries such as Ireland and Spain, which had a very large share of engineering workers below the age of 35 in 2007, are not likely to encounter replacement problems when their older engineering workers leave the workforce. However, countries such as Germany, Bulgaria and Norway, with a below-average share of young engineering workers, will face these replacement problems.

2.7 Employed Graduate Engineers

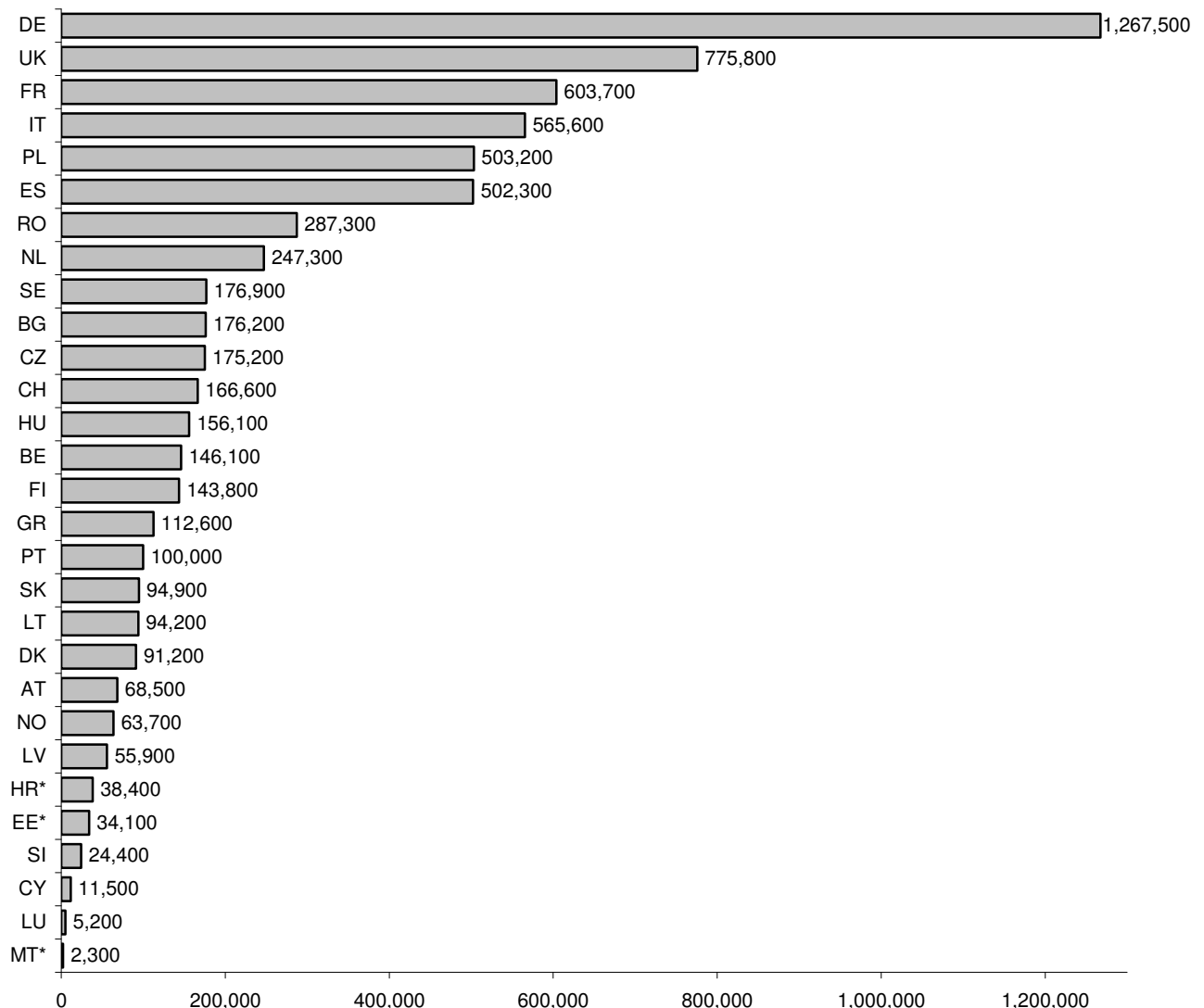
There can be a difference between an employed engineering worker and an employed person holding an engineering degree, henceforth referred to in this paper as ‘graduate engineer’. Although graduate engineers typically take up jobs in engineering-related professions, some of them choose to work in other professions, as business or IT consultants, for example. The same is true the other way around, as trained physicists or computer scientists may choose to work as engineers due to overlaps between the engineering and other professions. Fig. 7a demonstrates this graphically. Engineering workers are mostly graduate engineers and vice versa, but not always.

Fig. 7a – Overview: Engineering workers versus graduate engineers



Persons with an engineering degree are captured by ISCED (International Standard Classification of Education) levels 5A and 6. ISCED 5A contains tertiary educational programmes that are mainly theoretically based and provide sufficient skills to gain entry into advanced research programmes or professions with high skills requirements. ISCED 6 comprises the second stage of tertiary education leading to an advanced research qualification. More generally, ISCED 5A and 6 include common university and college degrees and advanced degrees such as the PhD. Based on this definition, the number of employed graduate engineers in 2007 is shown in Fig. 7b for 29 European countries.

Fig. 7b – Number of employed graduate engineers in 2007



* Data reliability limited due to small sample size.

Numbers rounded.

Source: Eurostat, 2009a

Generally, the ranking in Fig. 7b resembles that for employed engineering workers in Fig. 1. Both the number of employed engineering workers and the number of employed graduate engineers depend to a great extent on the size of the economy or the size of the labour force. With close to 1.3 million employees holding an engineering degree in 2007, Germany had the highest number of employed graduate engineers. A mere 2,300 – and consequently the lowest number of graduate engineers employed – were to be found in Malta. These countries were in the same respective positions in terms of their numbers of employed engineering workers (cf. Fig. 1).

Comparing the number of employed engineering workers in Fig. 1 to the number of employed graduate engineers in Fig. 7b, substantial differences emerge for specific countries. For example, 1.2 million engineering workers, but nearly 1.3 million graduate engineers were employed in

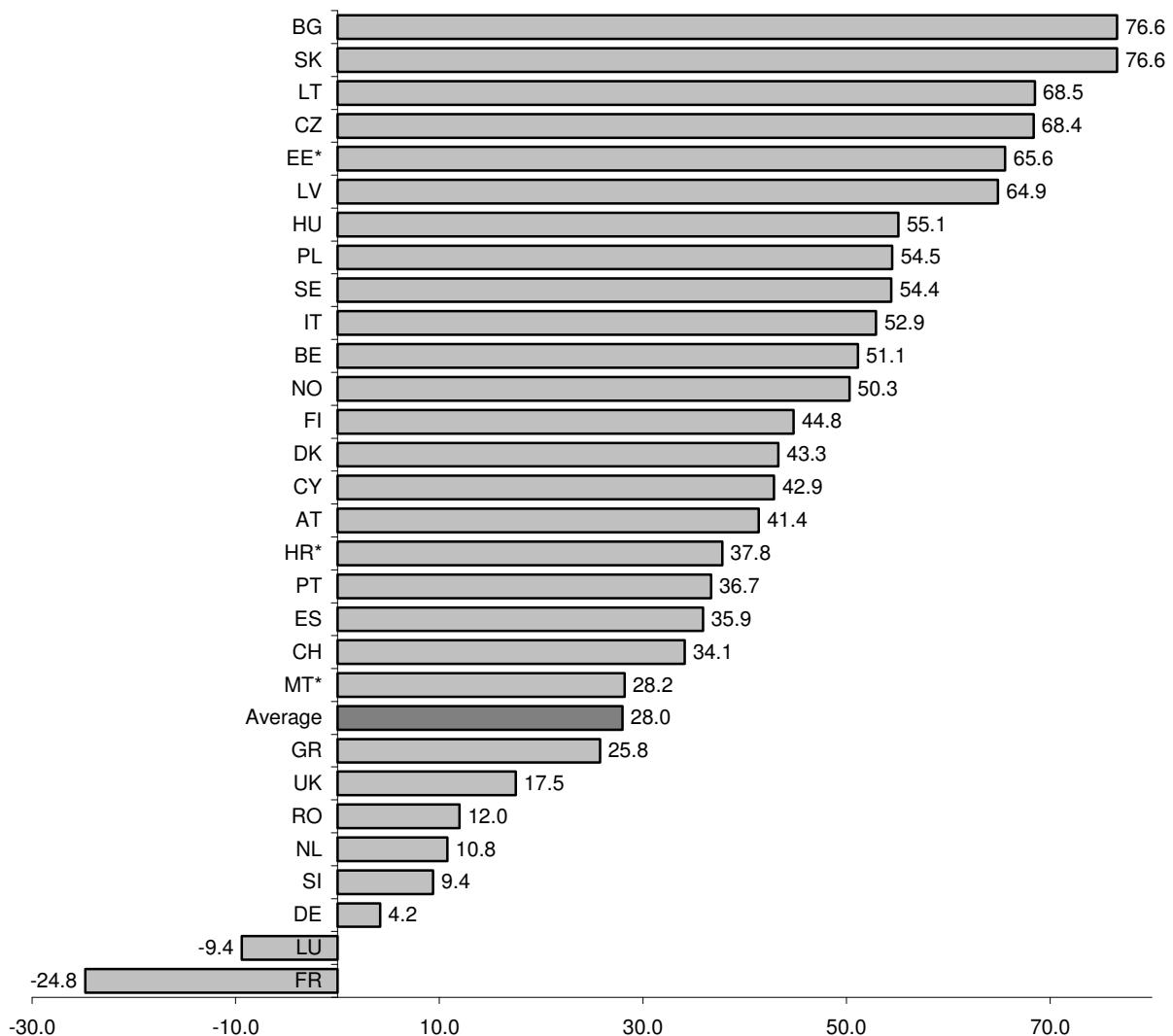
Germany. By contrast, some countries exhibited a higher number of employed engineering workers than employed graduate engineers. Luxembourg, for example, had 5,700 employed engineering workers, but only 5,200 of its employees held an engineering degree.

The relation between engineering workers and graduate engineers in the labour force indicates the country-specific composure of the engineering profession. If the number of employees holding an engineering degree exceeds the number of employed engineering workers, then at least some engineering graduates are working in a job outside the engineering profession. For example, the UK had 135,500 more graduate engineers than engineering workers. If all employed engineering workers actually held an engineering degree, then 135,500 graduate engineers were indeed working in non-engineering professions. Because it is possible that not all employed engineering workers actually held an engineering degree, the number of graduate engineers working in a different profession could be even higher.

Fig. 7c visualizes this relationship. It displays the difference between employed graduate engineers and employed engineering workers in relation to the employed graduate engineers. This ratio – labelled x in the following formula – reveals the minimum percentage of employed graduate engineers not working in the engineering profession.

$$x = \frac{\text{Employed graduate engineers} - \text{Employed engineering workers}}{\text{Employed graduate engineers}}$$

Fig. 7c – Minimum proportion of employed graduate engineers not working in the engineering profession in 2007



* Data reliability limited due to small sample size.

Numbers rounded.

Source: Eurostat, 2009a

On average, at least 28 per cent of the employed graduate engineers were not working in the engineering profession in the 29 European countries covered in Fig. 7c. This result shows how versatile employees holding an engineering degree are, because they are obviously able to adapt to other work environments than the engineering profession. By the same light, the fact that a minimum of more than a quarter of the employed graduate engineers in Europe were working in a different profession demonstrates that an engineering degree offers a wide choice of workplace, since employers value the qualifications of graduate engineers.

Fig. 7c also visualises the great differences between the European countries covered by the indicator. Between the highest share of graduate engineers not working as engineers and the lowest there are more than 100 percentage points. Whilst Bulgaria and the Slovak Republic ex-

hibited very high shares of about 77 per cent of graduate engineers not working in the engineering profession, around a quarter of French engineering workers actually did not hold an engineering degree in 2007.

France is not the only country where the data indicate that not all employed engineering workers hold a corresponding degree. At least one in ten engineering workers in Luxembourg had not received an engineering degree from a college or university. This proportion could indicate that these two countries are suffering a shortage of graduate engineers, thus having to fill vacancies with applicants with other degrees. However, this conclusion must be tentative. In France, the job title “engineer” (ingénieur) is not defined by law (cf. VDI, 2002), with the result that it can be used to describe jobs which do not require a graduate engineer. In consequence, the number of employed engineering workers in France could be an overestimate if the French definition of engineering worker was wider than in the European countries where the job title is protected by law.

For some European countries, the low minimum proportion of graduate engineers not working in their profession indicates a rather good match. Examples of this are Germany at 4.2 per cent, Sweden at 9.4 per cent and Luxembourg at 9.4 per cent. This does not mean that all engineering positions in these countries have in fact been filled by engineering graduates but only that, theoretically, they could have been.

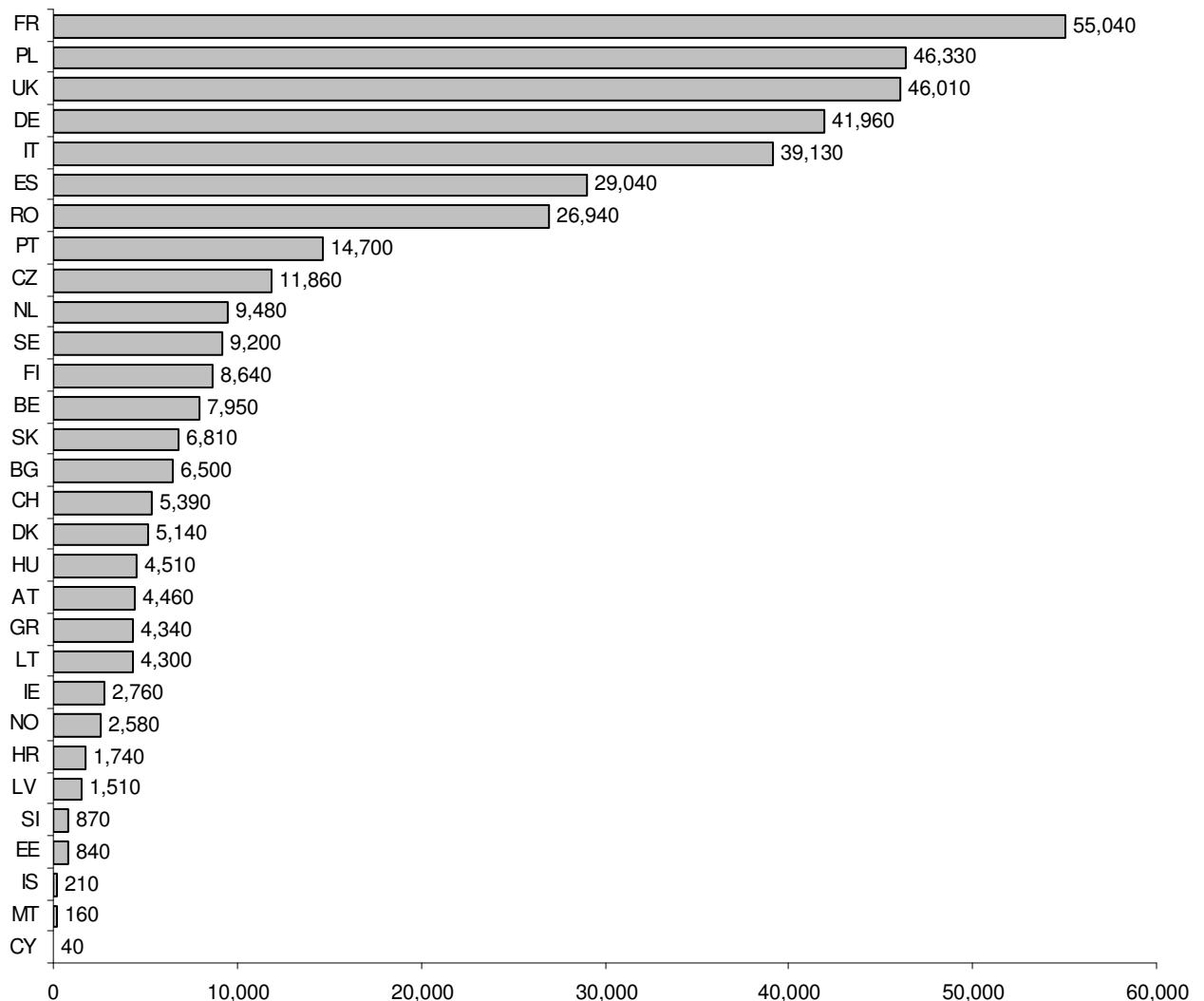
Eastern European countries mostly exhibited large shares of graduate engineers not working in the profession for which they were trained. More than 65 per cent of employees in Bulgaria, the Slovak Republic, Lithuania, the Czech Republic and Estonia who had acquired an engineering degree were not working in their profession. During communism, these countries encouraged students to study engineering (cf. Simard, 2007). Hence, the number of engineering graduates was exceptionally high during these times. This could explain the high percentage of graduate engineers in the workforce working outside the engineering profession. The countries ranked among the top 8 in Fig. 7c are all former communist countries, supporting this hypothesis.

In summary, whereas the majority of the European countries covered by the indicator exhibited a much higher number of employed graduate engineers than employed engineering workers, some of the engineering workers in Luxembourg and France did not hold an engineering degree in 2007. On average, at least 28 per cent of the graduate engineers in the workforce were working in a different profession.

2.8 Graduations in Engineering

Graduations in engineering are a useful means of comparing the education of engineers at universities or colleges in Europe. Graduation denotes the successful completion of the final year of education, generally by passing an examination or having attended the requisite number of course hours. The number of graduations in engineering in 2007 is shown in Fig. 8 for 30 European countries. There were no data available for Luxembourg.

Fig. 8 – Number of graduations in engineering in 2007



Numbers rounded.

Source: Eurostat, 2009i

France had the highest number of graduations in engineering at 55,040. Cyprus had the fewest, with only 40 graduations in this subject being counted there.

Generally, the number of graduations in a subject in a country is positively dependent on population size. Although the exact number of students in a subject naturally depends on other fac-

tors as well, such as the proportion of high school graduates going on to study or the attractiveness of the subject, in most instances larger countries have more students. A higher number of students then results in more graduations. The number of engineering workers in a country and the number of graduations in engineering are also interdependent. The more engineering workers are employed in a country, the more important a high number of graduations becomes if all the vacancies due to retirement are to be filled. This is demonstrated in Fig. 8. The seven countries ranked highest with respect to their number of employed engineering workers (cf. Fig. 1) also rank among the top 7 with respect to their number of graduations in engineering. Besides France, Poland, the UK, Germany, Italy, Spain, and Romania exhibited the highest numbers of graduations, with numbers varying between 26,940 and 55,040. The wide span in the number of graduations in engineering is obvious even with respect to only the largest European economies.

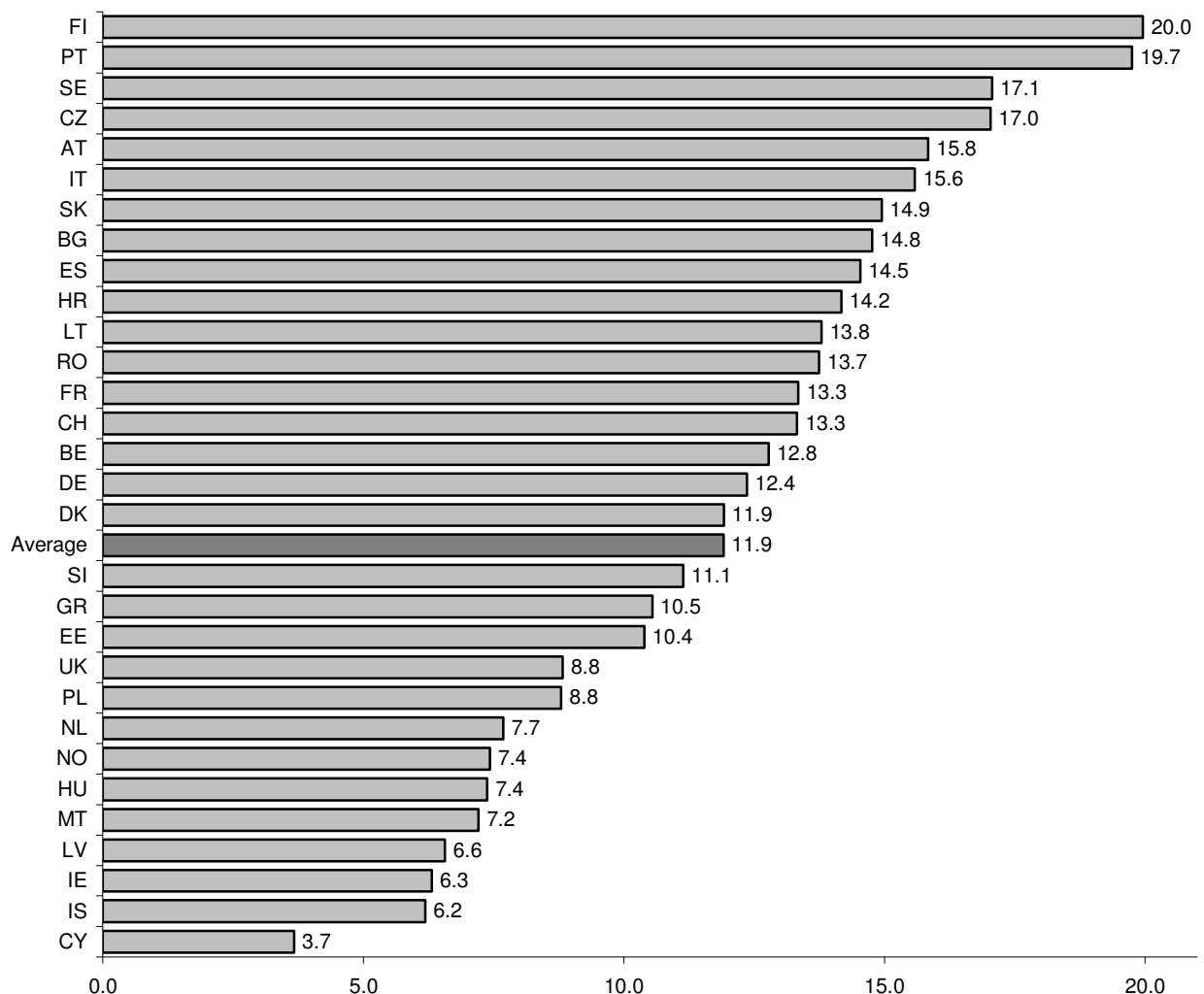
A comparison of the absolute numbers for the European countries always reveals a wide range due to different country size, for example. This is also true here and makes useful comparisons difficult. Basically, Fig. 8 displays three bands of countries grouped according to the number of their graduations in engineering. Each covers about a third of the European countries included. The first band contains countries such as Ireland, Norway and Latvia that had relatively few graduations in engineering, at most 2,760, in 2007. The second band features an intermediate number of graduations in 2007. Countries such as the Netherlands, Sweden and Switzerland mustered between 4,300 and 9,480 graduations in engineering. Finally, the last group includes the top 7 countries together with Portugal and the Czech Republic, which all had more than 11,000 graduations in engineering.

The number of graduations in engineering is strongly dependent on factors such as population size and number of students. Therefore, the results cannot be easily compared. France, with more than 55,000 graduations, and Cyprus, with less than 50 in 2007, show how widely the European countries differ in this respect.

2.9 Share of Graduations in Engineering

The share of graduations in engineering among all graduations is an additional indicator for comparing the education of engineers in the different European countries. In some cases, the number of graduates in any given year, that is the number of students graduating (head count), can fall short of the number of graduations (case count). This happens when students graduate in more than one subject in one year. A typical example of this is the education of teachers in Germany. They generally study the two or more subjects that they aim to teach later and often graduate in several subjects in one year. Generally, students in engineering study just one subject, so that this discrepancy with respect to the number of graduations can be ruled out. The total number of graduations, however, could be influenced and the share of graduations in engineering underestimated. Fig. 9 shows the graduations in engineering as a percentage of all graduations in 2007 for 30 European countries. Luxembourg is excluded.

Fig. 9 – Share of graduations in engineering in all graduations in 2007



Numbers rounded.

Source: Eurostat, 2009i

On average, around 12 out of every 100 graduations in the 30 countries covered by this indicator were in engineering. More than half of these countries had an above average share. Only 13 countries exhibited a share of graduations in engineering below 11.9 per cent. The range of shares covered was quite large: Between the highest share at 20 per cent and the lowest, at just 3.7 per cent, were 16.3 percentage points. In other words, the highest share of graduations in engineering among all graduations was more than five times the lowest.

At 20 per cent, Finland's share of graduations in engineering was the highest in Europe. Similarly high shares were to be found in Portugal at 19.7 per cent, Sweden at 17.1 per cent and the Czech Republic at 17.0 per cent. In contrast, a mere 3.7 per cent of all graduations in Cyprus were obtained in engineering, the lowest share of all European countries covered by the indicator. Fig. 8 demonstrates that this country not only had the smallest share, but also the smallest number, of graduations in this subject so that educating engineers seemed to play hardly any role in Cyprus. Iceland (6.2 per cent), Ireland (6.3 per cent) and Latvia (6.6 per cent) had the next highest shares of graduations in engineering, but these were still comparatively low.

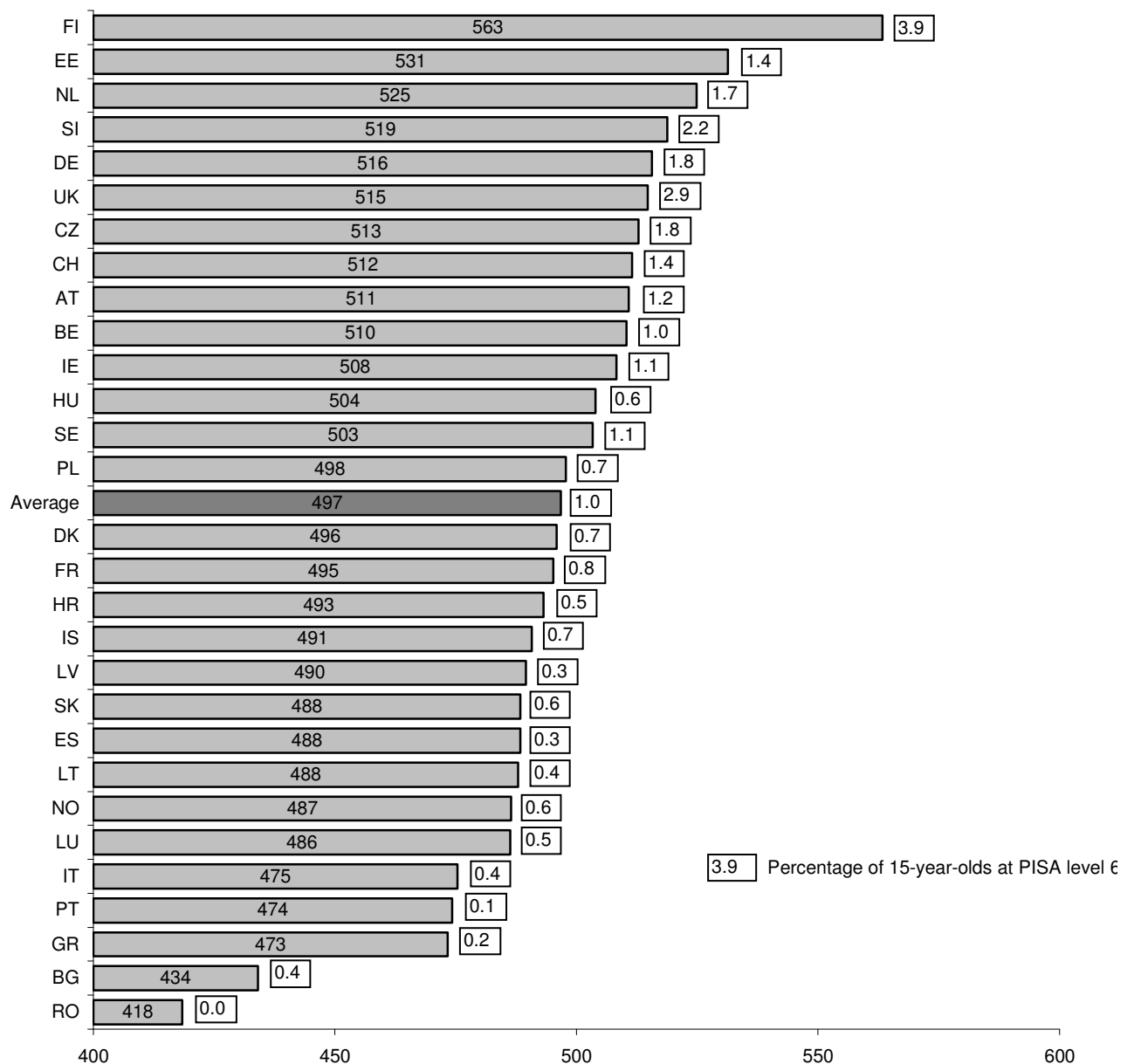
The above-mentioned low share of graduations in engineering in Ireland (6.3 per cent) stands out because the country had an exceptionally high share of young engineering workers in 2007 (cf. Fig. 6). Nearly half of all Irish engineering workers were younger than 35 years in 2007. The low share of graduations in engineering seems to conflict with this. Around 25,000 employed Irish engineering workers were younger than 35 in 2007. During that same year, there were 2,760 graduations in engineering in Ireland. Taking into account the fact that Irish tertiary graduates are comparatively young (cf. OECD, 2009), this number of graduations in the past few years would in fact have been more than sufficient to provide all those young engineering workers that are part of the Irish workforce now. Still, Ireland actively promotes the study of engineering through various initiatives aimed at young people in order to increase the number of engineering students and graduations. Examples include "STEPS to engineering" (www.steps.ie) and "Discover science + engineering" (www.discover-science.ie).

All in all, the share of graduations in engineering among all graduations in 2007 varied widely between countries. Finland had the highest share at 20 per cent, whilst Cyprus' share, at only 3.7 per cent, was negligible.

2.10 The Scientific Ability of 15-year-olds

Besides the labour market for engineers in Europe and the young engineers being educated at universities and colleges in Europe, the scientific abilities of high school students can also indicate the future of engineering in any given country. The scientific abilities of 15-year-olds can serve as a proxy for the importance attached to science in school and signal how well students are prepared for studying engineering. Fig. 10 presents data on two respective items for 29 European countries: On the one hand, the chart shows the mean PISA (Programme for International Student Assessment) score of 15-year-olds in science. It measures how well students use scientific knowledge, identify questions and draw evidence-based conclusions. On the other hand, Fig. 10 shows the percentage of 15-year-olds at PISA level 6 in science. This is the highest proficiency level within the PISA framework and indicates that a student is able to handle advanced scientific thinking and reasoning. To reach this level, students have to obtain at least 707.9 points in the science section of the PISA assessment. In general, each student is assigned to the highest proficiency level for which they would be expected to answer the majority of assessment questions correctly (cf. OECD, 2007). All data are for 2006.

Fig. 10 – Mean PISA score in science and share of 15-year-olds at PISA level 6 in science in 2006



Source: OECD, 2009

The average PISA science score in the OECD member states in 2006 was 500 points. The 29 European countries covered in Fig. 10 averaged 497 points, 3 points less than the OECD average. The highest science score was achieved by Finland, which generally did very well in the PISA assessment. At 563 points, Finland’s science score in 2006 exceeded the score of the second highest ranked country, Estonia, by 32 points or 6 per cent. Given that the average difference between two countries ranked consecutively was just 1 per cent, the Finnish score is exceptional. Besides Finland and Estonia, countries from other areas in Europe also rank among the top 5 in the PISA science scores: The Netherlands achieved 525 points on average; Slovenia 519 and Germany’s 15-year-olds 516 points on average in 2006.

Romania scored lowest of all the countries included in the indicator. In 2006, its PISA science score came to just 418 points. The second lowest score was Bulgaria's at 434 points. These two Eastern European countries are the most recent countries to have joined the European Union. After years under communist regimes, their educational systems are still being reformed. The Romanian PISA score was around a quarter lower than the Finnish one, which was the highest score. The difference amounted to 145 points. Thus Romanian 15-year-olds were far worse prepared for further education and a career in engineering than Finnish teenagers. The Romanian PISA science score was just 84 per cent of the average score of the 29 European countries, whereas the Finnish score was 13 per cent higher than the average.

In the OECD member states, the average percentage of 15-year-olds at PISA level 6 in science in 2006 was 1.3 per cent. Again, the European countries averaged slightly lower at 1.0 per cent, although a high average PISA score in science and a high percentage of students at level 6 do not necessarily go hand in hand. Nevertheless, in Finland the highest PISA science score and the highest percentage of students at PISA level 6 in science coincided in 2006. 3.9 per cent of the 15-year-olds in the country – and hence nearly four times as many as the average in Europe – reached the highest proficiency level. Also, the Finnish percentage was around a third higher than the percentage of 15-year-olds at level 6 in the UK, the country with the second highest share in 2006 at 2.9 per cent. The five countries with the highest fraction of students reaching level 6 in science were Finland, the UK, Slovenia (2.2 per cent), Germany and the Czech Republic (each at 1.8 per cent).

In 2006, Romania had both the lowest PISA score in science and the lowest percentage of 15-year-olds at PISA level 6 in science. Indeed, no Romanian 15-year-olds reached this level. For a country which employed a significant number of engineers in 2007 (cf. Fig. 1), this will pose a serious problem in the future.

Also among the countries that featured relatively small percentages of 15-year-olds at PISA level 6 in science were the Mediterranean countries Portugal (0.1 per cent), Greece (0.2 per cent) and Spain (0.3 per cent). They only attained between 10 and 30 per cent of the average percentage of teenagers at this proficiency level. Also, their shares were only between 3 and 8 per cent of the highest share. Here again, there was a wide range of results.

Overall, Finnish 15-year-olds seem to be exceptionally well prepared for further education and a career in engineering. On the other hand, Romania, with its 15-year-olds lagging far behind, will most likely face a dearth of young engineers in the future.

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