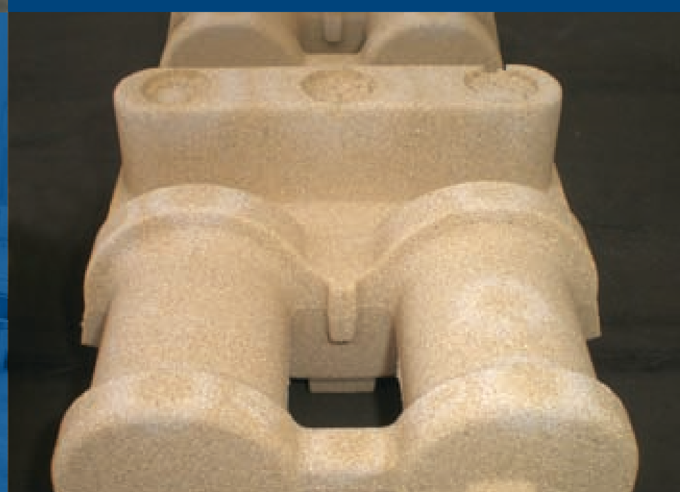
IFC Advisory Services in Eastern Europe and Central Asia

Resource Efficiency in the Ferrous Foundry Industry in Russia

BENCHMARKING STUDY



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RESOURCE EFFICIENCY IN THE FERROUS FOUNDRY INDUSTRY IN RUSSIA

BENCHMARKING STUDY

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CONTENTS

ABBREVIATIONS

RERG	*Resource Efficiency Reference Guide*
DG	*Diagnostics Guide*
BPG	*Best Practice Guide*
BAT	best available techniques
EBP	Europe – best practice performance
EAV	Europe – average performance
RBP	Russia – best practice performance
RAV	Russia – average performance
BP	best practice
Av	average
RUS	Russia
EU	Europe (excluding the Commonwealth of Independent States (CIS))
GER	Germany
OEE	overall equipment effectiveness
TEEP	total effective equipment productivity
kg	kilogram
t, to, tonne	metric tonne
ktonnes	thousand metric tonnes
m^3	cubic meter
mm^3	million cubic metres
kWh	kilowatt hour
GWh	Gigawatt hour
RUB	Russian ruble
EUR	Euro
$	US dollar
bln	billion
CAEF	The European Foundry Association
IMD	International Institute for Management Development (IMD), Lausanne, Switzerland
WCY	*World Competitiveness Yearbook 2009*

EXECUTIVE SUMMARY

Russia's ferrous foundry industry could save up to RUB100 billion ($3.3 billion) annually, and improve individual foundry profitability by up to 15 percent, by matching European Union (EU) standards in the more efficient use of natural resources.

The first ever cross-sector benchmarking study undertaken in Russia, this *Resource Efficiency in the Ferrous Foundry Industry: Case Study* report compares the Russian and European foundry sectors, showcasing efficiency potential and providing practical guidelines to individual foundries as well as to the broader sector.

The results of this research will enable financial institutions (particularly banks and leasing companies) to develop specialist financial products to support improved resource efficiency in Russian enterprises, as well as helping suppliers, service companies, and engineering firms to identify and develop technical solutions to meet the most immediate needs of the sector. Policymakers and senior management involved in the strategic development of the sector will also find the study helpful in identifying those areas in most urgent need of reform, and in developing the strategies necessary to support this.

Why is resource efficiency so important for Russia's ferrous foundry industry?

Given the low costs of labour, energy, and raw materials, Russia's ferrous foundry industry should benefit from a theoretical cost advantage of around 36 percent. However, poor resource efficiency means this advantage is almost entirely lost.

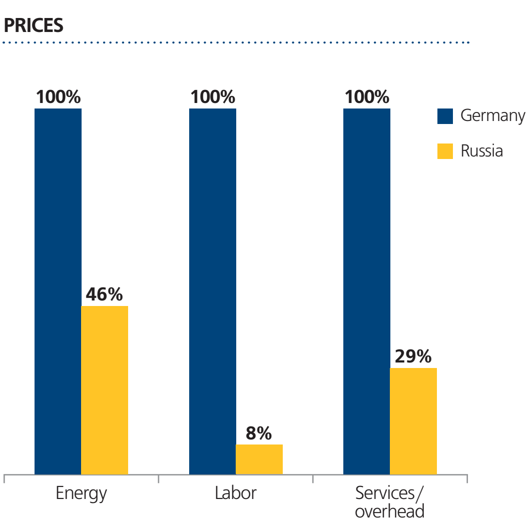
Thus far, Russian foundries have enjoyed highly competitive cost advantages in comparison with countries in Western Europe (for example, Germany):

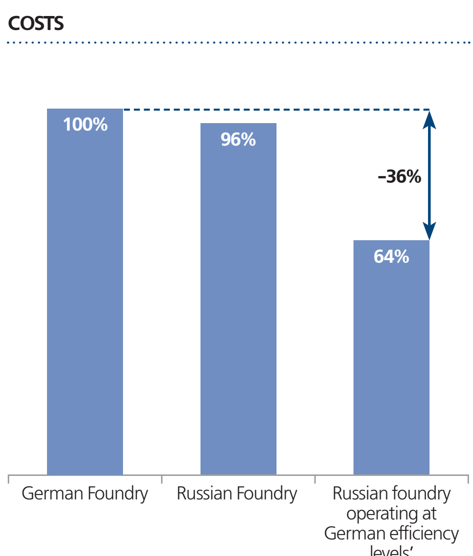
- energy costs are 54 percent lower;
- labour costs are 92 percent lower; and
- overheads and service costs are 71 percent lower.

These advantages do not translate to competitive prices for finished products, however.

- **Lower labour costs are negated by low levels of productivity.** Any competitive advantage in low labour costs is entirely theoretical, since the personnel resources needed to produce an equivalent amount of good-quality castings are 3.3 times higher than in Europe.
- **Low energy costs are negated by high volumes of consumption.** Any competitive advantage in low energy prices is similarly lost, due to high levels of consumption throughout the production process: basic procedures (such as, for example, smelting) use twice as much energy as analogous processes in Europe, and overall energy consumption levels are as much as three times higher.

Figure 1: POOR RESOURCES MANAGEMENT IS COSTING RUSSIAN FOUNDRIES THEIR COMPETITIVE ADVANTAGE





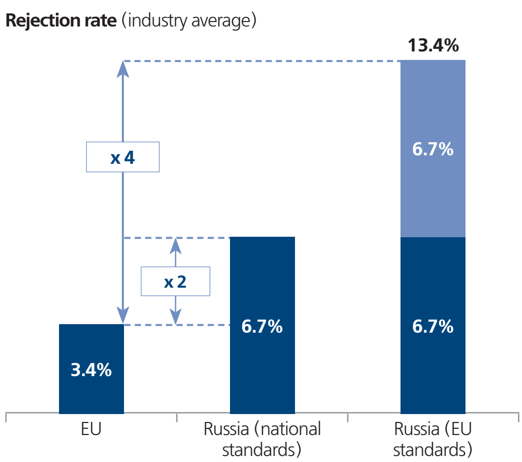
Source: IFC (2010), "Resource Efficiency in the Ferrous Foundry Industry in Russia: Benchmarking Study," October.

As a result, while the benefits of low-cost energy, labour, and natural resources should, as indicated above, give Russian foundries a theoretical competitive advantage in the order of **36 percent,** poor resources management eliminates any price advantage, making Russian products (perceived as offering lower quality and value) uncompetitive in terms of quality–price ratios, and putting them at a further disadvantage in export markets. While prices edge ever nearer to international levels, quality does not meet EU standards.

The current poor quality of castings means Russian producers are denied access to export markets, while falling demand puts even local markets at risk.

Only a few Russian foundries have any experience of exporting beyond the countries of the Commonwealth Independent States (CIS). Foundries producing goods for domestic customers or for export to customers in the CIS have never been subject to the more stringent quality controls in force in the international markets. The volumes of scrapped and rejected products at Russian foundries show considerable variation. While leading producers waste less than one percent of production, the volume of wasted and rejected product can reach between 15 and 30 percent at foundries throughout the country. Waste levels in Russian foundries (i.e., as a percentage of total production) are twice as high as those in European enterprises: and EU quality standards far exceed those in Russia. If Russian foundries were required to adhere to the more stringent quality standards of the European markets, waste volumes would be, on average, four times higher.

Figure 2: REJECTION RATES AT RUSSIAN FOUNDRIES ARE BETWEEN TWO AND FOUR TIMES HIGHER THAN THOSE AT EUROPEAN ENTERPRISES



Source: IFC (2010), "Resource Efficiency in the Ferrous Foundry Industry in Russia: Benchmarking Study," October.

It is therefore extremely important that foundry owners recognise the importance of improved quality as a strategic objective in the capital refurbishment of existing foundries, and the construction of new ones. **Higher quality castings will result in higher added value throughout the market, leading to higher profit margins: better efficiency in resources management (particularly in containing raw materials and energy consumption levels and costs, as well as in improving labour productivity) will also be essential in improving and maintaining profitability.**

Where does the greatest potential for better resources management lie?

Matching the efficiency of the best-performing EU plants would save enough energy to power a typical Russian city of 1.5 million people: and matching EU standards in water efficiency would result in savings equivalent to total residential consumption in the Netherlands.

For each tonne of good-quality castings produced, Russian foundries, in comparison with EU plants, use:

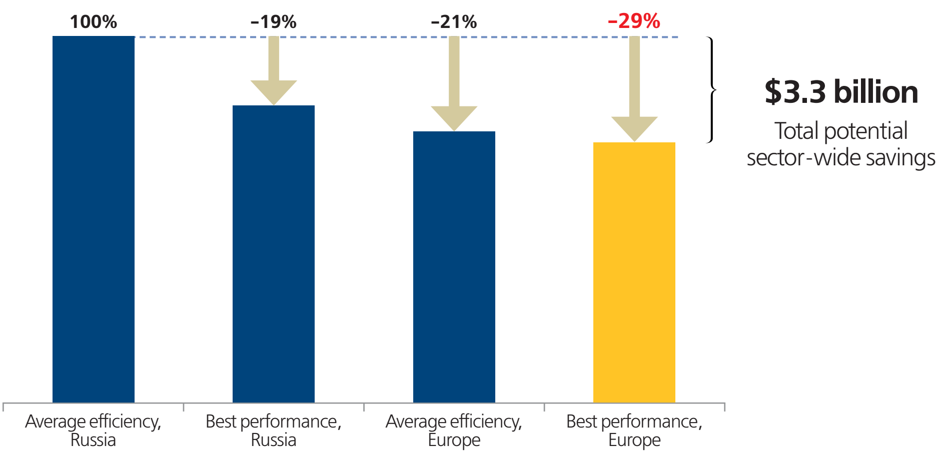
- three times more energy;
- 3.6 times more sand; and
- 161 times more water.

On the basis of Russia's current annual production of 6.1 million tons, matching the efficiency of European plants would save 19,882 gigawatt hours (GWh) of energy, 5.7 million tons of sand, and 879 million cubic meters of water, per year.

Russia's ferrous foundries could save up to $3.3 billion per year.

Matching the resource efficiency of the best-performing EU plants could save RUB100 billion ($3.3 billion) per year (excluding capital expenditure).[1] The study also showed that, in moving towards European best practice, matching even average levels of European efficiency could achieve cost savings in the order of 25 percent (Figure 3).

Figure 3: BETTER RESOURCE EFFICIENCY COULD SAVE $3.3 BILLION ANNUALLY



Assumed cost base comprises raw materials, energy, labor, equipment, and overheads.

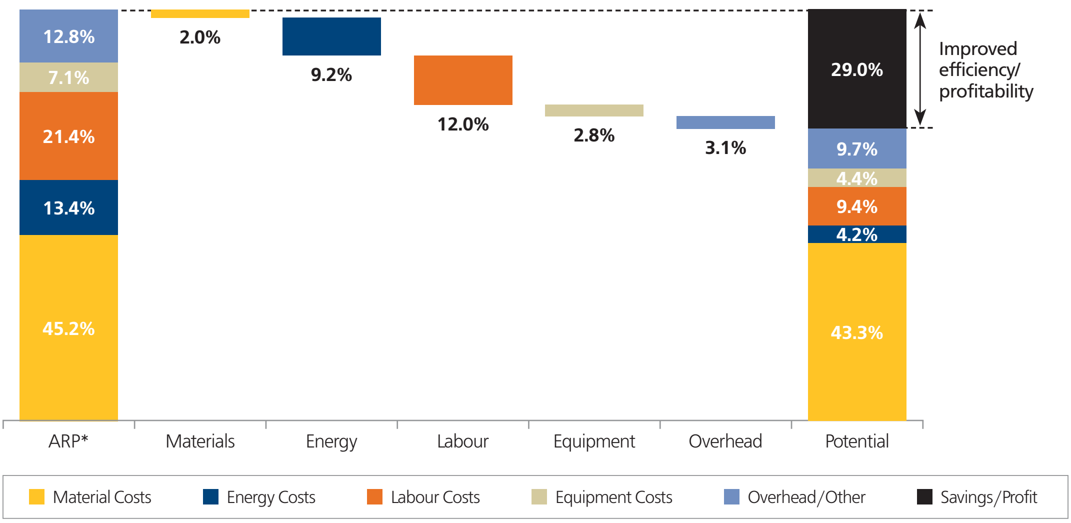
Source: IFC (2010), "Resource Efficiency in the Ferrous Foundry Industry in Russia: Benchmarking Study," October.

1 On the basis that total annual production of 6.1 million tons of castings incurs an estimated total cost of RUB350 billion.

The study also suggests that Russian foundries lag significantly behind their European peers on certain key performance indicators (KPIs), with a direct impact on profitability. In comparison with European foundries, Russian enterprises:

- use 14 percent more metal per tonne of finished product;
- achieve average production volumes per employee 3.6 times lower than those in the EU; and
- utilise equipment and machinery for twice as long as plants in Europe, while utilising only 50 percent of total production capacity.

Figure 4: ENERGY COSTS AND LABOUR SHOW THE GREATEST POTENTIAL FOR IMPROVED EFFICIENCY



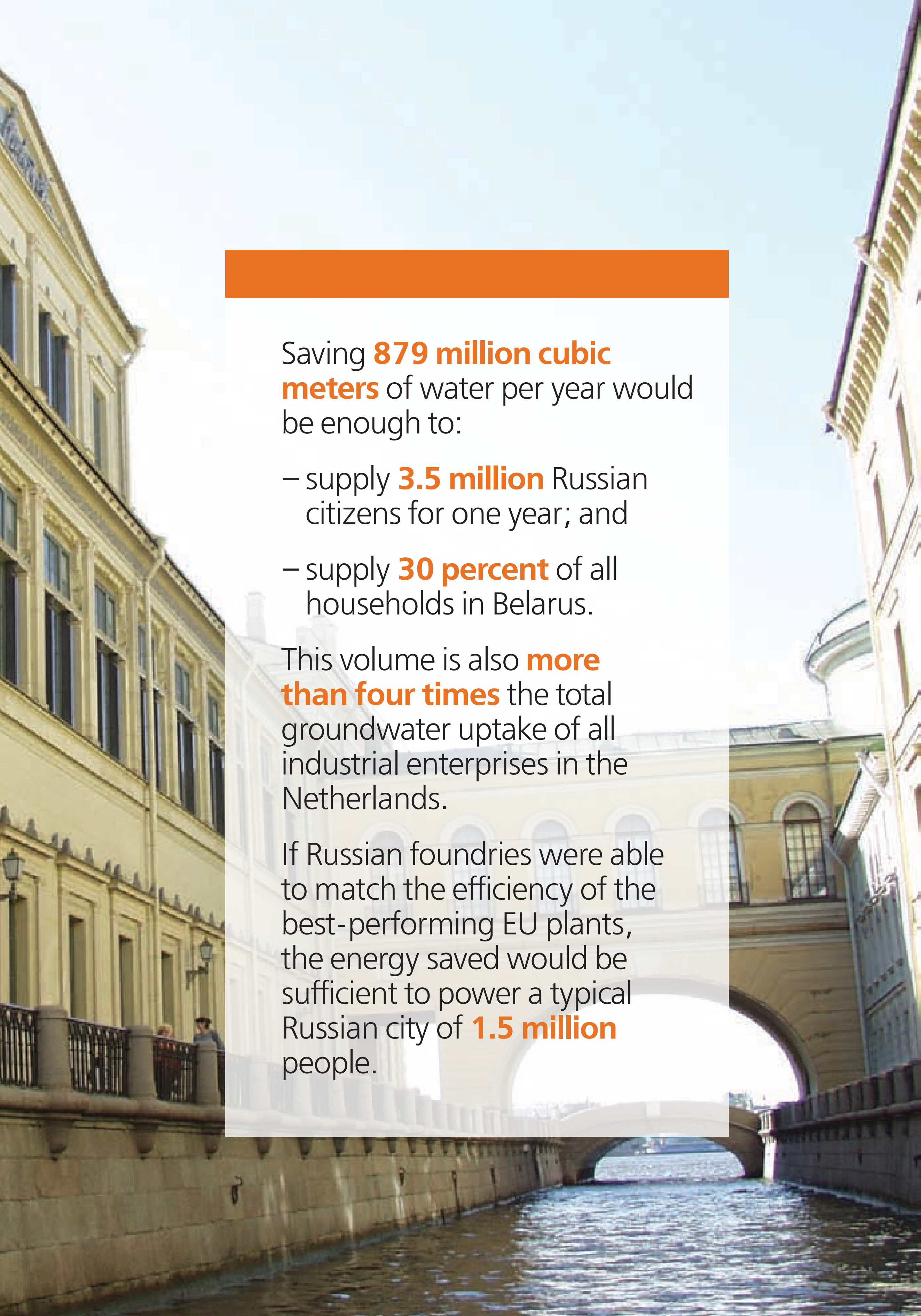
*ARP = av. Russian performance

Source: IFC (2010), "Resource Efficiency in the Ferrous Foundry Industry in Russia: Benchmarking Study," October.

Matching the efficiency of the leading Russian enterprises could achieve savings in the order of 19 percent across the sector as a whole, while individual enterprises could increase operational profitability by up to 15 percent.

The study showed that many leading Russian companies are already actively implementing best international practice in production and resource efficiency. While KPIs for the best Russian enterprises currently only match average efficiency standards in Europe, achieving these standards could, in addition to raising the overall efficiency of the Russian ferrous foundry industry, result in cost savings in the order of 19 percent – or RUB65 billion per year.

Even on the basis of current operating costs and profit margins, better resource efficiency could potentially increase the operating profit of individual enterprises by up to 15 percent.



Saving **879 million cubic meters** of water per year would be enough to:

- supply **3.5 million** Russian citizens for one year; and
- supply **30 percent** of all households in Belarus.

This volume is also **more than four times** the total groundwater uptake of all industrial enterprises in the Netherlands.

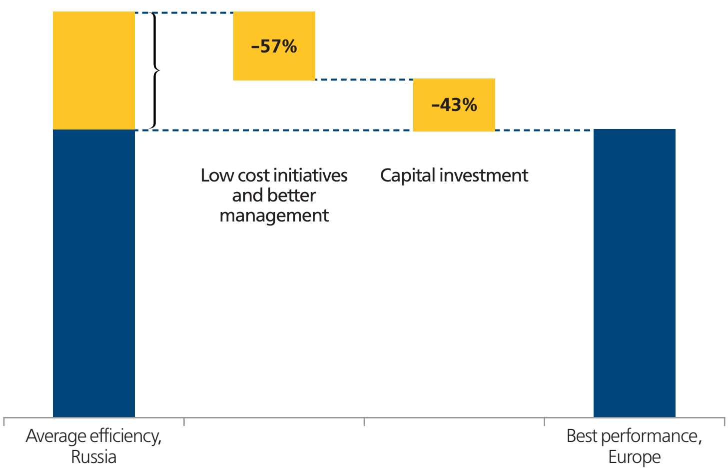
If Russian foundries were able to match the efficiency of the best-performing EU plants, the energy saved would be sufficient to power a typical Russian city of **1.5 million** people.

How can the benefits of better resource efficiency be optimised?

More than half of the savings and benefits that might be achieved through better resource efficiency could be realised through better management practices and various low-cost initiatives alone, with no need for major capital expenditure.

Of the total potential for better resource efficiency in the Russian foundry sector, around 57 percent could be achieved solely through the implementation of low-cost initiatives and improved management practices: less than half (43 percent) would require any capital expenditure or refurbishment.

Figure 5: MOST POTENTIAL COULD BE REALISED THROUGH BETTER MANAGEMENT AND LOW-COST INITIATIVES



Source: IFC (2010), "Resource Efficiency in the Ferrous Foundry Industry in Russia: Benchmarking Study," October.

Opportunities for low-cost initiatives and economically viable resource efficiency projects are often missed because of enterprises' failure to monitor resources consumption.

The study found that 42 percent of Russian foundries have no formal or systematic procedures in place to monitor resources consumption during production: and a substantial majority experience difficulties in monitoring and tracking KPIs. Only one third have certified quality management or management accounting systems in place. Recognised environmental management systems are extremely rare, and training in "lean" management occurs only at the largest enterprises.[2]

2 "Lean" management refers to the cost-driven production management systems initially developed in Japanese industry in the latter half of the 20th century.

The introduction of appropriate process management practices and better monitoring of resources consumption would enable Russian foundries to close the gap on their European peers without, necessarily, incurring significant capital expenditure.

Russian foundries could achieve their optimum potential – in terms of resource efficiency, competitiveness, and profitability – by:

A. Improving operational efficiency and productivity.

1. Attention needs to be most closely focused on those KPIs relating to operational procedures and technological processes since these, more than any others, have the greatest influence on cost reduction.
2. Taking every available opportunity to improve energy efficiency can improve profitability levels by five percent or more. Improved management processes and investment in more energy-efficient plant and machinery can be vital here: minimising energy costs must be a priority in the face of the inexorable rise in energy prices.

B. Making change management an ongoing process.

1. Benchmarking techniques should be used to gain a clear understanding of an enterprise's competitiveness against peers in both Russia and Europe.
2. Clear objectives should be set. Viable cost-reduction and consumption targets should be made clear, as well as the timeframe over which these might realistically be achieved.
3. An environment of continuous improvement is essential. A 2008 report by consultancy firm McKinsey argues that only one third of change-management programs actually succeed – largely because success depends predominantly on the behavior and motivation of individuals.[3] Establishing an environment conducive to the implementation of optimum resource efficiency depends not only on setting key objectives and determining the best way of achieving these, but also on educating and engaging individuals in developing appropriate skills and behaviors. Setting up a dedicated project team (with both internal and external specialist advisors) can be a good first step here: the involvement of external experts acts as a catalyst in eradicating redundant processes and habits, as well as generating new ideas.

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3 *The Inconvenient Truth About Change Management* (2008), Keller, S., and Aiken, C., McKinsey & Company. Available at: http://www.mckinsey.com/clientservice/organisationleadership/The_Inconvenient_Truth_About_Change_Management.pdf.

C. Making full use of available resources.
Following the completion of its *Resource Efficiency in the Ferrous Foundry Industry in Russia: Benchmarking Study,* IFC has recently issued the ***Practical Guide to Resource Efficiency in the Russian Ferrous Foundry Industry,*** published in four standalone volumes.

1. Compendium of Key Performance Indicators

The *Compendium of Key Performance Indicators* includes reference tables of potential KPIs for enterprises in Russia and Europe, including:

- best-performance and average standards, according to various criteria;
- 32 separate classifications covering specific aspects of iron and steel production; and
- KPIs specific to the ferrous foundry industry.

2. Self-diagnostic Guide

Based on the methodologies used in conducting this study, the *Self-diagnostic Guide* enables individual enterprises to collate information and analyze results against various KPIs. With recommendations on data collection, and on the evaluation and analysis of information, resulting conclusions may then be benchmarked against best practice and average standards in Russia and Europe.

3. Best Practice Guide for the Russian Ferrous Foundry Sector

This guide includes a number of strategies for improving performance, and analyzes cross-sectoral experience and best practice in the implementation of new technologies. It includes practical advice on the continuous improvement of new production processes, as well as strategies for the analysis of potential investment in new technologies.

4. Resource Efficiency in the Ferrous Foundry Industry in Russia: Benchmarking Study

The full text of this report brings together the key findings from the benchmarking study, together with recommendations on how the industry's full potential might be realised.

INTRODUCTION

The ferrous foundry industry is fundamental to machine building contributing to up to 90 percent of the its final product. High-quality castings are essential to a range of heavy industries, including railroad and electro industries, vessels building, automotive industry, and many others. Over 80 percent of all ferrous castings in Russia are currently produced in foundries attached to machine-building plants. As a result of obsolete equipment (and low utilization rates of such equipment as exists), these enterprises are frequently cost rather than profit centres – and, moreover are among the most environmentally polluting.

Russia is the fourth largest producer of ferrous castings worldwide – an industry which, globally, is highly dynamic, and showing good levels of growth. During the period 1999–2008, the compound annual growth rate (CAGR) in the BRIC countries averaged 12 percent per year.[4] Production in Russia, however, demonstrated a more modest CAGR of three percent per year (prior to the economic crisis of 2008–09), of which only marginal volumes were produced for export: the poor quality of Russian castings resulting in a less than one percent of total Russian casting being exported. If this trend is allowed to continue Russia will, ultimately, cease to become a net exporter of cast iron, and will be forced to rely increasingly on imports from China and India.

4 The "BRIC" countries comprise Brazil, Russia, India, and China.

A key strategic question for senior management at machine-building and engineering plants, therefore, is: should existing foundries be modernised (and domestic production thus maintained), or should the procurement of castings be outsourced abroad?

Comparing or benchmarking key performance indicators (KPIs) at individual foundries against comparators in Russia and Europe can inform decision making in this respect, highlighting a plant's standing against its domestic and international peers. Identifying shortfalls against KPIs at "average" or "best" enterprises and industry leaders can identify the benefits to be gained in improving performance, and the initiatives necessary to achieve this.

Russian foundries differ significantly from foundries in Europe and the United States, with a lower degree of specialisation and poor quality equipment ultimately resulting in a lower level of competitive-ness.

Benchmarking enables senior management to take informed decisions on whether to: a) invest in modernisation and expansion; b) dispose of or "spin-off" foundries as independent economic units; c) engage in the construction of new, greenfield plants; or d) phase out internal production in favour of outsourcing.

Russian foundries in general have a far lower degree of specialisation than their peers in Europe and the United States, which, benefitting directly from greater independence (i.e., in not being tied to a specific machine-building or engineering plant, as many Russian foundries are) are more competitive on the international markets.

- Over 80 percent of Russian foundries are tied to an affiliated machine-building or engineering plant, and gear the majority of their production to that single client. In Europe and the United States, the position is reversed, with eight percent of all foundries being entirely independent, and supplying a range of clients. Only 20 percent of foundries in these countries are attached to an affiliated machine-building or engineering company.
- Competitiveness is also hampered by the sheer diversity of products that affiliated Russian foundries have to produce. Almost every second foundry in Russia produces different types of final casting products and thus has to maintain different types of technology lines, which are difficult to re-orient for production from one type of casting product to another and which are often not used at their full capacity. All this leads to lower levels of efficiency.

The study also exposed a number of issues with regard to technology and equipment:

- The majority of Russian foundries still utilise outdated and obsolete equipment, with industry-wide deterioration rates of equipment being 75 percent. The use of morally obsolete technologies, as well as resulting in lower levels of efficiency and production, further inhibits Russian foundries' ability to produce goods that are globally competitive in terms of quality and price.
- Only one third of all Russian foundries use fully automated molding lines: a level of automated production prevalent throughout the industry.

The *IFC Resource Efficiency in the Ferrous Foundry Industry in Russia: Benchmarking Study* was undertaken on the basis of comparisons of seven key performance indicators driving the costs and operating profit of a foundry. The study did not cover any issues relating to the strategic development of the foundry sector as a whole (i.e., in terms of industry-wide trends, government policy, or incentives to promote innovation or to support specific sub-sectors) since these demand more in-depth macroeconomic analysis.

The study did, however, identify that the ferrous foundry industry in Russia has considerable potential for better resource efficiency, and that exploiting this potential could have a considerable bearing on the industry's competitiveness.

To support owners, senior management, and specialists at foundry plants in Russia, and based on the results of its *Resource Efficiency in the Ferrous Foundry Industry in Russia: Benchmarking Study,* IFC has recently issued a Practical Guide to Resource Efficiency in the Russian Ferrous Foundry Industry, published in four standalone volumes.

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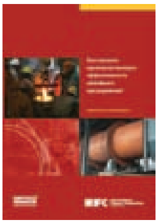

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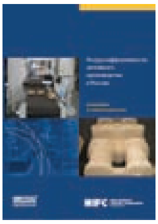
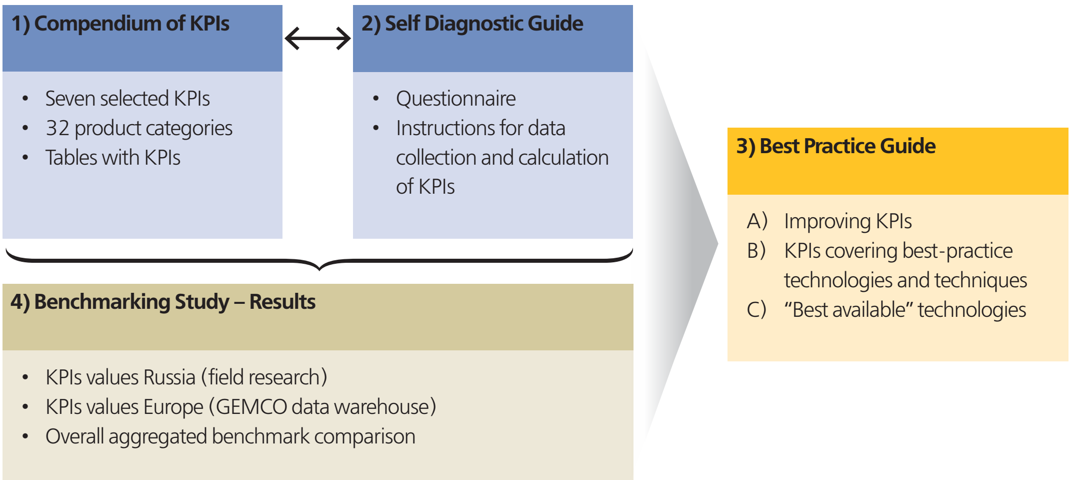


4. Resource Efficiency in the Ferrous Foundry Industry in Russia: Benchmarking Study

The full text of this report brings together the key findings from the benchmarking study, together with recommendations on how the industry's full potential might be realised.

Figure 1.6: PRACTICAL GUIDES ON RESOURCE EFFICIENCY IN THE FERROUS FOUNDRY INDUSTRY IN RUSSIA



Structure of this report

This report is structured as follows.

- Chapter 2 outlines the methodology used in conducting the benchmarking study.
- Chapter 3 summarises the key findings of the study, with analysis of results and data. In addition to comparing aggregated data for plants in Russia and Europe, the implications of this are assessed in terms of the seven KPIs on which the study was based: i) process yield; ii) production efficiency; iii) capacity utilisation; iv) energy consumption; v) fresh water consumption; vi) fresh sand consumption; and vii) labour productivity. The chapter concludes with an analysis of the potential financial benefits of improved performance in respect of each KPI, and includes an overview of technologies and management systems currently used in Russia.
- Chapter 4 outlines key recommendations on maximising the potential of improved resource efficiency in ferrous foundries in Russia.

There is no doubt that improving the competiveness of individual foundries in Russia will raise the competitiveness of the ferrous foundry and machine-building industries in the country, as a whole.

The results of this research will also enable financial institutions (particularly banks and leasing companies) to develop specialist financial products to support improved resource efficiency in Russian enterprises, as well as helping suppliers, service companies, and engineering firms to identify and develop technical solutions to meet the most immediate needs of the sector. Policymakers and senior management involved in the strategic development of the sector will also find the study helpful in identifying those areas in most urgent need of reform, and in developing the strategies necessary to support this.

BENCHMARKING STUDY: METHODOLOGY

The *Resource Efficiency in the Ferrous Foundry Industry in Russia: Benchmarking Study* was conducted on the basis of hard data received from Russian foundries returning a completed questionnaire, analysed against data maintained by GEMCO Engineers B.V./Knight Wendling GmbH on projects undertaken at various European ferrous foundries.

The *Resource Efficiency in the Ferrous Foundry Industry in Russia: Benchmarking Study* was conducted on the basis of the following criteria.

- Seven specific KPIs, consisting of: i) process yield; ii) production efficiency; iii) capacity utilisation; iv) energy usage; v) fresh water consumption; vi) fresh sand consumption; and vii) labour productivity.
- KPIs determined on the basis of production profiles and volumes derived from nationwide average trends, calculated on the basis of all foundries participating in the data collection process.
- Values derived from 32 different foundry product categories.
- Factual data received from Russian ferrous foundries returning a completed questionnaire: foundries were classified according to categories outlined in the IFC *Compendium of Key Performance Indicators.*
- Product categories adjusted to reflect Russian and world ferrous casting categories.

The data collected was deemed to constitute an adequate database for analysis and evaluation.

- Fifty five datasets were sourced from individual foundry production units.
- Data were analysed on the basis of averages calculated over the years 2007, 2008, and 2009 – meaning that, effectively, some 150 individual datasets were returned and analysed.
- The total production volumes of all foundries participating in the study amounted to 478,000 tonnes. Production covered products from 27 of the 32 product categories classified in the study (84 percent).
- At 478,000 tonnes, the total production volumes of all foundries participating in the study constituted 14 percent of total Russian ferrous casting production).
- Data were received from both major and smaller foundries.
- Data were received from foundries using a range of technological processes, for the production of both castings and mouldings.
- Data were received from both "single-product" and "multiple-product" foundries.

Foundries were benchmarked on the basis of seven specific KPIs.
The following KPIs were used to monitor the operational performance of key manufacturing functions within individual ferrous foundries.

- **KPI No. 1, "Process yield."**
  This KPI was compiled on the basis of four sub-indicators:
  - melting loss;
  - pig and spillage;
  - runners and risers; and
  - scrap castings and rejects.
- **KPI No. 2, "Production efficiency" (overall equipment effectiveness (OEE)).**
  This KPI was compiled on the basis of four sub-indicators relating to the moulding process:
  - down time;
  - slow running effects;
  - bad moulds; and
  - scrap castings and rejects.
- **KPI No. 3, "Capacity utilisation" (total effective equipment productivity (TEEP)).**
- **KPI No. 4, "Energy consumption."**
- **KPI No. 5, "Fresh sand consumption."**
- **KPI No. 6, "Fresh water consumption."**
- **KPI No. 7, "Labour productivity."**

Figure 2.1: KEY PERFORMANCE INDICATORS (KPIS)

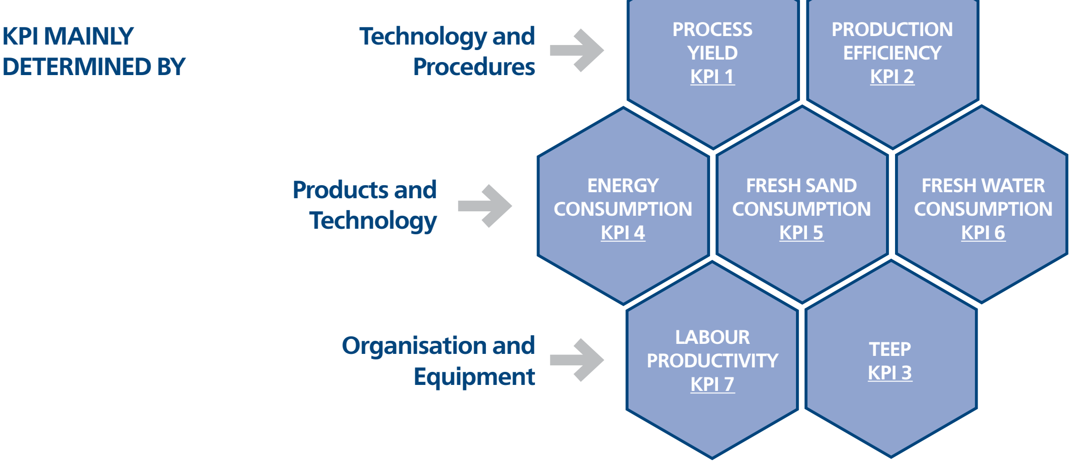
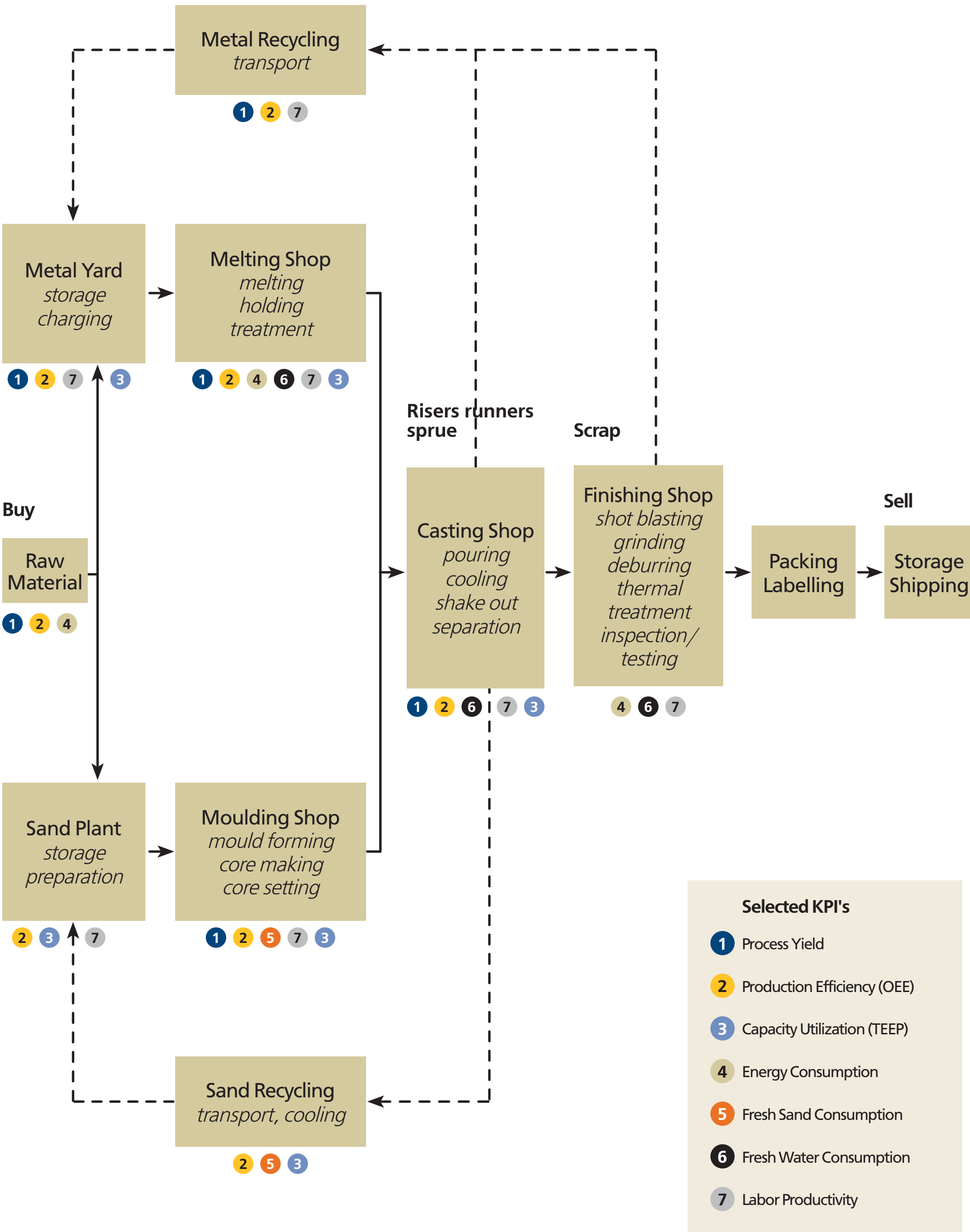


Figure 2.2: SELECTED KPIS



Benchmarking comparisons were based on KPIs across the full product mix of all foundries in the survey, calculated as a weighted average on the basis of total production in each product category.

Product categories:

- The survey focused on three major product categories: "grey iron," "ductile iron," and "steel castings," each of which differs in terms of the specific KPIs most relevant to it. For that reason, it was important to ensure the data reflected a mix of foundries and products consistent with the wider ferrous foundry industry in Russia.
- The data sample was cross-matched against statistics sourced from the European Foundry Association (CAEF) and the Russian Foundry Association (RFA). It was found to deliver a good match in terms of the product categories outlined in Table 2.1, below.

Table 2.1: SURVEY DATA COMPOSITION (BY PRODUCT CATEGORY AND DATA SOURCE)

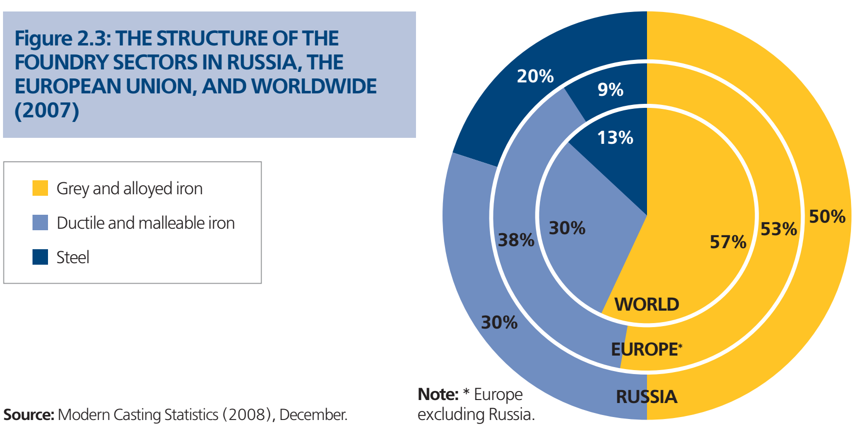
Product category		Benchmarking Study (data 2007, 2008, 2009)		CAEF (data 2007–08)	RFA (data 2008)
Grey iron	Automatic	35%	50%	50%	84%
	Mechanised	11%			
	Hand	5%			
Ductile iron	Automatic	25%	26%	30%	
	Mechanised	0.4%			
	Hand	1%			
Steel	Automatic	0.1%	24%	20%	16%
	Mechanised	22%			
	Hand	2%			

Note: "CAEF" is the European Foundry Association (www.caef.org) and "RFA" is the Russian Foundry Association (www.ruscastings.ru).

Global comparisons (by product category)

Overall benchmarking standards were set on the basis of industry-wide production in Russian foundries, despite some differences in the total Russian product mix in comparison with European and worldwide production (Figure 2.3, below). Russia produces proportionately more steel castings and fewer ductile castings (by volume), than both Europe and the rest of the world.

Figure 2.3: THE STRUCTURE OF THE FOUNDRY SECTORS IN RUSSIA, THE EUROPEAN UNION, AND WORLDWIDE (2007)



Source: Modern Casting Statistics (2008), December.

Note: * Europe excluding Russia.

It is anticipated that ductile and malleable iron will become increasingly important in terms of total production in Russia as production of steel castings, forgings, and fabrications begins to decrease.

Ductile iron castings exhibit many similar properties to steel castings. However, they are much cheaper than steel castings and are easier to cast. Purchasers in price-sensitive industries (e.g., the automotive industry) prefer to use ductile castings rather than steel castings, where possible. Producers operating throughout Russia, and those exporting on the international markets, will require more ductile castings (and fewer steel-cast components) in the future.

Data were collected from Russian foundries over a period of three years, from 2007 to 2009, inclusive. However, production volumes showed considerable variation during this period, as a result of the current economic crisis.

KPIs were calculated as an average across all years from 2007 to 2009. On that basis, total production across all three years was 84 percent of total production in 2007. This lower average volume was found to have a significant impact on two KPIs in particular:

- production efficiency (OEE) (scheduled operational time unadjusted); and
- capacity utilisation (TEEP).

Table 2.2: A TOTAL 32 PRODUCT CATEGORIES WERE IDENTIFIED

Since the ferrous foundry industry is so highly segmented, it is important that any benchmarking analysis take account of key differentiating factors (material, technology, and product type).

GREY IRON (product categories)	DUCTILE IRON (product categories)	STEEL (product categories)
Automatic moulding		
GABH = automotive engine blocks and cylinder heads **GAAO** = automotive other **GAAG** = agriculture **GAMI** = mining	**DAAU** = automotive other **DAGE** = general engineering	**SARC** = railway components (c) **SAMM** = mining components (m) **SAAC** = commercial vehicles (c) **SAGC** = general engineering (c)
Mechanised moulding		
GMBH = medium size engine blocks and heads (energy generation) **GMAG** = agriculture **GMMI** = mining **GMGE** = general engineering	**DMAU** = automotive **DMGE** = general engineering	**SMRC** = railway components (c) **SMMM** = mining components (m) **SMPC** = pumps and valves (c) **SMPS** = pumps and valves (s) **SMGC** = general engineering (c) **SMAC** = commercial vehicles (c)
Manual (hand) moulding		
GHBH = large size engine blocks and heads (energy generation) **GHMI** = mining **GHGE** = general engineering	**DHEN** = energy generation components **DHCO** = compressor components **DHGE** = general engineering	**SHMM** = mining components (m) **SHPC** = pumps and valves (c) **SHEA** = energy components (a) **SHGC** = general engineering (c)

Key: (c) is carbon steel; **(s)** is stainless steel; **(m)** is manganese steel; **(a)** is high-alloy steel

The data collected provides an adequate basis for analysis and evaluation.

- The total production volumes of all foundries participating in the study amounted to 478,000 tonnes, and covered products from 27 of the 32 of the product categories identified (84 percent).
- Any gaps in the coverage of product categories was covered by the interpolation of data based on total-industry, Russia-wide performance.
- Data were also cross-matched against the proportional distribution of all product categories comprising total Russia-wide production.

The quality of the analysis, and of the conclusions reached, can only be as good as the quality of the data provided, however.

- All data has been taken at face value, and has been used on the basis of questionnaires returned.

- Some of the data received had clearly not been measured, but, rather, had been estimated or projected. This was evidenced by:
  - performance levels recorded as identical for all three years;
  - consumption levels identical across all three years;
  - individual parameters recorded as precise whole numbers (rather than recorded to one or more decimal points); and
  - parameters showing no change despite changes in the product mix.

- Some data received was deemed to be dubious. Such data included:
  - foundries recording no melting loss (no furnace can melt without some melting loss); and
  - foundries recording no scrap, bad moulds, or downtime over the three years from 2007–09.

- Where Knight Wendling GmbH believed responses to be questionable further clarification was sought: questionable data which could not be clarified were disregarded.

The collection of data is the start of a process, not the end of one.

The data reported clearly indicate that performance monitoring could be improved, potentially by:

- measuring and recording data accurately, automatically, and on a regular basis; and
- analysing data and instigating measures for the continuous improvement of this process.

On some KPIs **Russia's best foundries triumph over** the best in Europe. However, these cases are rare and, where they occur, unique.

In terms of competitiveness, the Russian foundry industry lags significantly behind Europe – being between **1.5 and four times less competitive.**

3

BENCHMARKING STUDY: KEY FINDINGS

3.1 ANALYSIS OF AGGREGATED DATA

Key performance indicators (KPIs) monitor operational performance on the basis of physical values (tonnes, cubic metres, time, man-hours, etc.). By comparing KPIs, e competitive advantage (or the “operations gap”) can be monitored. This section compares the aggregated performance of all those Russian ferrous foundries participating in the benchmarking survey, together producing the total product mix as described above.

Results for KPIs across all foundries
(all categories: grey iron, ductile iron, and steel castings)

Table 3.1: KEY PERFORMANCE INDICATORS (KPIs) – EUROPE AND RUSSIA

Overall Foundries Key Performance Indicators Iron and Steel	EUROPE		RUSSIA	
	Overall weighted		Overall weighted	
	Best practice	Average perfor-mance	Best practice	Average perfor-mance
1. Process yield (%) (from four sub-indicators)	**64.1**	**59.4**	**66.2**	**52.3**
melting loss (%)	1.9	3.2	2.6	4.5
pig and spillage (%)	2.4	3.0	1.7	3.3
runners & risers (%)	31.5	34.5	29.3	39.3
scrap & rejects (%)	2.1	3.4	2.2	6.7
2. OEE (moulding) (%) (from four sub-indicators)	**81.1**	**77.3**	**86.9**	**48.4**
downtime (%)	11.9	14.2	4.6	22.7
slow running (%)	5.1	5.7	6.5	30.3
bad moulds (%)	0.8	1.1	0.5	3.8
scrap & rejects (%)	2.1	3.4	2.2	6.7
3. TEEP (%) Capacity utilisation	**63.9**	**53.5**	**43.6**	**25.2**
4. Energy consumption (kWh per to produced)				
for melting (kWh/to melt)	544**	560**	779**	1164**
for casting (kWh/to cast)	1247	1453	3155	4506
5. Sand consumption (per ton good casting)				
Fresh sand (to sand/to cast)	0.312	0.349	0.583	1.252
Sand regeneration (%)	95.9	94.0	95.6	89.2
6. Fresh water consumed (m^3 per to good casting)	**0.76**	**0.90**	**17.10**	**144.89**
7. Labour productivity (man-hr/to good casting)	**15.1**	**21.0**	**26.7**	**75.2**

** **Note:** Excludes post-tap refining

Efficiency levels at ferrous foundries differ significantly between those producing iron (grey and ductile iron) and those producing steel products.

Analysis of average performance against benchmarks

The benchmarking of average performance levels highlights significant differences between European and Russian foundries.

To produce an equivalent volume (one tonne) of good castings, Russian foundries:

- process 14 percent more metal (of which most is recycled);
- operate plant and facilities for 60 percent longer;
- consume 2.1 times more energy for melting;
- consume 3.1 times more energy, in total;
- consume 3.6 times more fresh sand;
- consume 161 times more fresh water;
- need 3.6 times more man-hours;
- operate at only half the capacity utilisation of European foundries.

Table 3.2: KPIs AT FOUNDRIES PRODUCING GREY IRON AND DUCTILE IRON, AND THOSE PRODUCING STEEL PRODUCTS (BENCHMARK SURVEY SAMPLE)

Overall Foundries Key Performance Indicators	Iron Castings				Steel Castings			
	Europe		Russia		Europe		Russia	
	Best practice	Average perfo-mance	Best practice	Average perfo-mance	Best practice	Average perfo-mance	Best practice	Average perfo-mance
	Iron Castings *weighted*	Iron Castings *weighted*	Iron Castings *weighted*	Iron Castings *weighted*	Steel Castings *weighted*	Steel Castings *weighted*	Steel Castings *weighted*	Steel Castings *weighted*
1. Process yield (%) (from four sub-indicators)	**69.1**	**64.2**	**64.6**	**52.5**	**49.6**	**45.3**	**71.0**	**51.6**
melting loss (%)	1.0	2.0	2.0	4.1	4.9	7.1	4.3	5.8
pig and spillage (%)	1.9	2.4	1.6	2.9	4.0	5.0	1.9	4.7
runners & risers (%)	27.8	30.9	31.3	39.2	43.5	46.0	23.0	39.5
scrap & rejects (%)	1.6	2.9	2.3	7.2	3.8	5.0	1.7	5.0
2. OEE (moulding) (%) (from four sub-indicators)	**81.9**	**77.9**	**85.9**	**44.1**	**78.7**	**75.1**	**90.1**	**63.2**
downtime (%)	11.9	14.3	4.1	23.8	12.0	14.0	6.2	19.1
slow running (%)	4.6	5.2	8.0	35.1	6.8	7.5	1.6	15.3
bad moulds (%)	1.0	1.3	0.5	4.0	0.3	0.5	0.6	2.9
scrap & rejects (%)	1.6	2.9	2.3	7.2	3.8	5.0	1.7	5.0
3. TEEP (%) Capacity utilisation	**68.3**	**56.3**	**35.7**	**22.3**	**50.2**	**44.8**	**69.5**	**34.2**
4. Energy consumption (kWh per to produced)								
for melting (kWh/to melt)	558	571	807	1118	500**	525**	686**	1310**
for casting (kWh/to cast)	1165	1338	3014	4235	1503	1815	3604	5359
5. Sand consumption (per ton good casting)								
Fresh sand (to sand/to cast)	0.31	0.34	0.35	0.70	0.33	0.36	1.31	2.99
Sand regeneration (%)	96.1	94.8	96.6	94.3	95.1	91.6	92.6	73.0
6. Fresh water consumed (m^3 per to good casting)	**0.8**	**0.9**	**20.9**	**173.2**	**0.7**	**0.8**	**4.6**	**55.8**
7. Labour productivity (man-hr/to good casting)	**11.5**	**16.3**	**24.0**	**59.6**	**26.3**	**35.7**	**34.3**	**124.3**

** **Note:** Excludes post-tap refining

Ratios of KPIs across Russia and Europe (benchmark survey sample)

Ratios of KPIs highlight the volume of resources used in Russian foundries in comparison with those in Europe: depending on the KPI, a high ratio can indicate a good or bad performance.

Table 3.3: RATIOS OF KPIs ACROSS RUSSIA AND EUROPE (BENCHMARK SURVEY SAMPLE)

RATIO Key Performance Indicators	Iron Castings		Steel Castings		Iron and Steel		
	Best practice	Average perfo-mance	Best practice	Average perfo-mance	Best practice	Average perfo-mance	
	RUS/EU *weighted*	RUS/EU *weighted*	RUS/EU *weighted*	RUS/EU *weighted*	RUS/EU *weighted*	RUS/EU *weighted*	
1. Process yield (%) (from four sub-indicators)	**0.93**	**0.82**	**1.43**	**1.14**	**1.03**	**0.88**	High ratio = high performance
melting loss (%)	2.00	2.05	0.88	0.82	1.37	1.41	High ratio = high losses => low performance
pig and spillage (%)	0.84	1.21	0.48	0.94	0.71	1.10	
runners & risers (%)	1.13	1.27	0.53	0.86	0.93	1.14	
scrap & rejects (%)	1.44	2.48	0.45	1.00	1.05	1.97	
2. OEE (moulding) (%) (from four sub-indicators)	**1.05**	**0.57**	**1.14**	**0.84**	**1.07**	**0.63**	High ratio = high performance
downtime (%)	0.34	1.66	0.52	1.36	0.39	1.60	High ratio = high losses => low performance
slow running (%)	1.74	6.75	0.24	2.04	1.27	5.32	
bad moulds (%)	0.50	3.08	2.00	5.80	0.63	3.45	
scrap & rejects (%)	1.44	2.48	0.45	1.00	1.05	1.97	
3. TEEP (%) Capacity utilisation	**0.52**	**0.40**	**1.38**	**0.76**	**0.68**	**0.47**	High ratio = high performance
4. Energy consumption (kWh per to produced)							High ratio = high consumption => low performance
for melting (kWh/to melt)	1.45	1.96	1.37	2.50	1.43	2.08	
for casting (kWh/to cast)	2.59	3.17	2.40	2.95	2.53	3.10	
5. Sand consumption (per ton good casting)							
Fresh sand (to sand/ to cast)	1.14	2.03	3.97	8.23	1.87	3.59	
Sand regeneration (%)	1.01	1.00	0.97	0.80	1.00	0.95	High ratio = high performance
6. Fresh water consumed (m³ per to good casting)	**26.13**	**192.44**	**6.57**	**69.75**	**21.38**	**161.00**	High ratio = high consumption => low performance
7. Labour productivity (man-hr/to good casting)	**2.09**	**3.66**	**1.30**	**3.48**	**1.77**	**3.58**	

* **Note:** The large gap in water consumption reflects the data returned, and may merit more detailed analysis on site. It is assumed that some foundries included recycled water in their calculation of “fresh” water consumption.

Russian foundries could save approximately RUB100 billion per year on total production of six million tonnes of castings by matching European best practice in the more efficient use of energy, sand, and water.

Russian foundries use **14% more metal to produce one tonne of finished product.**

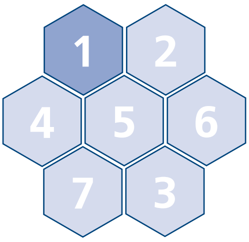
Why?

– wastage and scrap volumes are **twice as high as those in Europe;**

– **melting losses** are, on average, **40 percent higher;**

– obsolete technologies and inadequate control procedures constrain productivity.

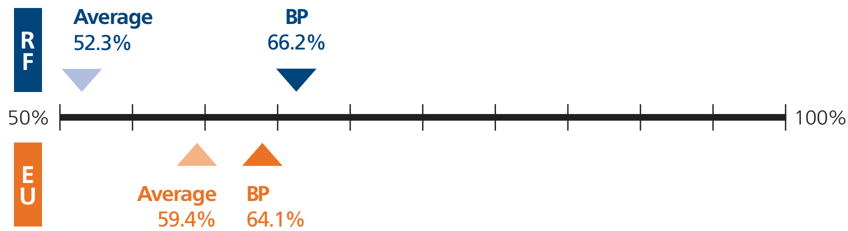
3.2 COMPARISON OF KPIS FOR RUSSIA AND EUROPE



3.2.1 PROCESS YIELD

Comparative results for KPI No. 1, "Process yield"

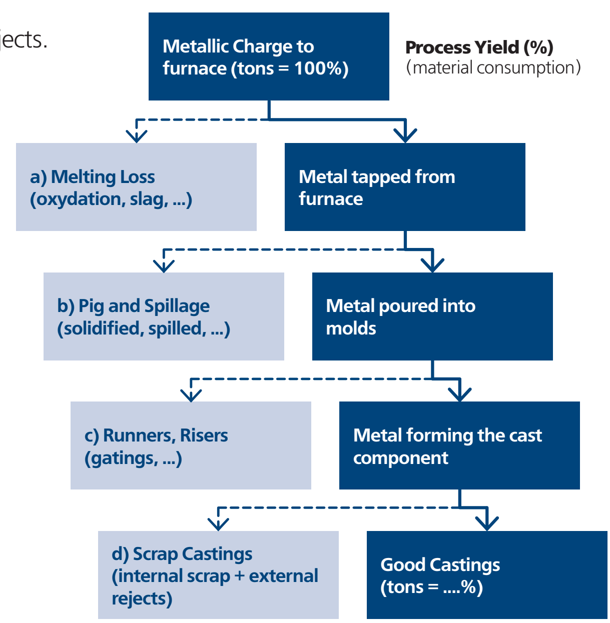
Factor	Europe	Russia
Best practice (BP)	1.0	1.03
Average practice	1.0	0.88[5]



The "process yield" describes the material balance over the manufacturing process. The quantity of good castings sold is expressed as a percentage of the metallic raw material charged to the furnaces. This is an important parameter as it measures how efficiently a foundry uses its raw material.

Process yield comprises four sub-indicators (each expressed as a percentage of total production):

a) melting loss;
b) pig and spillage;
c) runners and risers;
d) scrap castings and rejects.



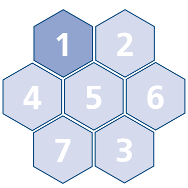
5 On average, Russian foundries have to process 14 percent more metal than European foundries to produce the same volume of good-quality castings: 59.4 / 52.3 = 1.14.

Increasing the process yield has an effect on:
- improved material use, as well as on:
  - lower energy consumption;
  - the potential for higher labour utilisation and the potential for improved capacity utilisation.

The main areas of difference (on average, in terms of Russian losses vs. those in the EU) concern:
- scrap castings and rejects: 1.97 (or 97 percent more);
- melting loss: 1.41 (or 41 percent more);
- box yield (runners and risers): 1.14 (or 14 percent more).

Major differences between Russian and European foundries include:
- the greater use of arc furnaces in Russia;
- generally lower-technology moulding systems;
- lack of process control.

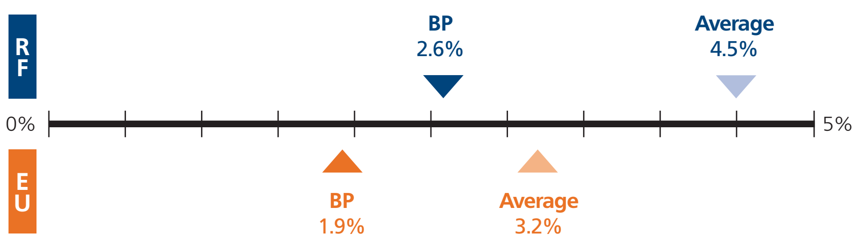
Actions
Carry out detailed foundry audits on individual plants to identify specific differences and potential improvements.



3.2.1.1 Improving KPI No. 1.1, "Melting loss"

Comparative results for KPI No. 1.1, "Melting loss"

Factor	Europe	Russia
Best practice (BP)	1.0	1.37
Average practice	1.0	1.41



"Melting loss" is the material lost during melting (either by oxidation or incorporation into the slag), expressed as a percentage of the metallic material charged to the melting furnaces.

The melting loss has a direct impact on the consumption and cost of raw materials. The melting loss includes:
- a "necessary" loss, necessary to achieve the required chemical composition for the desired alloy properties;
- an "unnecessary" loss, resulting from sub-optimal material qualities, production processes, and technology.

The impacts of melting loss on the performance of a foundry include the following.
- A direct impact on the consumption and cost of raw materials.
- A direct impact on energy costs (since the lost metal has been melted).
- If the melting plant is the bottleneck of the foundry:
  - an impact on capacity utilisation (capital costs);
  - an impact on labour costs (productivity).

The melting loss differs in accordance with the melting processes applied.

KPI 1.1 "Melting loss"	EUROPE		RUSSIA	
	Best practice	Average	Best practice	Average
Induction melting	1.0%	2.0%	1.0–3.0%	1.4–7.7%
Cupola melting	2.0%	4.0%	2.8–5.0%	2.8–9.0%
Arc melting	4.0–5.0%	5.0–7.5%	4.2–5.6%	4.3–9.2%

Reasons for excessive melting loss include:
a) the quality of charged material;
b) the sequence of charged material;
c) holding material at high temperatures for extended periods of time;
d) incorrect refractory application (inferior material as a lining would cause more slag);
e) poor slag chemistry control;
f) inadequate melting equipment.

To improve KPI 1.1, "Melting loss:"

a) Select charge material of the correct quality:
- the composition of the "cold set-up" of raw materials must fit the required final cast material specification, in order to:
  - avoid the later addition of missing alloy/trim additions, because these are higher in burn-off;
  - avoid additional metallurgical steps to reduce elevated chemical elements;

- ensure the raw material is kept dry and free from white frost or any other source of water, and purchase alloy additions with a low content of chemically bond water inside:
  - humidity will cause chemical reactions resulting in oxidation and hydration, as well as losses of various important chemical elements;
  - moisture influences the consumption of elements initially provided to compose the required specification;

- ensure the raw material is kept free from dirt such as oil, grease, sand, rust, etc.:
  - dirt of this kind is weighed and charged but does not contribute to the amount of liquid metal: it must therefore be replaced by additions;
  - the emission of oxygen (i.e., evidenced by rust) or other gases in the melt will lead to increased burn-off or excessive slag;
  - since dirt influences the chemistry and leads to the necessary addition of certain elements, keep the material clean and, if possible, shot-blast the return;
  - avoid the use of zinc-coated scrap.

b) Follow the optimum sequence when charging material:
- an incorrect cold set-up sequence will lead to inhomogeneous melt, which finally results in higher burn-off (stirring by overheating and convection);
- the later addition of elements in order to correct the melt will always lead to higher burn-off or slag.

c) Avoid non-metallurgical overheating and extended holding times:
- avoid losses related to diffusion: diffusion is a function of temperature and time – higher temperatures and longer periods of time rapidly increase losses;
- melt as quick as possible and accomplish the necessary overheating;
- avoid high corrections between melting and tapping by adjusting the metal analysis in the charge preparation.

d) Apply the correct refractory (lining of the furnace);
- if the melt and refractory do not fit together the melt will chemically react with the refractory, leading to elevated slag, burn-off, and conglomerates.

e) Control slag chemistry carefully:
- if slag control is poor some important elements may be trapped in the slag and need to be replaced later.

f) Apply adequate melting technology:
- for select certain technology (induction, cupola, arc, etc.) the melting loss is fixed within a certain range. Despite this, losses can be reduced by upgrading equipment to state-of-the-art technology;
- modern state-of-the-art equipment has improved performance in the following ways:
  - higher-energy density increases the melting rate and reduces losses over time;
  - better heat-exchange processes allow much higher energy transfer effectiveness and thereby reduce losses over time.

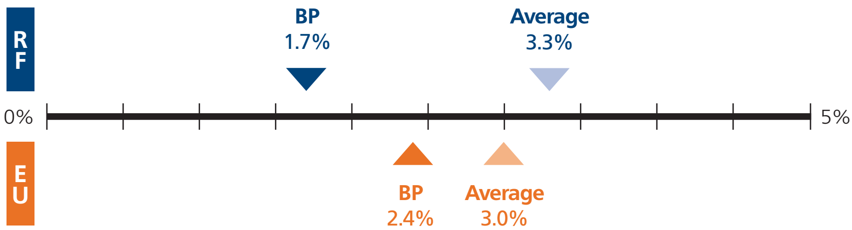
Impact on the bottom line.

Reducing melting loss will result in:
- reduced consumption of metal (because most of the metal lost has to be replaced);
- reduced consumption of energy (because the energy consumed in melting the lost metal is wasted).

3.2.1.2 Improving KPI No. 1.2, "Pig and spillage"

Comparative results for KPI No. 1.2, "Pig and spillage"

Factor	Europe	Russia
Best practice (BP)	1.0	0.71
Average practice	1.0	1.10



"Pig and spillage" refers to the amount of liquid metal tapped from the furnaces (and which does not get poured into moulds), expressed as a percentage of the liquid metal tapped.

The impact of pig and spillage loss on the performance of a foundry is as follows.

- Some five to ten percent of pig and spillage is lost material and has to be disposed of; such material cannot be recycled since it contains ingredients which are not required in the next scheduled charges.
- Some 90–95 percent of material can be recycled but:
  - further losses occur with melting loss;
  - it is necessary to add further alloys or trimming additions;
  - further energy is required for melting;
  - further melting capacity and labour are required at the melt shop;
  - if the melt shop is the bottleneck, further plant capacity and labour are consumed.

Losses incurred through pig and spillage vary:

- in relation to the melting processes applied;
- in relation to moulding technology: the hand-moulding process will always involve an excess of melt, necessary to avoid having insufficient metal available (which could potentially ruin an entire large casting).

KPI 1.2 "Pig and spillage"	EUROPE		RUSSIA	
	Best practice	Average	Best practice	Average
Induction melting	1.6–4.0%	2.5–5.0%	1.0–4.8%	1.5–6.0%
Cupola melting	1.6–4.0%	2.5–5.0%	1.0–4.8%	1.5–6.0%
Arc melting	4.0%	5.0%	1.0–5.0%	2.4–9.1%

Reasons for excessive pig and spillage loss include:
a) incorrect metal analysis (which cannot be poured into moulds since this would result in scrap castings);
b) incorrect metal temperature in the ladle (as above);
c) moulding line breakdown after tapping;
d) fragile or vulnerable production plan;
e) inadequate pouring technology and procedures.

To improve KPI 1.2, "Pig and spillage:"

a) Release melt for pouring only in line with correct metal analysis:
- install test equipment close to the furnaces for:
  - thermal analysis;
  - wedge test;
  - spectrometer;
- edit instructions for sampling, testing, and documentation.

b) Ensure the correct metal temperature in the ladle:
- use only preheated ladles;
- measure temperature before tapping;
- closely synchronise tapping with progress at moulding.

c) Minimise moulding line breakdown time:
- always have spare patterns ready, to replace damaged patterns;
- repair damaged patterns as soon as possible;
- ensure the repair of moulding line damage as fast as possible;
- ensure essential spare parts for moulding lines need are available at all times.

d) A robust and synchronised production plan should be:
- robust throughout the entire manufacturing system (including the melting, moulding, cores, and pouring functions);
- sufficiently flexible to allow alterations without the need to change melt batches.

e) Ensure adequate pouring technology and procedures:
- choose an appropriate pouring technology, from:
  - manual ladle pouring for medium-sized (mechanised moulding) to large castings (manual moulding);
  - automatic pouring (auto-pour) for castings on automated moulding lines;
- ensure casters involved in manual pouring are fully skilled:
  - ensure employees are fully trained in pouring;
  - motivate the workforce to pour carefully;
- maintain vigilant control of auto-pour devices in automatic pouring:
  - take care that the nozzle is clean to ensure sealed closure;
  - ensure vigilant temperature control if unheated pouring vessels are used.

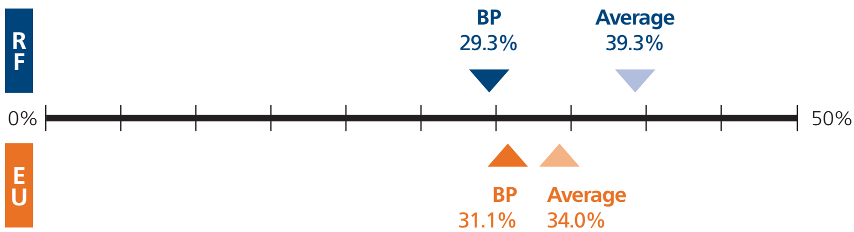
Impact on the bottom line.

Reducing pig and spillage will:
- reduce consumption of metal, since between five and ten percent of pig and spillage material is lost, and must be replaced;
- reduce consumption of energy, because any pig and spillage losses will have been melted without success, and must therefore be melted again.

3.2.1.3 Improving KPI No. 1.3, "Runners and risers"

Comparative results for KPI No. 1.3, "Runners and risers"

Factor	Europe	Russia
Best practice (BP)	1.0	0.93
Average practice	1.0	1.14



This KPI concerns the weight of any liquid metal poured into a mould, which is not subsequently used to form a casting, expressed as a percentage of the liquid metal poured into that mould. In this context, the term "box yield" is often used. This refers to the percentage of metal poured into the mould, which is subsequently used to form a casting.

The impact of runners and risers on the performance of a foundry is as follows.

- More castings are produced for the same amount of liquid metal, resulting in:
  - savings in energy consumption;
  - savings in labour;
  - improved capacity utilisation;
  - savings in the cost of materials (alloy and trimming additions).

The losses arising from runners and risers vary in accordance with:

- casting materials (designed to material-specific properties such as volume deficit (cubic contraction, micro-porosity, macro-porosity, shrinkage, etc.);
- the type of product (large-series castings will be optimised whereas in small series and single castings a sub-optimum is acceptable);
- the type of process (mould rigidity);
- the geometry of castings: this also influences the proportion of runners and risers – complex castings require more runners and risers than simple designs.

KPI 1.3 "Runners and risers"	EUROPE		RUSSIA	
	Best practice	Average	Best practice	Average
Grey/alloy iron	20.0–38.0%	25.0–40.0%	20.4–34.9%	25.7–42.0%
Ductile iron	35.0–38.0%	37.5–40.0%	17.9–49.7%	45.3–54.2%
Steel	30.0–48.0%	32.5–50.0%	29.9–59.9%	33.0–50.8%

Reasons for low box yield include:
a) runners too large for the size of castings;
b) feeders larger than is necessary;
c) large pouring cups;
d) an insufficient number of impressions per mould;
e) size of moulding box inappropriate for casting size.

To improve KPI 1.3, "Runners and risers:"

a) Redesign the running system (runners, feeders), including:
- balance systems;
- use of insulating and exothermic sleeves;
- use of predictive solidification simulation packages (mainly steel).

b) Optimise the dimensions of pouring cups:
- ensure the pouring cup is of the smallest size possible, consistent with the speed of metal delivery;
- where, appropriate an auto-pour system allows the size of the pouring cup to be minimised.

c) Improve mould utilisation:
- use appropriate mould packages of a size appropriate to the size of the casting;
- improve mould utilisation by increasing the number of impressions per mould;
- ensure adequate mould rigidity.

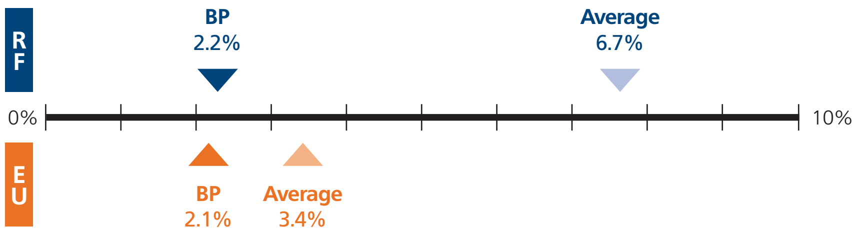
Impact for the bottom line.

Reducing runners and risers will:
- reduce consumption of energy, since losses incurred through runners and risers will have been melted without being used as a casting, and must be melted again;
- reduce man-hours in the casting process since, if runners and risers are reduced, labour is concentrated on the production of saleable castings;
- improve capacity utilisation: the availability of casting manufacturing equipment is the predominant factor in limiting capacity. If runners and riders are reduced then proportionately more capacity can be dedicated to the production of saleable cast components.

3.2.1.4 Improving KPI No. 1.4, "Scrap casting and rejects"

Comparative results for KPI No. 1.4, "Scrap casting and rejects"

Factor	Europe	Russia
Best practice (BP)	1.0	1.05
Average practice	1.0	1.97



This KPI monitors the weight of scrap castings (including customer returns), expressed as a percentage of the weight of gross castings produced.

A comparison of European and Russian scrap levels should take into account:
- the fact that scrap and general quality requirements are based on Western specifications and customer requirements;
- the fact that Russian KPI values predominantly relate to domestic standards.

The impact of reducing the volume of scrap and rejects on the performance of a foundry is as follows.
- More good-quality castings are produced in proportion to the same volume of gross castings, resulting in:
  - savings in energy consumption;
  - improved labour productivity;
  - improved capacity utilisation;
  - savings in material costs (alloy and trimming additions);
- better relationships with customers, leading to fewer losses through customer returns.

The losses connected to scrap and rejects vary in relation to:
- material applications (e.g., X-ray requirements for oil-related steel castings);
- the size of the series run (higher series have lower scrap levels).

KPI 1.4 "Scrap casting and rejects"	EUROPE		RUSSIA	
	Best practice	Average	Best practice	Average
Grey/alloy iron	1.0–4.0%	2.5–5.0%	1.0–3.0%	5.4–25.6%
Ductile iron	1.2–4.0%	2.5–5.0%	2.2–16.5%	6.3–14.0%
Steel	2.5–4.5%	5.0%	0.5–4.7%	1.8–7.4%

There are many reasons for excessive scrap castings and high scrap levels, but they generally involve:

a) insufficient process controls;
b) incorrect metallurgy;
c) sand-related problems;
d) casting design;
e) incorrect manufacturing processes.

To improve KPI 1.4, "Scrap casting and rejects:"

a) Instigate a systematic approach to identifying potential causes, and set clear priorities:

- investigate scrap levels by weight, volume, and cost;
- identify high scrap items by product type, individual castings, and defect causes;
- implement an improvement programme targeted at the highest scrap values.

b) Implement product process control procedures and data collection, to include:

- manufacturing process control data (e.g., analysis and temperature controls, etc.);
- metallurgical requirements (e.g., microstructure, hardness, etc.);
- sand properties;
- customer requirements on casting quality (acceptance standards).

c) Instigate continuous improvement and updating of process control data.

d) Ensure all design is conducted on the basis of ensuring optimum manufacturing efficiency (e.g., remove sharp corners, insufficient draft angles, hot spots, insufficient radius, etc.), and establish desirable standards and parameters through discussion with customers.

e) Re-equip the foundry with production processes and/or equipment more appropriate to the castings being manufactured.

Impact on the bottom line.

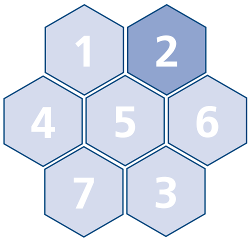
Reducing the volume of scrap castings and rejects will:

- reduce consumption of energy, since losses incurred due to scrap castings and rejects will have been melted without producing a saleable good casting, and must be melted again;
- improve labour efficiency: labour can be concentrated on the production of viable castings as the level of scrap and rejects is reduced (and with it the incidence of runners and risers);
- improve capacity utilisation as the proportionate volume of saleable castings increases.

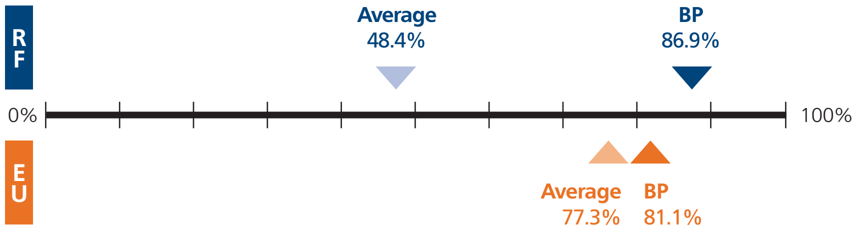
Low production efficiency means producing one ton of good-quality castings takes

60 percent longer

in Russia than in Europe.

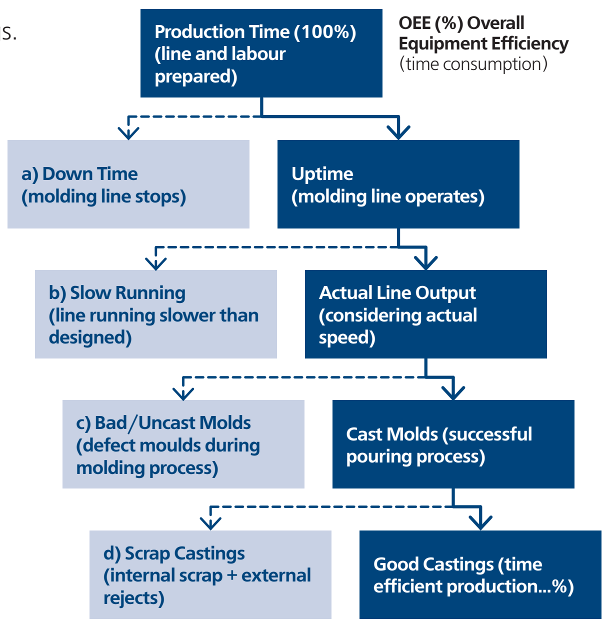


3.2.2 PRODUCTION EFFICIENCY ("OVERALL EQUIPMENT EFFICIENCY" (OEE))



"Production efficiency" refers to the utilisation of the time available for production. It refers to the time used for the production of good-quality castings, expressed as a percentage of the planned time available.

This KPI comprises four sub-indicators (each expressed as a percentage):
a) KPI 2.1: Down time;
b) KPI 2.2: Slow running;
c) KPI 2.3: Bad moulds;
d) KPI 2.4: Scrap castings.



This KPI has an impact on:
- increased labour productivity;
- improved capacity utilisation.

Performance factors:
OEE: (Russian time consumption/casting vs. EU time consumption)
- Best practice (86.9/81.1): 1.07
- Average (48.4/77.3): 0.63[6]

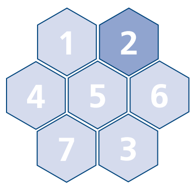
6 On average, Russian foundries have to run plant for periods up to 60 percent longer than those in Europe to produce an equivalent volume of good-quality castings: 77.3/48.4 = 1.60.

The main areas of difference (on the basis of average time losses in Russia vis-à-vis time losses in the EU) are:

- slow running: 5.32;
- bad moulds: 3.45;
- downtime: 1.60.

Major differences include:

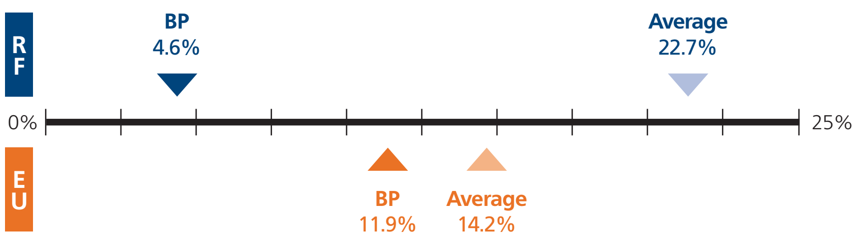
- excessive spare capacity in Russia (see TEEP), which reduces downtime through the availability of alternative production capacity;
- the "slow running" figure of c. 30 percent indicates a complete lack of supervision and hides other problems;
- the level of downtime and the incidence of bad moulds reflect the standard of the maintenance of much equipment.



3.2.2.1 Improving KPI No. 2.1, "Down time" (moulding)

Comparative results for KPI No. 2.1, "Down time" (moulding)

Factor	Europe	Russia
Best practice (BP)	1.0	0.39
Average practice	1.0	1.60



This KPI monitors the time during which a moulding facility is not in operation (as a result of breakdowns or for other operational reasons), expressed as a percentage of the total time available for production (often described as "net operating time").

The impact of less downtime on the performance of a foundry is as follows.

- More gross castings are produced during the same amount of time, resulting in:
  - better labour efficiency;
  - better capacity utilisation.

The losses connected to downtime differ.

- Losses vary according to moulding technology:
  - manual moulding – little sophisticated equipment is involved in this process, resulting in fewer breakdowns and less impact; equipment failure does not necessarily result in production downtime;
  - mechanised moulding lines – these have higher levels of breakdowns due to the greater volume of equipment involved, resulting in downtime for virtually all breakdowns;

– plants with automatic moulding lines are at risk of breakdowns but tend to have a fault indication system and organised maintenance schemes.

- Within automatic and mechanised moulding differences in performance relate to different types of moulding processes:
  – high-pressure boxed (green sand);
  – flaskless vertically parted (green sand);
  – mechanised pattern flow (chemically bonded/no bake).

KPI 2.1 "Downtime" (moulding)	EUROPE		RUSSIA	
	Best practice	Average	Best practice	Average
Automatic moulding	11.5–13.0%	15.0%	0.6–16.3%	1.1–35.9%
Mechanised moulding	13.0–14.5%	15.0%	4.3–20.7%	11.8–50.4%
Manual moulding	2.5%	5.0%	2.6–14.4%	5.0–21.3%

Reasons for excessive downtime include:

a) mechanical and electrical stoppages;
b) waiting periods and delays for metal or sand;
c) a high number of pattern changes;
d) operational and/or organisational inefficiencies;
e) poor scheduling.

To improve KPI 2.1, "Downtime (moulding):"

a) Instigate a systematic approach to identify the main causes of downtime:
- investigate stoppage times by cause;
- identify incidences of high or frequent stoppage and rectify these;
- structure and classify the reasons for downtime, in terms of:
  – equipment failures;
  – inadequate support services (waiting for metal, sand, cores, etc.);
  – organisational shortcomings (scheduling, pattern changes, etc.);
  – inadequate management control.

b) Implement and support a recognised maintenance scheme to reduce breakdowns:
- define maintenance strategy in terms of:
  – targeted equipment;
  – preventive maintenance;
  – monitoring of the condition of plant and equipment;
- retain adequate spare parts in storage to support maintenance strategy;
- ensure engineering staff are adequately trained to maintain the specific foundry equipment in use.

c) Ensure adequate supplies of metal, sand, and cores to moulding lines:
- organise the production process in supply departments;
- eliminate bottlenecks by further investment in capacity in supply departments.

d) Reduce the impact of pattern change through improved production scheduling.

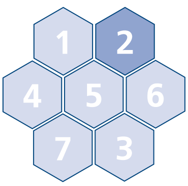
e) Ensure employees do not impact on moulding line performance:
- ensure adequate staffing levels and ensure personnel are fully trained, with the correct professional attitude.

Foundries with higher levels of downtime tend also to experience higher scrap rates.

Impact on the bottom line:

The major impact of reducing downtime (measured at the moulding line) is that more gross castings can be produced within the same period of time, resulting in:

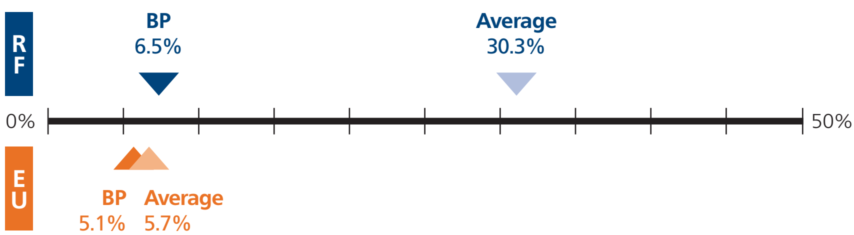
- improved labour efficiency, due to:
  - the workforce of the plant being available for (and committed to) continuous production, and avoiding "non-productive waiting" caused by downtime;
  - the avoidance of downtime at the moulding line resulting in the elimination of bottlenecks in other areas (e.g., at the melt shop, core shop, quality checks, logistics, etc.);
  - the avoidance of bottlenecks leading to better capacity utilisation, since the moulding line is usually the decisive capacity in this respect (other bottlenecks having been eliminated), and the avoidance of downtime here ensures better capacity utilisation and no wastage of correlating equipment costs.



3.2.2.2 Improving KPI 2.2, "Slow running" (moulding)

Comparative results for KPI No. 2.2, "Slow running"

Factor	Europe	Russia
Best practice (BP)	1.0	1.27
Average practice	1.0	5.32



This KPI monitors the production time lost through the operation of a moulding facility below design capacity or calculated output, expressed as an equivalent percentage of the net operating time.

The impact of reducing slow running in foundry is as follows.

- More gross castings are produced over the same period of time, resulting in:
  - improved labour productivity;
  - better capacity utilisation.

The losses connected to slow running vary:

- in accordance with moulding technology:
  - the manual moulding rate is controlled by people – and production rates can therefore fall below standard relatively easily;
  - in mechanised and automatic plants the moulding speed is machine-controlled but can be stopped or slowed by personnel;

- within automatic and mechanised moulding – differences in performance relate to the type of moulding process:
  - high-pressure boxed (green sand);
  - flaskless vertically parted (green sand);
  - mechanised pattern flow (chemically bonded/no bake);
- in accordance with production parameters, affecting both mechanised and automatic lines, including:
  - core setting requirements;
  - casting cooling requirements;
  - residual stresses;
  - pouring rate.

KPI 2.2 "Slow running" (moulding)	EUROPE		RUSSIA	
	Best practice	Average	Best practice	Average
Automatic moulding	0.0–5.6%	0.0–6.0%	0.0–24.3%	6.5–60.2%
Mechanised moulding	4.5–6.4%	5.0–7.0%	0.0–12.7%	11.0–27.3%
Manual moulding	10.1%	12.5%	0.0–11.4%	8.4–39.8%

Reasons for excessive slow running include:

a) difficulty in casting to mould in normal machine cycle time;
b) a series of small stoppages occurring and not recorded as downtime;
c) individual operations not synchronised with moulding operations;
d) long pouring times for very heavy castings;
e) poor supervision.

To improve KPI No. 2.2, "Slow running" (moulding):

a) Monitor any incidences of slow running, investigate the reasons for this, and rectify them.
b) Among the large variety of solutions that may come to light, three categories will be evident:
- organisational improvements which can be influenced by management, such as:
  - the unauthorised reduction of moulding speed, or stoppages by personnel;
  - downtime not recorded as such;
- production restrictions which usually cannot be improved without investment, such as:
  - moulding and core setting not possible within machine cycle time;
  - long pouring times for heavy box weights;
- inadequate supervision:
  - in which case it is important to ensure employees carry out the required operations within stipulated time periods (particularly in manual moulding).

Impact on the bottom line.

As with KPI No.2.1, the main impact of reducing the losses caused by slow running at the moulding line is that more gross castings can be produced within the same amount of time. This results in:

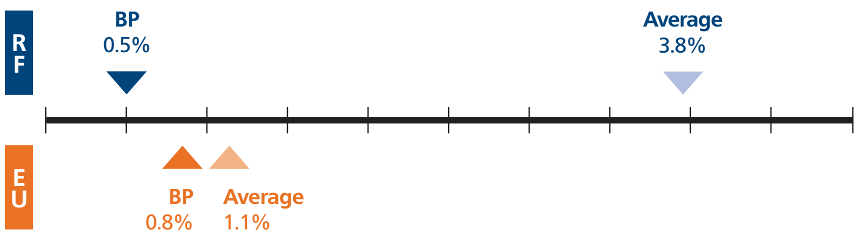
- improved labour productivity, since reduced productivity on the moulding line can have implications throughout the production chain;
- better capacity utilisation, because capacity utilisation on the moulding line is

often the decisive capacity, insofar as slow running on the moulding line reduces the output of the total plant, with the result that correlating equipment costs are wasted.

3.2.2.3 Improving KPI 2.3, "Bad moulds"

Comparative results for KPI No. 2.3, "Bad moulds"

Factor	Europe	Russia
Best practice (BP)	1.0	0.63
Average practice	1.0	3.45



This KPI monitors the number of moulds produced that are not poured: it is expressed as a percentage of the total number of moulds produced.

The impact of fewer bad moulds on the performance of a foundry is as follows.

- More gross castings can be produced over the same period of time, resulting in:
  - better labour productivity;
  - improved capacity utilisation;
  - the potential saving of cores placed in bad moulds.

The losses arising from bad moulds vary according to the following issues.

- Moulding technology:
  - manual moulding: bad moulds can sometimes be repaired;
  - at mechanised and automatic plants the moulding line cannot normally be stopped for mould repair, and only minor defects can be rectified.
- Within automatic and mechanised moulding the differences in performance relate to the various types of moulding processes:
  - high-pressure boxed (green sand);
  - flaskless vertically parted (green sand);
  - mechanised pattern flow (chemically bonded/no bake).

KPI 2.3 "Bad moulds"	EUROPE		RUSSIA	
	Best practice	Average	Best practice	Average
Automatic moulding	0,5–1,2%	1,0–1,5%	0,0–4,0%	1,3–9,0%
Mechanised moulding	0,4–0,9%	0,5–1,0%	0,4–1,4%	1,3–7,1%
Manual moulding	0,2%	0,5%	0,0–1,4%	0,1–2,2%

Reasons for excessive bad moulds include:

a) the condition of the sand used;
b) the condition of the patterns used;
c) problems in moulding machine alignment;
d) non-poured moulds.

To improve KPI 2.3, "Bad moulds":

a) Ensure appropriate sand conditions:
- monitor and investigate appropriate sand properties and adjust to required level.

b) Ensure pattern equipment and tooling are properly maintained:
- check the condition of pattern equipment:
  - check pattern and tooling dimensions;
  - check pattern equipment and tooling for damage;
  - check curves and radii for undercuts;
  - polish and clean pattern equipment;
- instigate a comprehensive procedure for the inspection of pattern equipment and tooling:
  - after every production all pattern equipment, core boxes, and tooling must be cleaned, polished, and checked;
  - dimensional checks should be carried out on pattern equipment, and castings produced on a regular basis (in line with customer requirements);
- improve the design and construction of tooling:
  - ensure appropriate core print fit, radii, draft angle, etc.;
  - ensure appropriate tooling relative to production volumes.

c) Ensure correct moulding machine alignment:
- measure the position of the pattern plate bolster to the squeeze plate;
- measure the position of the pattern plate relative to the mould box closure system (check castings for mismatch);
- check the stripping action of the pattern, relative to the bolster;
- for automatic moulding lines, implement frequent checks of test pieces;
- rectify and adjust the moulding line accordingly.

d) Avoid producing moulds which are not poured.

Impact on the bottom line.

Again, as with KPI No. 2.1 and KPI No. 2.2, the major impact of reducing the frequency of bad moulds will be in making possible the production of more gross castings during the same period of time. Other benefits include:
- improved labour productivity, since greater productivity on the moulding line (due to fewer bad moulds) will ensure production is maintained at the intended output levels;
- improved capacity utilisation, because capacity utilisation on the moulding line is often the decisive capacity (since other bottlenecks are assumed to have been eliminated): reducing the production of bad moulds here will reduce waste in correlating equipment costs and wasted core.

Operational efficiency at Russian foundries currently runs at only

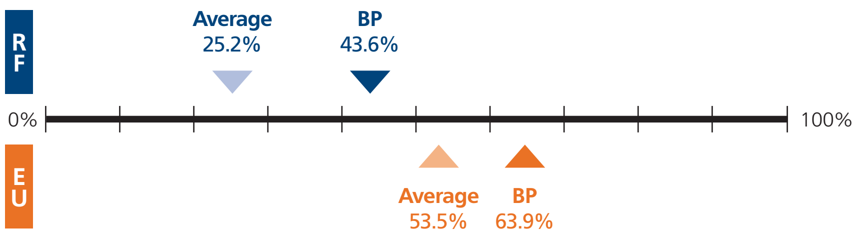
50 percent

of capacity.

3.2.3 TOTAL EFFECTIVE EQUIPMENT PERFORMANCE (TEEP), "CAPACITY UTILISATION"

Comparative results for KPI No. 3, "Total effective equipment performance" (TEEP)

Factor	Europe	Russia
Best practice (BP)	1.0	0.68
Average practice	1.0	0.47



Total effective equipment performance (TEEP) measures overall equipment effectiveness (OEE) in terms of calendar hours – i.e., 24 hours per day, 365 days per year. Total effective equipment performance per annum is expressed as a percentage of total plant capacity, assuming operation for 24 hours per day, 365 days per year.

Improving a foundry's TEEP will result in:
- a better return on overhead costs;
- more effective utilisation of capital employed.

Total effective equipment performance varies in accordance with various factors.
- Moulding technology:
  - the higher the capital investment, the greater the capacity utilisation required.
- In automatic and mechanised moulding, differences in TEEP in connection with OEE performance relate to various types of moulding processes:
  - high-pressure boxed (green sand);
  - flaskless vertically parted (green sand);
  - mechanised pattern flow (chemically bonded/no bake);

KPI No. 3 "TEEP"	EUROPE		RUSSIA	
	Best practice	Average	Best practice	Average
Automatic moulding	70.7–78.6%	57.5–63.1%	25.3–56.0%	16.3–28.4%
Mechanised moulding	51.1–53.2%	46.0–48.0%	21.4–74.4%	17.7–53.7%
Manual moulding	36.7–37.7%	32.8–33.7%	22.0–52.5%	14.8–49.0%

Reasons for low TEEP include:
- a low level of OEE (KPI No. 2, "Production efficiency");
- insufficient orders;
- limited access to electrical power;
- excessively high electricity tariffs during peak hours.

Improved capacity utilisation is dependent on the identification of certain critical factors:

1) if a foundry is subject to any limitations in respect of orders, then eliminate all technical bottlenecks that reduce capacity;

2) restructure the organisation and the workforce to operate at maximum capacity;

3) if the foundry is suffering from insufficient orders then take measures to increase these;

4) if there is no likelihood of increasing sales volumes at all, then downsize by cutting out excess capacity at all levels.

To improve KPI 3, "TEEP:"

Total effective equipment performance is driven by loading, multiplied by OEE. Since "loading" (the percentage of total calendar time that is actually scheduled for operation) will usually be limited by the orders a foundry can produce, three scenarios need to be considered, as follows.

- **If a foundry is not subject to any limitation in respect of orders** (such that the foundry could produce maximum volumes within its existing installed capacity and operational performance standards), then:
  - eliminate all technical bottlenecks that reduce capacity (e.g., limitations in power supply, ancillary departments, etc.);
  - restructure the organisation and the workforce to operate at maximum capacity: for example, increase the working schedule from two shifts (i.e., in operation for 16 hours a day) to three shifts (in operation 24 hours per day), and from five days per week to seven;
  - increase OEE (see KPI 2, "Production efficiency").

- **If a foundry is suffering from insufficient orders,** take measures to increase these:
  - with existing customers, through the development of new products (this may require investment in training and skills);
  - with new customers, through the production and sale of existing products (improve skills in sales and marketing for domestic markets).

- **If a foundry is currently seeking new customers in export markets** improve skills in operations with regard to customer requirement standards, and improve sales and marketing skills to develop international business.

- If there is no intention of increasing sales volumes at all, then downsize (after due consideration of all financial implications). This will ultimately result in a more competitive plant, operating at a higher level of capacity utilisation:
  - through the removal of excess capacity at all levels of the plant (or group of plants), including moulding, melting, workforce, overheads, etc.;
  - as a result of consolidation within the foundry sector (through the disposal and outsourcing of foundries within vertically integrated enterprises, and through mergers and acquisitions, etc.), as has happened and continues to occur throughout Europe.

Impact on the bottom line.

The major impact of improved TEEP is:

- better utilisation of capital employed – the capital invested in allowing the foundry to operate at the intended capacity should be utilised to the greatest possible extent, to ensure that the cost of such capital is not wasted;
- better utilisation of overheads – better capacity utilisation need not, necessarily, involve significantly higher overheads if the additional volumes produced are within an existing product category.

Matching the efficiency of the best-performing EU plants would save enough power to power a typical Russian city of

1.5 million

people.

3.2.4 ENERGY CONSUMPTION

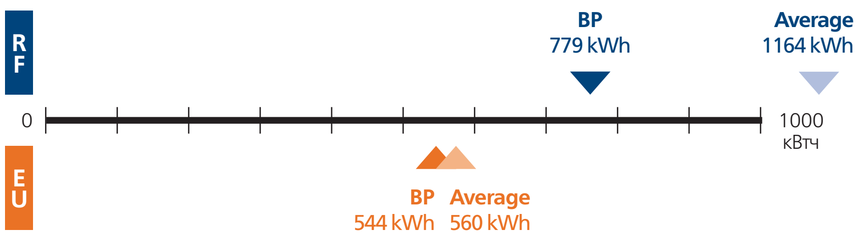
As well as raw materials, energy constitutes one of the most important cost factors in a foundry's operations: the energy involved in melting can often be a factor in limiting capacity.

- KPI 4.1 concerns "Energy consumption in melting" ("Melting efficiency"), expressed in terms of the energy necessary to produce one tonne of melt (kWh/tonne melted).
- KPI 4.2 concerns "Energy consumption in foundry," expressed in terms of the energy necessary to produce one tonne of good-quality castings (kWh/tonne of good-quality castings).

3.2.4.1 Improving KPI 4.1, "Energy consumption in melting" ("Melting efficiency")

Comparative results for KPI No. 4.1, "Energy consumption in melting"

Factor	Europe	Russia
Best practice (BP)	1.0	1.43
Average practice	1.0	2.08



This KPI monitors the furnace power consumption (kWh) divided by the tonnage of metallic material charged to the furnaces. Increasing melting efficiency has the effect of reducing energy costs.

Energy consumption varies in accordance with:

- induction melting:
  - iron castings: by alloy type and manufacturing process;
  - steel castings: by alloy type;
- arc melting:
  - iron castings: no longer produced by arc melting in European foundries;
  - steel castings: arc furnaces are the most common furnace for melting steel.

KPI 4.1 "Energy consumption in melting" (kWh/per tonne melted)	EUROPE		RUSSIA	
	Best practice	Average	Best practice	Average
Induction melting				
– Iron	540–620	550–625	543–1478	893–1447
– Steel	580–700	675–800		
Arc melting				
– Iron	–	–		
– Steel	500 [1),2)]	525 [1),2)]	645–884	859–1564

1) Excludes any post-tap refining.
2) Does not involve the use of oxygen.

Reasons for low energy efficiency in melting include:
a) holding liquid metal for long periods of time;
b) electrically inefficient and old equipment;
c) outdated processes for operating the melting process (specific to arc furnaces);
d) low power density of some furnaces, causing long tap-to-tap times (specific to arc furnaces).

To improve KPI 4.1 "Energy consumption in melting:"

a) Avoid holding and treating metal for long periods of time in melting furnaces:
- review melting procedure.

b) Replace old, inefficient, or inappropriate melting equipment:
- induction furnaces with high electrical efficiency should be installed;
- arc furnaces should have a high power density, with oxygen injection;
- check the efficiency and suitability of cupola furnaces on the basis of a comprehensive feasibility analysis, covering all aspects of operating costs and potential implications.

Impact on the bottom line.

The key impact of reducing energy consumption in melting is lower energy costs.

Example:

Assume an "average-performing" multi-product foundry in Russia wishes to check the optimum impact of matching European best practice. Since the melt shop is by far the largest energy consumer in a foundry, any initiatives on energy efficiency should be concentrate on the melting process and equipment.

KPI actual performance	KPI target performance	KPI room for improvement
1164 kWh/tonne	544 kWh/tonne	620 kWh/tonne = 53.3%

The basic cost structure data of the individual enterprise are:
- energy costs as a proportion of total costs: **13.4%**
  - energy costs as a proportion of total melting energy costs **70.0%**

An improvement of 53.3 percent in KPI No. 4.1, "Energy consumption in melting" will equate to 5.0 percent of total plant costs per tonne of good castings:
- energy costs savings: 0.533 x 0.134 x 0.70 = 0.0499 = 5.0%

For each tonne of good-quality castings they produce, Russian foundries use

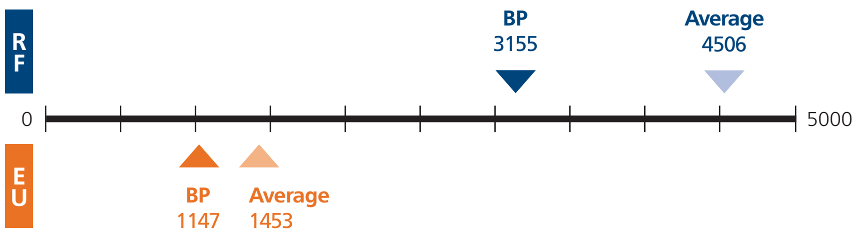
three times more energy

than those in Europe.

3.2.4.2 Improving KPI 4.2, "Energy consumption in foundry"

Comparative results for KPI No. 4.2, "Energy consumption in foundry"

Factor	Europe	Russia
Best practice (BP)	1.0	2.53
Average practice	1.0	3.10



This KPI monitors total energy consumption (kWh) across various foundry departments, divided by the tonnage of net good castings produced. Decreasing energy consumption in a foundry has the effect of reducing energy costs.

Energy consumption within a foundry varies in accordance with:

- the material, alloys, and processes involved in melting;
- other additional factors, including:
  - variations in process yield;
  - variations in heat treatment operations.

KPI 4.2 "Energy consumption in foundry" (kWh/tonne of good-quality castings)	EUROPE		RUSSIA	
	Best practice	Average	Best practice	Average
Grey iron	1000–1305	1169–1483	1521–4533	2939–5428
Ductile iron	1284–1566	1744–1758	2344–3539	3322–5016
Steel	1165–2088	1391–2676	2874–6996	3285–7464

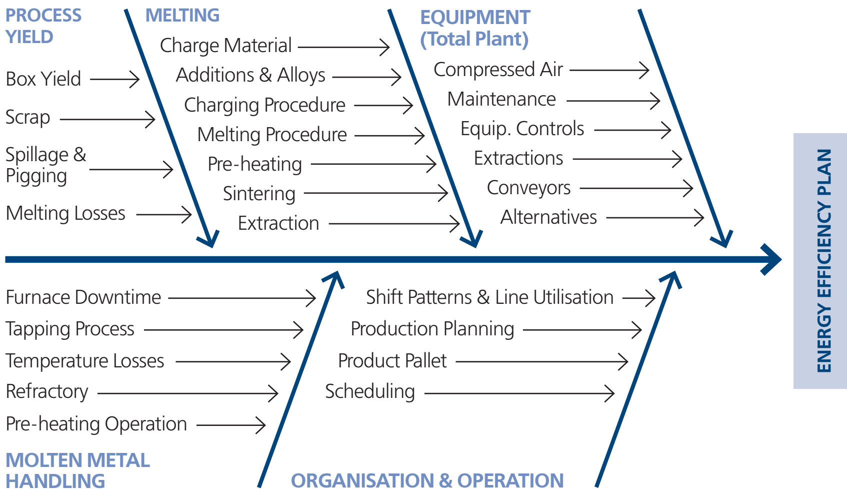
Reasons for high total energy consumption include:

a) inefficient melting plant;
b) extensive heat treatment cycles;
c) inefficient heating and ventilation systems;
d) insufficient awareness of energy efficiency.

To improve KPI 4.2, "Energy consumption in foundry:"

a) Refer to section 3.2.4.1 (above) on improving KPI 4.1, "Energy consumption in melting;"
b) Check the condition and efficiency of heating, ventilation, and extraction systems, and rectify as necessary;
c) Inform and educate employees on energy efficiency and conservation.

Figure 3.1: KPI 4.2, "ENERGY CONSUMPTION IN FOUNDRY"



Impact on the bottom line.

The key impact of reducing energy consumption is reduced energy costs.

Example:

Assume an "average-performing" multi-product foundry in Russia wishes to check the optimum impact of matching European best practice. Energy consumption in the melt shop should have been checked as a first step, but the efficiency gap remains high and total plant-wide energy consumption must now be checked.

KPI actual performance	KPI target performance	KPI room for improvement
4506 kWh/tonne	1247 kWh/tonne	3259 kWh/tonne = 72.3%

The basic cost structure data of the individual enterprise are:

- energy costs as a proportion of total costs: **13.4%**
  - energy costs as a proportion of plant-wide total energy costs: **95.0%**

The total cost savings achievable by reducing energy consumption across the total plant by 72.3 percent will be 9.2 percent of total plant costs per tonne of good castings:

- energy costs savings: 0.723 x 0.134 x 0,95 = 0.0920 = 9.2%

Further to the potential for cost savings in the melting process (i.e., of five percent), a further potential saving of 4.2 percent is identified throughout the remainder of the plant.

For each tonne of good-quality castings they produce, Russian foundries use, on average, average

3.6 times more

sand than their European peers.

3.2.5 FRESH SAND CONSUMPTION

The sand used in making moulds should be recycled and regenerated as far as possible. A perfectly designed and effectively operating sand regeneration plant will reduce the costs of buying sand, and will also improve the quality of castings.

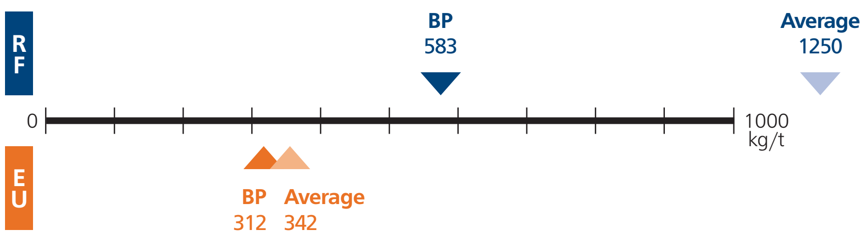
- KPI 5.1, "Fresh sand consumption" monitors the weight of new (fresh) sand used, divided by the volume (tonnes) of net good-quality castings produced. This indicator includes the sand used in moulding as well as sand used in the production of core.
- KPI 5.2, "Rate of sand regeneration" monitors the percentage of sand that is re-used in each moulding cycle (expressed as an average of all moulding cycles included in the sampling period).

Reducing the consumption of fresh sand has the effect of reducing the costs of raw materials, as well as the costs of specialist services and facilities for the dumping of sand waste.

3.2.5.1 Improving KPI 5.1, "Fresh sand consumption"

Comparative results for KPI No. 5.1, "Fresh sand consumption"

Factor	Europe	Russia
Best practice (BP)	1.0	1.87
Average practice	1.0	3.59



This KPI monitors the weight of new (fresh) sand used, divided by the volume (tonnes) of net good-quality castings produced. This indicator includes sand used in moulding as well as sand used in the production of core.

Reducing the consumption of fresh sand has the effect of reducing material costs.

Consumption of fresh sand varies in accordance with:
- product type, and the extent and complexity of core-making requirements;
- the extent of recovery of core material before shake out (e.g., engine blocks).

KPI 5.1 "Fresh Sand consumption" (tonne sand used/tonne of core produced)	EUROPE		RUSSIA	
	Best practice	Average	Best practice	Average
Grey iron	1.60–0.87	0.19–0.98	0.22–1.22	0.52–2.60
Ductile iron	0.17–0.37	0.20–0.41	0.25–0.51	0.33–1.10
Steel	0.17–0.87	0.19–0.96	0.24–4.37	0.51–5.39

Reasons for excessive consumption of new sand include:
a) large or intensive core-making requirements;
b) a low sand-to-metal ratio, causing high sand burn-out;
c) poor-quality sand (roundness, size distribution, refractoriness, pH, etc.).

To improve KPI 5.1, "Fresh sand consumption:"

a) Where possible, use hollow and/or back-filled cores.
b) Improve sand-to-metal ratios to reduce high sand burn-out.

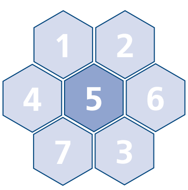
__Note:__ increasing sand-to-metal ratios (and hence improving rates of sand consumption) should not be carried out at the expense of reducing the box yield and, subsequently, the process yield.

c) Improve the quality of sand purchased.
d) Improve system sand properties (compactability, shatter, etc.): refer to process control measures elsewhere in this document.
e) Review shake-out operations:

- check the separation of core sand if possible;
- ensure system sand is not carried out with castings;
- check all processes to insure sand is not lost at shake-out.

Impact on the bottom line.

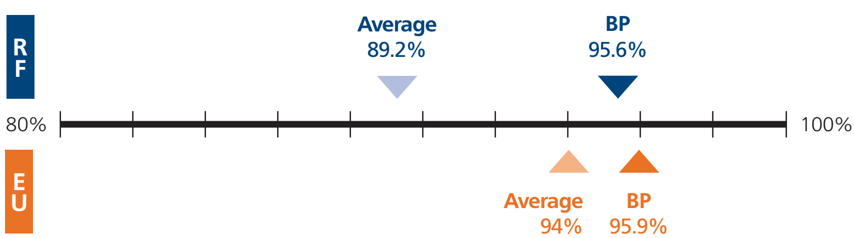
Reducing fresh sand consumption reduces the costs of raw materials.



3.2.5.2 Improving KPI 5.2, "Sand regeneration"

Comparative results for KPI No. 5.2, "Sand regeneration"

Factor	Europe	Russia
Best practice (BP)	1.0	1.00
Average practice	1.0	0.95



This KPI monitors the percentage of sand that is re-used in each moulding cycle (expressed as an average of all moulding cycles included in the sampling period).

Sand regeneration should be carried out at an optimum level for individual products and processes, bearing in mind certain factors, including the following:
- core intensity;
- the addition of new sand. Additions must be made at a minimum of 10 percent of the metal weight if the appropriate weight of cores is not added; if this is not carried out the system sand will become unusable;
- increasing the rate of sand generation does not necessarily represent an improvement in performance.

The rate of sand regeneration differs in accordance with:
- the type of system sand used (green sand or chemical-bonded);
- the extent of core requirements and complexity;
- the moulding process.

KPI 5.2 "Sand regeneration"	EUROPE		RUSSIA	
	Best practice	Average	Best practice	Average
Automatic moulding	92–98%	91–97.5%	93.0–98.4%	91.8–96.6%
Mechanised moulding	88–98%	84–95%	84.2–97.6%	74.7–93.6%
Manual moulding	84–98%	82–95%	82.2–95.3%	79.3–91.8%

Reasons for low rates of sand regeneration include:
a) high core usage;
b) high burn-out levels;
c) poor sand quality;
d) the choice of resin binder system (e.g., for the same volume of base sand a furan binder will reclaim at a higher rate than an alkaline phenolic system);
e) the surface requirement of the casting, resulting in the need for a separate facing sand.

To improve KPI 5.2, "Sand regeneration:"

a) Regarding burn-out levels and sand quality issues: refer to section 3.2.5.1 on KPI 5.1, "Fresh sand consumption," above.

b) Review the selected binder system in chemical-bonded plants:
- investigate alternative binder systems that have greater potential for reclamation;
- mixed binder systems tend to have greater potential for reclamation than mono-systems.

c) The same factors that reduce new sand consumption will also improve sand regeneration levels (refer to section 3.2.5.1 on KPI 5.1, "Fresh sand consumption," above.

Impact on the bottom line.

The better a foundry's sand regeneration the less new sand must be bought.

Russian foundries use, on average,

161 times

more fresh water than those in Europe.

Matching EU standards in water efficiency would save enough to supply more than

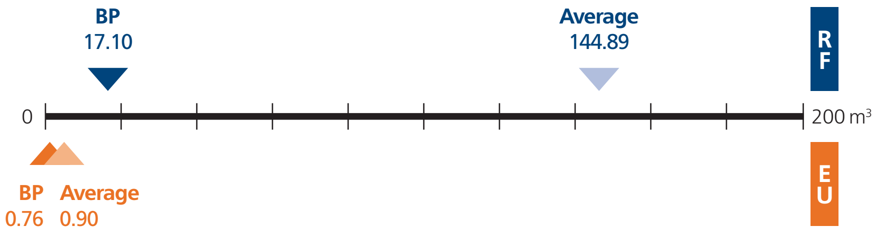
3.5 million

Russian citizens for one year.

3.2.6 FRESH WATER CONSUMPTION

Comparative results for KPI No. 6, "Fresh water consumption"

Factor	Europe	Russia
Best practice (BP)	1.0	21.38
Average practice	1.0	161.00



KPI 6, "Fresh water consumption" monitors the fresh water consumed per unit of product (e.g., per tonne of net good castings produced).

Reducing fresh water consumption has the effect of reducing utility and service charges for water.

Volumes of fresh water consumption vary in accordance with:
- the moulding medium used (green sand, chemical-bonded sand, etc.);
- systems and cooling requirements;
- equipment cooling requirements;
- heat treatment cycles that have a quench requirement.

KPI 6 "Fresh water consumption" m^3/tonne good castings	EUROPE		RUSSIA	
	Best practice	Average	Best practice	Average
Grey iron	0.60–1.10	0.78–1.25	2.5–25.5	5.0–218.7
Ductile iron	0.60–0.81	0.71–1.06	6.4–59.2	54.7–435.6
Steel	0.60–1.50	0.76–1.77	2.5–27.3	10.6–234.1

Reasons for high levels of fresh water consumption include:
a) heat treatment cycles involving water quench;
b) excessive green sand temperatures requiring high cooling rates by evaporation;
c) process water for green sand systems;
d) general evaporative loss from cooling systems;
e) low efficiency of cooling systems;
f) the use of water-based dust cleaning systems.

To improve KPI 6, "Fresh water consumption:"

a) Some reasons for high levels of water consumption cannot be changed:

- heat treatment is necessary to reach required properties;
- in areas of high ambient temperature/humidity more water is required for evaporative cooling.

b) Reduce sand cooling requirements by reducing sand temperature:

- increase the storage volume of sand in the sand system, thus increasing the dwell time before sand re-use and thereby reducing cooling requirements; this may also have the additional benefit of improving the overall sand quality;
- reduce sand-to-metal ratios, thereby reducing sand temperature and thus reducing cooling requirements.

Note: *increasing sand-to metal ratios (and hence improving rates of sand consumption) should not be carried out at the expense of reducing the box yield and, subsequently, the process yield.*

c) Maintain correct sand properties (particularly moisture/clay relationships) as this will avoid producing sand that is too wet.

d) Reduce cooling water requirements for ancillary plant:

- ensure all cooling systems are operating effectively, and replace defective systems;
- replace water-based dust collection systems with dry-bag filters (this replacement will be necessary at some point in any case, to meet environmental standards).

e) Where possible, replace fresh water with collected surface water (rain water) instead of taking water from the distribution network.

Impact on the bottom line.

The financial impact of reducing fresh water consumption is lower utility and supply costs.

It takes Russian foundries

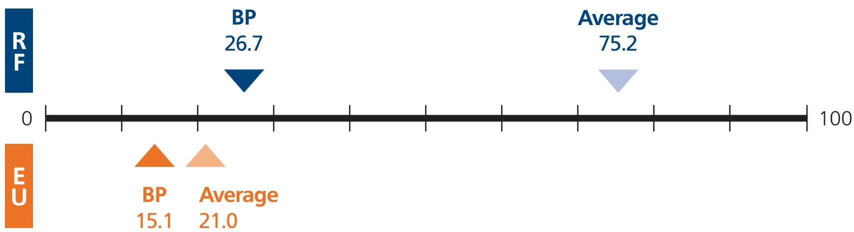
3.6 times more man-hours

to produce the same volume of quality castings as their European peers.

3.2.7 LABOUR PRODUCTIVITY

Comparative results for KPI No. 7, "Labour productivity"

Factor	Europe	Russia
Best practice (BP)	1.0	1.77
Average practice	1.0	3.58



KPI 7, "Labour productivity" monitors the total number of man-hours worked (excluding management and supervisory hours) divided by the tonnage of net good castings produced.

Improving labour productivity has the effect of:
- reducing direct labour costs;
- potentially reducing certain related indirect overhead costs.

Labour productivity varies in accordance with:
- manufacturing processes (automatic, mechanised, or manual);
- the volumes produced (volume regression effect);
- the degree of automation (e.g., block grinder, rotary grinder for discs, etc.);
- the extent of process requirements on casting type (e.g., the greater degree of processing involved in steel castings).

KPI 7 "Labour productivity" (man-hours/tonne of good castings)	EUROPE		RUSSIA	
	Best practice	Average	Best practice	Average
Automatic moulding	5–25	10–34	19.7–89.8	36.2–173.9
Mechanised moulding	12–27	19–37	16.1–101.7	31.9–162.7
Manual moulding	22–30	24–40	24.0–114.2	52.9–234.7

Reasons for low labour productivity include:
a) over-manning;
b) low standards of automation;
c) poor management of certain business processes and operational practices;
d) poor performance levels of production equipment.

To improve KPI 7, "Labour productivity:"

a) Conduct a full review of manning levels:

- identify and clarify the roles and responsibilities of all personnel (both on the shop floor, and in management);
- establish clear staffing levels for each department within the plant:
  - on the basis of existing equipment;
  - on the basis of increased automation following investment.

b) Develop a new and improved manning strategy:

- reduce manpower consistent with a) above;
- where manpower reductions are not possible instigate an investment programme to increase automation levels (e.g., through the use of materials-handling equipment, etc.);
- conduct training sessions (for shop floor employees and management) in order to familiarise the workforce with any necessary changes in working practices.

c) Before investing in greater automation existing equipment should be made to operate more effectively wherever possible.

Impact on the bottom line.

The major impacts of improved labour productivity are:

- lower direct labour costs;
- potentially lower related indirect overhead costs.

Example:

Assume an "average-performing" multi-product foundry in Russia wishes to check the optimum impact of matching European best practice in labour productivity.

KPI actual performance	KPI target performance	KPI room for improvement
75.2 man-hours/tonne castings	15.1 man-hours/tonne castings	60.1 man-hours/t = 80.0%

The basic cost structure data of the individual enterprise are:

- labour costs as a proportion of total costs: **21.4%**
  - direct labour hours as a proportion of total man-hours **70.0%**
- overhead costs as a proportion of total costs **12.8%**
  - overhead costs related to workforce levels **30.0%**

The total cost savings achieved through improving labour productivity by 80.0 percent will be 15.2 percent of total plant costs per tonne of good castings:

- labour costs savings: 0.800 x 0.214 x 0,70 = 0.1198 = **12.1%**
- overhead cost savings: 0.800 x 0.128 x 0.30 = 0.0307 = **3.1%**

Matching European best practice could improve the profitability of individual foundries by

15 percent

and reduce costs by up to

RUB100 billion ($3.3 billion)

for a sector at large per year.

3.3 THE BOTTOM-LINE BENEFITS OF BETTER RESOURCE EFFICIENCY

The financial implications of improving KPIs have been estimated on the following basis.

1) Benchmarking survey questionnaires returned by Russian ferrous foundries were used to estimate the total annual production of ferrous castings. Overall Russian cost structure data were calculated on the basis of the aggregated weighted average of all responses, as follows:

Material costs:	45.2%
Energy costs:	13.4%
Labour costs (direct and indirect labour):	21.4%
Equipment costs (depreciation and maintenance):	7.2%
Overhead costs (including all other costs)	12.8%
Total	**100.0%**

2) A project database supplied by GEMCO Knight Wendling GmbH was used to estimate the proportional cost of specific items within total cost categories (this database having been developed on the basis of GEMCO Engineers B.V./ Knight Wendling GmbH's prior experience and projects), as follows:

Table 3.4: ITEM COSTS AS A PROPORTION OF TOTAL CATEGORY COSTS

Cost category	Specific cost item	Item cost as a proportion of category costs
Material costs	Metal	70% of material costs
	Metal lost through pig and spillage (i.e., the proportion not possible to recycle)	10% of pig and spillage cannot be recycled
	Sand (new sand)	2% of material costs
	Water (total fresh water)	1% of material costs
Energy costs	Energy for melting	70% of energy costs
	Energy for plant operations	95% of energy costs
Labour costs	Direct labour for melting and moulding	20% of labour costs
	Direct labour for finished casting	80% of labour costs
	Direct labour for running equipment	60% of labour costs
	Labour directly related to productivity	70% of labour costs
Equipment costs	Equipment for melting, cores, and moulding	55% of equipment costs
	Equipment involved up to the detection of scrap castings	60% of equipment costs
Overhead costs	Fixed costs for overheads designed for full capacity utilisation	100% of overhead costs

Source: GEMCO Engineers B.V./Knight Wendling GmbH (2010).

Any individual foundry will use its own cost structure and cost categories for calculating the financial impact of improved performance against specific operational KPIs.

Scope for cost reduction through improved performance

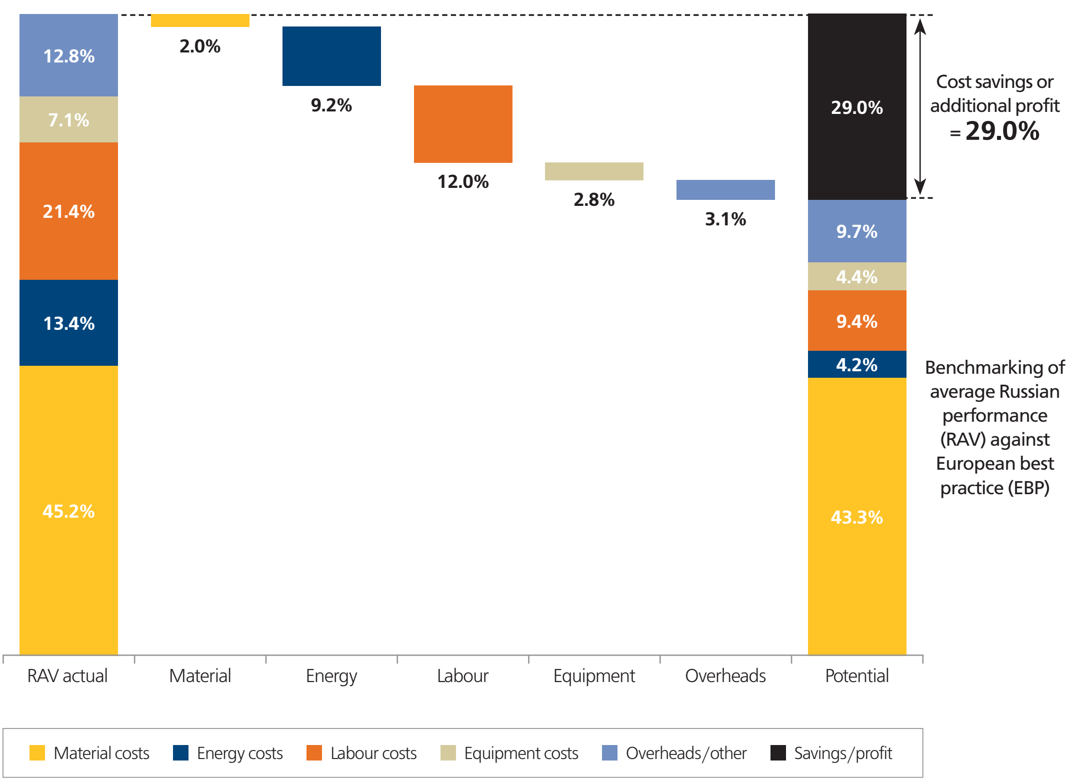
Table 3.5 below illustrates the scope for improvement across all seven KPIs, expressed in terms of potential cost reductions: calculated on the basis of the average performance of Russian foundries in comparison with European best practice.

Scope for improvement is expressed as: RAV vs. EBP = 29%.

A typical (average) Russian foundry could reduce its costs (and improve its profitability) by as much as 29 percent of total costs by matching European best practice in various areas (survey sample results).

The potential savings achievable in financial terms through cost reductions of 29 percent can be calculated by multiplying this percentage against the total costs incurred in total volume castings production.

Figure 3.1: POTENTIAL COST REDUCTIONS IN FINANCIAL TERMS



Source: GEMCO Engineers B.V./Knight Wendling GmbH (2010).

Table 3.5: SCOPE FOR IMPROVEMENT ACROSS ALL KPIS

Impact of Improvements of KPI Nr. 1) – Nr. 7) based on Survey Sample Results

Sample results for improvement of all 7 KPI	KPI ->	Process Yield Nr. 1)				Production Efficiency OEE Nr. 2)				TEEP Nr. 3)	Energy Nr. 4)		Sand Nr. 5)	Water Nr. 6)	Labour Nr. 7)	Potential Change	
	KPI and sub-indicator ->	Melting Loss	Pig & Spillage	Runners & Risers	Scrap & Rejects	Downtime	Slow Running	Bad Moulds	Scrap & Rejects	Capacity Utilisation	Energy Melting	Energy Plant	Fresh Sand	Fresh Water	Labour Productivity	All Improvements	Potential Cost Structure per tonne including potential Savings
	KPI Nr. ->	1.1)	1.2)	1.3)	1.4)	2.1)	2.2)	2.3)	2.4)	3)	4.1)	4.2)	5)	6)	7)	1) – 7)	
	KPI RAV ->	4.5%	3.3%	39.3%	6.7%	22.7%	30.3%	3.8%	6.7%	25.2%	1.164	4.506	1	144.9	75.2		
	KPI EBP ->	1.9%	2.4%	31.5%	2.1%	11.9%	5.1%	0.8%	2.1%	63.9%	544	1.247	0	0.76	15.1		
	KPI change ->	-2.6%	-0.9%	-7.8%	-4.6%	-10.7%	-25.2%	-3.0%	-4.6%	-38.8%	-53.3%	-72.3%	-75.0%	-99.5%	-80.0%		
Cost Structure	Initial	change	change	change	change	change	change	change	change	change	change	change	change	change	change	change	FINAL
Material Costs	42.5%	70%	7%										2%	1%		-2.0%	43.3%
		-0.8%	-0.03%										-0.7%	-0.4%			
Energy Costs	13.4%	70%	70%	70%	70%						70%	95%				-9.2%	4.2%
		-0.2%	-0.08%	-0.7%	-0.4%				in 1.4)		-5.0%	-2.7%*					
Labour Costs	21.4%			20%	80%	60%	60%	60%							70%	-12.0%	9.4%
				-0.3%	-0.8%	-1.4%	-3.2%	-0.4%	in 1.4)						-5.9%*		
Equipment Costs	7.1%			55%	60%	55%	55%	55%		100%						-2.8%	4.4%
				-0.3%	-0.2%	-0.4%	-1.0%	-0.1	in 1.4)	-0.7%*							
Overhead/Other	12.8%									100%					30%	-3.1%	9.7%
										-5.0%					1.9%		
Total plant	**100%**	**-4.0%**				**-6.5%**				**-5.7%**	**-7.7%**		**-0.7%**	**-0.4%**	**-4.0%**	**-29.0%**	**71.0%**
Savings/add. profit										*excl. other 1.3) –2.4)		*excl. 4.1) 1.1) – 1.4)			*excl. other 3)		**29.0%**

CALCULATION PROCEDURE:

Potential = A x B x C

A = KPI change (gap between Russian average performance (RAV) and European best practice (EBP))

KPI change (target) = EBP – RAV

B = cost category as a proportion of total costs

C = relevant proportional impact on cost category

EXAMPLE:

Impact of improving KPI No.1.1, "Melting loss:"

A = KPI change = 1.9% – 4.5% = – 2.6%

B = material costs as a proportion of total costs = 45.2%

C = cost of metal as a proportion of material costs = 70%

Potential = A x B x C =

-0.026 x 0.452 x 0.70 = -0.0082 = -0.8%

SOURCES:

KPI data and initial cost structure sourced from benchmark survey data. Other data (relevant impact on cost structure components) sourced from GEMCO Engineers B.V./Knight Wendling GmbH project samples.

Based on the assumption that the total production costs for Russian castings would be at current European market prices, total potential cost savings are equivalent to RUB100 billion ($3.3 billion) per year.

Table 3.6: SAMPLE CALCULATION FOR RUSSIAN FOUNDRIES

Castings	Production (tonnes, 2008)	Market price* (EUR/kg)	Costs (EUR billion)	Costs (RUB billion)
			39.23 RUB/EUR	
Grey iron	3 070 000	0.80	2.5	96.3
Ductile iron	1 830 000	1.30	2.4	93.3
Steel	1 200 000	3.50	4.2	164.8
Total RUS	**6 100 000**		**9.0**	**354.4**
Potential savings		28.8%	2.6	102.1

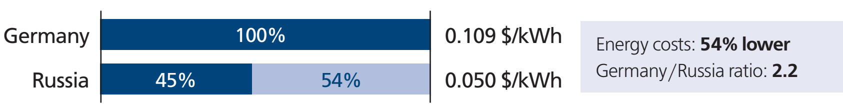
*** Note: Assumption of market price for this benchmarking exercise:**
- actual costs in Russia would be equal to EU market prices;
- the market price is the average across all casting material groups (wide differentiation by type of product)

Source: IFC, GEMCO Engineers B.V./Knight Wendling GmbH (2010).

Highly competitive cost advantages – a good starting point

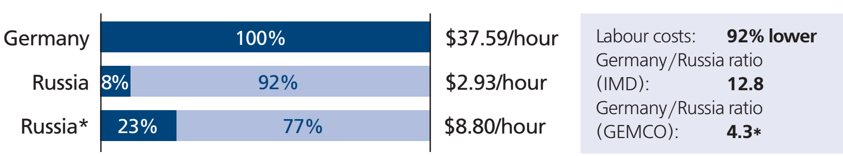
To date, Russian foundries have enjoyed highly competitive cost advantages in comparison with countries in western Europe (for example, Germany).

Table 3.7: ELECTRICITY COSTS FOR INDUSTRIAL CLIENTS (2008)



Source: IFC, GEMCO Engineers B.V./Knight Wendling GmbH (2010).

Table 3.8: LABOUR COSTS – TOTAL HOURLY COMPENSATION FOR INDUSTRIAL WORKERS (2007)

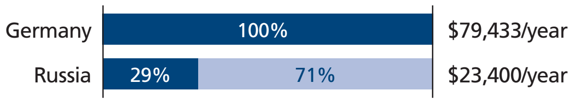


*** Note:** GEMCO/Knight Wendling GmbH audits at foundries in Russia found labour costs at $8.8 0/hour = 77% lower.

Source: IFC, GEMCO Engineers B.V./Knight Wendling GmbH (2010).

As a result, while the benefits of low-cost energy, labour, and natural resources should, as indicated above, give Russian foundries a theoretical competitive advantage in the order of 36 percent, poor resources management eliminates any price advantage.

Table 3.9: OVERHEAD COST LEVELS – REMUNERATION OF DEPARTMENT HEADS IN SERVICE PROFESSIONS (2006)

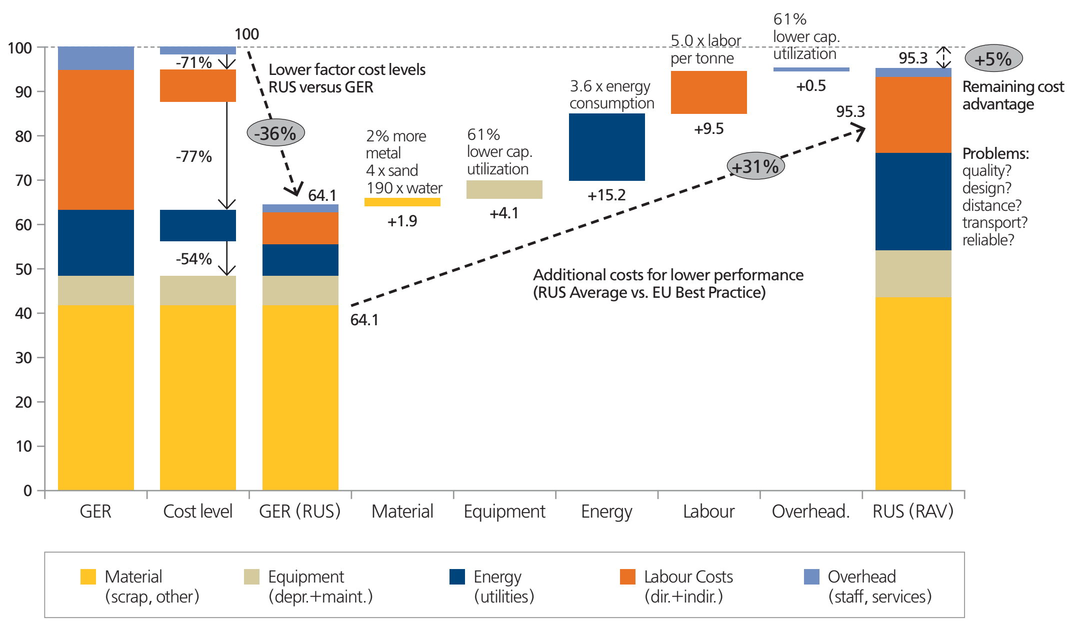


Specialist advisors/ services: **71% lower**
Germany/Russia ratio: **3.4**

Source: IFC, GEMCO Engineers B.V./Knight Wendling GmbH (2010).

- There is little point in having an advantage in energy costs (with a ratio of 2.2) if melting consumption is 2.1 times European levels, and overall consumption 3.1 times higher; this represents a competitive disadvantage (benchmarks for average performance).
- There is little point in having an advantage in labour costs with a ratio of 4.3 if 3.6 times more people are employed; this represents only a marginal advantage (average).
- The advantages of low energy and labour costs are lost because of performance shortfalls which impact on many aspects of the cost structure (see Figure 3.2, below). In this example the cost advantage equates to 4.7 percent – which is too low to compensate for other costs (such as freight, quality, long distance support, extra stocks, etc.).

Figure 3.2 RUSSIAN FOUNDRIES ARE NOT CAPITALISING ON THEIR COMPARATIVE COST ADVANTAGE



NOTE:
GER: Sample cost index structure of a competitive ferrous foundry in Germany, producing iron castings for the automotive industry.
GER (RUS): Cost index structure if the German foundry could operate at Russian cost levels (energy, labour, overheads).
Performance gaps: Russian average vs. European best practice.

Despite the prices of major resources being as much as

half those in Europe,

inefficient resources management is costing Russian foundries any competitive advantage.

Producing one tonne of good-quality castings, for example, takes

three times

more energy than in Europe.

3.4 TECHNIQUES AND TECHNOLOGIES USED IN RUSSIAN FERROUS FOUNDRIES

The survey included questions on the technology and management techniques used in Russian foundries.

Manufacturing technology – findings:

- Russian foundries exhibit a low level of specialisation – in sharp contrast to European enterprises, which have been forced to specialise in order to remain competitive.
  - Ninety two percent of Russian foundries produce items in more than one product category:

Product categories	One category	Two to four categories	Five or more categories
Companies	8%	58%	33%

  - Most of the Russian foundries participating in the survey process more than one category of materials, and more than half of all foundries produce steel castings:

Materials	One material	Two materials	Three materials
Companies	33%	54%	13%
Combinations	Only iron	Iron and steel	Only steel
Companies	42%	46%	13%

  - Almost half of the Russian foundries surveyed apply more than one technology:

Technologies	One technology	Two technologies	Three or more techn.
Melting:	58%	29%	13%
Moulds:	63%	29%	8%
Moulding:	46%	38%	17%
Core production:	42%	50%	8%

- **Specific observations regarding manufacturing technology include the following:**
  - multiple technologies are applied to serve multiple product mix categories;
  - the data indicate high utilisation of arc furnace technology: the percentage of arc furnaces is higher than the it would have been needed to produce the current volume of steel castings;
  - there is a high requirement for robust moulds (chemical-bonded, dry sand, permanent, etc.);
  - Russian foundries demonstrate a low level of automation: only 34 percent are equipped with automatic moulding lines;
  - there is a high incidence of outdated technology: many Russian foundries still use out-of-date techniques which are inaccurate, inappropriate, less efficient, and lead to the production of lower quality castings. These include:
    - moulding using sodium silicate;
    - core-making using oil sand;
    - multiple charging of arc furnaces and extended melting cycles;
    - insufficient post-melting metal treatment facilities (e.g., AOD).
- **Specific observations regarding management techniques include the following:**
  - the percentage of companies familiar with techniques to improve performance is low;

– many foundries (42 percent) experience difficulties in measuring, recording, and evaluating key KPIs;
– those foundries familiar with product-related items are also those most likely to implement initiatives for improvement (continuous improvement programs);
– workforce-related programs ("lean production" programs) are initiated predominantly at the larger foundries;
– environmental certificates are not yet in widespread usage, and are secured mainly by the larger foundries;
– most companies hold general quality certificates on Russian standards (GOST,) but also frequently make reference to international ISO standards;
– customer-related quality certificates are maintained by one third of the companies surveyed, but are expected to become increasingly important as foundries engage in business beyond their own vertically integrated companies and/or as they begin to export beyond the CIS.

Statistics on the prevalence of manufacturing technologies and management techniques

The prevalence of certain manufacturing technologies and management techniques is reflected by two key statistics:

- "Companies (%)" indicates the percentage of all companies responding to the survey that apply this technology;
- "Percentage by volume" indicates how much (the percentage) of a foundry's production is produced using this technology.

If the percentage value for "Companies (%)" is higher than the value for "Percentage by volume" then this indicates that the technology in question is preferred by smaller companies.

Table 3.10: PREVALENCE OF SPECIFIC TECHNOLOGIES AND MANAGEMENT TECHNIQUES

Criteria (Russian foundries)*	Companies (%)	Percentage by volume	Remarks (Russian foundries)
Melting/metal treatment			
Induction	58%	53%	• Proportional production of cast materials (Russian foundries): – grey iron (induction or cupola) 50% – ductile iron (induction) 26% – steel (arc) 24% • Russian foundries exhibit a clear preference for arc furnaces
Arc	54%	68%	
Cupola	33%	20%	
Oil/gas-fired	0%	0%	
AOD	0%	0%	
VOD/VAD	4%	0.3%	
Moulding system			
Green sand	83%	93%	• Green-sand mould technology is preferred at larger Russian foundries, while smaller foundries prefer chemical-bonded sand moulds
Chemical-bonded sand	46%	24%	
Permanent moulding	8%	6%	
Vacuum moulding	0%	0%	
Dry sand	4%	4%	
Other	8%	3%	

Criteria (Russian foundries)*	Companies (%)	Percentage by volume	Remarks (Russian foundries)
Moulding facilities			4% automatic, 92% mechanised, 4% manual
Automatic green sand moulding	50%	60%	• Mechanised moulding is very common in Russia: many foundries also use floor/hand moulding for minor quantities
Mechanised (semi) green sand	67%	31%	
Mechanised chemical-bonded loop	13%	1%	
Floor or pit hand-moulding	50%	8%	
Core making			
Oil sand	29%	12%	• A substantial number of smaller Russian foundries still apply outdated technologies for core production (oil sand, sodium silicate, etc.)
Shell sand (croning)	13%	35%	
Cold box	46%	59%	
Hot box	46%	82%	
Sodium silicate	29%	16%	
Chemical-bonded sand	8%	1%	
Other	4%	6%	
Core production			
Machine manufacture	50%	83%	• Automatic machine manufacture of core is predominantly utilised at larger foundries
Handmade	83%	56%	
Heat treatment			
Batch	54%	51%	• Eighty three percent of Russian foundries apply heat treatment: a greater number of smaller Russian foundries concentrate on normalising, quenching, and tempering
Continuous	25%	26%	
Normalising	67%	47%	
Quenching and tempering	63%	43%	
Management techniques			
Company is familiar with:			• Only a minority of Russian companies are familiar with state-of-the-art management techniques for operational performance improvement • Continuous improvement programs and lean production techniques are predominantly used in larger foundries
continuous improvement programs	36%	37%	
Six Sigma methodologies	32%	14%	
lean production	55%	62%	
Company has already applied:			
continuous improvement programs	27%	68%	
Six Sigma methodologies	0%	0%	
lean production	27%	55%	
Certificates:			
Environmental certificates	17%	45%	• Environmental certificates are in evidence at larger foundries: the majority of Russian foundries respect quality standard regulations
General quality certificates	63%	86%	
Customer quality certificates	33%	41%	

Note: *Russia data, based on the percentage of foundries responding to the benchmarking survey and corresponding production volumes.

RECOMMENDATIONS

Closing the resource-efficiency gap on European standards will require Russian foundry owners and management to face up to the necessity of engaging in certain key strategic initiatives, including:

1) **improving operational performance –** much of which can be undertaken internally, without major capital investment, through improvements in processes and organisation, as well as investment in equipment;

2) **revising the business models of many foundries** (in line with company and/or group strategy) to:

   a. specialise on core competencies (in terms of products and technology);

   b. penetrate attractive market sectors and geographic regions: this may require the development of sales and marketing strategies and customer-service skills directed at developing both domestic and international markets.

Improved operational performance could be achieved through the following steps.

- Improving those process-related KPIs most likely to deliver direct cost savings and improve the bottom line:

Process yield:	4.0%	potential reduction in total costs
Production efficiency:	6.5%	potential reduction in total costs
Total:	**10.5%**	**potential reduction in total costs**

  Many of these improvements could be realised through organisational changes and managerial initiatives, without, necessarily, any need for major capital investment.

- Better energy efficiency in the melting process could reduce total costs by as much as five percent. While a degree of capital investment may be required (in the replacement of outdated equipment with more energy-efficient plant) a number of savings might also be achieved through organisational initiatives. Minimising energy costs will become increasingly important as energy prices continue their inexorable rise.

- Improved labour productivity could result in a saving of up to four percent on total costs: much of it achievable without the need for any financial investment, through organisational initiatives such as reductions in over-manning and improved operational and administrative processes. This will become increasingly important as wages rise in line with Russia's developing economy.

- Lower consumption of fresh water and sand will also become increasingly important in future as water charges and waste disposal costs rise. Better resource efficiency in both cases could be achieved, however, though organisational initiatives (requiring only limited investment) as well as through major capital projects.

On the basis of the results of the IFC *Resource Efficiency in the Ferrous Foundry Industry in Russia: Benchmarking Study,* matching European best practice could deliver the following results.

Table 4.1: IMPROVEMENTS ACROSS ALL KPIS

Sample results for improvement across all 7 KPIs	Savings/ additonal profit (% total costs)	Organisational measures (minor investment only)		Major capital investment required	
		% potential	% total costs	% potential	% total costs
1. Process yield (%) (from four sub-indicators)	**-4.0%**	**68%**	**-2.7%**	**32%**	**-1.3%**
melting loss (%)	-1.1%	50%	-0.5%	50%	-0.5%
pig and spillage (%)	-0.1%	50%	-0.1%	50%	-0.1%
runners & risers (%)	-1.4%	75%	-1.0%	25%	-0.3%
scrap & rejects (%)	-1.4%	75%	-1.1%	25%	-0.4%
2. OEE (moulding) (%) (from four sub-indicators)	**-6.5%**	**70%**	**-4.6%**	**30%**	**-1.9%**
downtime (%)	-1.8%	25%	-0.4%	75%	-1.3%
slow running (%)	-4.2%	95%	-4.0%	5%	-0.2%
bad moulds (%)	-0.5%	25%	-0.1%	75%	-0.4%
scrap & rejects (%)	0.0% *)		0.0%		0.0%
3. TEEP (%) Capacity utilisation	**-5.7% *)**	**70%**	**-4.0%**	**30%**	**-1.7%**
4. Energy consumption (kWh per to produced)	**-7.7%**	**25%**	**-1.9%**	**75%**	**-5.8%**
for melting (kWh/to melt)	-5.0%	25%	-1.3%	75%	-3.8%
for casting (kWh/to cast)	-2.7% *)	25%	-0.7%	75%	-2.0%
5. Sand consumption (per ton good casting)	**-0.7%**	**25%**	**-0.2%**	**75%**	**-0.5%**
6. Fresh water consumed (m^3 per to good casting)	**-0.4%**	**50%**	**-0.2%**	**50%**	**-0.2%**
7. Labour productivity (man-hr/to good casting)	**-4.0% *)**	**75%**	**-3.0%**	**25%**	**-1.0%**
Total Plant Savings	**-29.0%**	**57%**	**-16.6%**	**43%**	**-12.4%**

Note: * Excluding double counts.

Source: GEMCO Engineers B.V./Knight Wendling GmbH (2010).

Russian foundries have opportunities to increase their international competitiveness if performance is improved and cost advantages exploited and maintained. But only when the quality of castings is improved will Russian foundries be able to increase production volumes significantly, and on a sustainable basis.

- Very few foundries have experience of exporting outside the CIS. Foundries manufacturing for in-house, domestic, or CIS clients are not yet exposed to the strict quality systems and requirements in force internationally.

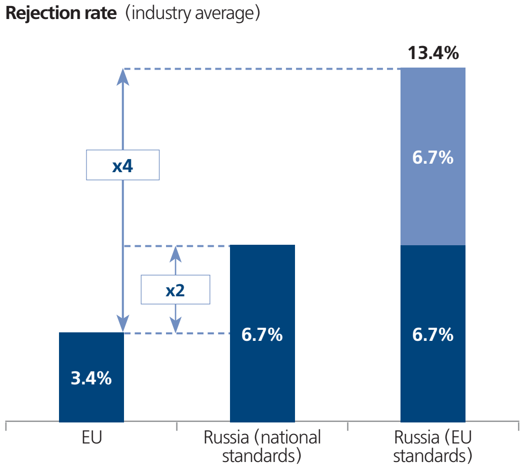
Table 4.2: DOMESTIC AND EXPORT MARKETS

Markets served (by volume) (survey sample results)	
In-house	62.4%
Domestic	32.9%
Export to CIS countries	4.2%
Export outside the CIS	0.5%

Source: GEMCO Engineers B.V./Knight Wendling GmbH (2010).

- The scrap and reject volumes currently borne by Russian foundries are relative to (domestic) quality standards and customer quality acceptance levels. However:
  - quality requirements are currently higher in Europe than in Russia;
  - if Russian castings were subject to European quality standards it is likely that scrap and reject volumes would be considerably higher.

Figure 4.2: REJECTION RATES AT RUSSIAN FOUNDRIES ARE BETWEEN TWO AND FOUR TIMES HIGHER THAN THOSE AT EUROPEAN ENTERPRISES



Source: IFC (2010), "Resource Efficiency of the Ferrous Foundry Industry in Russia Benchmarking Study," October.

- Evidence from GEMCO Engineers B.V., as well as various Russian specialists in the sector, suggests that if Russian foundries were subject to European quality standards scrap and reject volumes would be likely to double.
- Quite apart from the need to reduce scrap and reject volumes, Russian foundries also need to improve the "visual appearance" of castings in order to compete effectively on the international markets.

It is of vital importance for Russia's machine-building and engineering industries that quality standards improve:

- high quality castings are a precondition for state-of-the-art construction and performance;
- they are also a precondition for the technological competitiveness of Russian foundries;
- and for fully efficient resources management.

Key recommendations

Following the completion of its *Resource Efficiency in the Ferrous Foundry Industry in Russia: Benchmarking Study,* IFC has recently issued the ***Practical Guide to Resource Efficiency in the Russian Ferrous Foundry Industry,*** providing a series of tools to support Russian foundries in benchmarking and operational improvement. Specifically, the guide also includes the following volumes:

1. Self-diagnostic Guide	Based on the methodologies used in conducting this study, the *Self-diagnostic Guide* enables individual enterprises to collate information and analyze results against various KPIs. With recommendations on data collection, and on the evaluation and analysis of information, resulting conclusions may then be benchmarked against best practice and average standards in Russia and Europe.
2. Best Practice Guide for the Russian Ferrous Foundry Sector	This guide includes a number of strategies for improving performance, and analyses cross-sectoral experience and best practice in the implementation of new technologies. With 55 concrete proposals on improving performance against KPIs, as well as 150 indicators on the evaluation of capital equipment and 200 "best available techniques," it also includes practical advice on the continuous improvement of new production processes.

Key strategies for senior management in implementing performance improvement.

- Clearly define the proposed scope of all projects, and set clear and achievable targets, timeframes, policies and procedures.
- Set clear leadership goals and objectives, and ensure both management and employees are fully engaged in these, through regular reporting and communications.
- Establish a dedicated "Project team" staffed by internal specialists and external independent advisers: the involvement of external experts will act as a catalyst in eradicating redundant processes and habits, as well as generating new ideas.
- Ensure all personnel understand the necessity for change, and are fully engaged in all change management initiatives.

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