Air Conditioning Mapping Report
An Overview of the Russian Market

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BY

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in Partnership with
The Collaborative Labeling and Appliance
Standards Program (CLASP)

clasp

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Abbreviations and Acronyms

AC	Air Conditioner, or Air Conditioning
CDD	Cooling Degree-Days is an indicator of the amount of cooling required. It is calculated as the integration of the amount of time that the outdoor temperature is above a specified base temperature, multiplied by the average positive temperature difference (outdoor T - base T) over a time interval (e.g. monthly CDDs, annual CDDs).
CF	Coincidence Factor is the ratio of the actual electrical load of a population of devices on the power system, such as air conditioners to the total connected or rated load of the population of devices. Seasonal Coincidence Factor is the CF during the highest system demand periods.
CLASP	Collaborative Labeling and Appliance Standards Program
EER	Energy Efficiency Ratio, used to measure AC efficiency at a single operation point.
EU	European Union
FGC-UES	Federal Grid Company of the Unified Energy System is the electricity transmission grid operator in Russia, formed in July 2008
GW	Gigawatt = 1,000 MW
GWh	Gigawatt-hour = 1000 MWh
HDD	Heating Degree-Days is an indicator of the amount of heating required. It is calculated as the integration of the amount of time that the outdoor temperature is below a specified base temperature, multiplied by the average positive temperature difference (base T - outdoor T) over a time interval (e.g. monthly HDDs, annual HDDs).
kW	Kilowatt = 1,000 watts
kWh	Kilowatt-hour; the amount of energy used by a kW over a 1-hour period
MEPS	Minimum Energy Performance Standard
MW	Megawatt = 1,000 kW
MWh	Megawatt-hour = 1,000 kWh
RAO-UES	Unified Energy System of Russia, which became part of FGC-UES in July 2008
S&L	Standards and Labeling
TW	Terawatt = 1,000 GW
TWh	Terawatt-hour = 1,000 GWh
UEC	Unit Energy Consumption, is the amount of energy used by an AC unit in one year
W	Watt; measures the rate of energy usage

1 Introduction

In 2011, CLASP completed the first in a series of appliance mapping and energy performance benchmarking studies to provide an international comparison of energy efficiency performance and policy measures. CLASP's 2011 *Cooling Benchmarking Study*[1] provides policymakers and energy efficiency program managers with tools for comparing the test standards and efficiencies of common air conditioning (AC) products under the different test procedures that are currently used in major world economies. This 2011 cooling study did not include the Russian economy.

In collaboration with the European Bank for Reconstruction and Development (EBRD), CLASP here extends the analytical approach of the *Cooling Benchmarking Study* to the Russian market in order to provide a set of findings and recommendations that will help the Russian AC market align with international efficiency levels. This initial literature review and mapping task is the first step in implementing a full Russian AC benchmarking study. The mapping summary report provides an overview of available information on the Russian electricity supply system, on historic growth and the current status of the air conditioning market in Russia, and estimates the likely impact of the air conditioning load on electricity demand in Russia.

The report concludes that:

- The Russian AC market is in a growth phase, with 2010 overall sales reported at about 1.8 million units, compared to 145 thousand units in 2000. Residential sector sales rose even faster, to about 1.17 million units in 2010 compared to 46,000 units in 2000.
- The total stock of AC units in Russia grew from about 1.37 million units in 2001 to about 10.33 million units in 2011. The stock of residential AC units grew from about 0.20 million units in 2001 to about 5.51 million units in 2011. By 2011 it is estimated at over 11% of Russian household are equipped with air conditioning.
- The stock of Russian AC units is estimated to have used 12 TWh of electricity in 2011. Residential units used about 34%, and commercial units used about 66% of the total annual electricity consumed by air conditioners.
- The 2011 stock of Russian AC units represents a connected electric load of about 23.9 GW. These AC units are estimated to have contributed about 14.3 GW, or over 14% of the peak demand on the power system in the summer.

The report concludes with an identification of the missing information necessary to undertake a more complete mapping and benchmarking study of Russian air conditioners.

2 Overview of Electricity Supply and Consumption in Russia

2.1 Russia's Electricity Supply

Russia's electricity production is the fourth largest in the world. In 2010, total electricity production (including transmission, distribution, and other losses) was 1,036 TWh, of which 17 TWh were exported [21]. Russia exports electricity to the Commonwealth of Independent States consisting of Armenia, Azerbaijan, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan and Uzbekistan, as well as to Latvia, Lithuania, China, Poland, Turkey and Finland.

Electricity in Russia has been supplied by the state electricity monopoly, Unified Energy System of Russia (RAO-UES), which became part of the Federal Grid Company Unified Energy System (FGC UES) in 2008 [22]. The power grid extends over 11 time zones. According to a 2005 IEA Report[2], Russia has been pursuing a strategy of high economic growth. Growth will rely on the development of a competitive marketplace that can be sustained through investment. In order to break up the monopoly, the government proposed to create as many as 26 wholesale generation companies which could compete among themselves across the entire wholesale market. The proposal could produce considerable diversity of ownership and a highly competitive wholesale market structure. According to the proposed plan, the three largest generators would control about 34% of generating capacity. The single largest generator, the aggregated hydroelectric generator, would control about 15% of total generating capacity. The government plans to maintain its control over nuclear and hydroelectric generation, or about 25% of Russia's total generating capacity.

The transmission of power from generators to consumers also requires a robust and flexible network and commercially viable enterprises to build and operate the transmission and distribution grid. The creation of an independent national system operator would be helpful for providing accurate and detailed information about the transmission network's needs, performance, as well as direction for optimizing the use of generation and minimizing the cost of production. This was accomplished in July 2008 with the formation of a single operating company called the Federal Grid Company Unified Energy System (FGC UES), which was created by merging 54 companies that operated transmission systems of former regional power utilities [22].

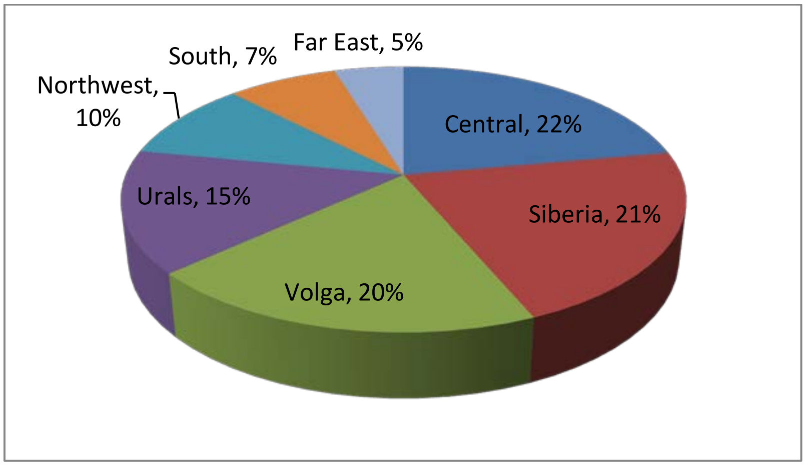
2.1.1 Power Generating System

The power system in Russia is divided into 7 regional grids, of which, the Central, Siberia and Volga regions have the highest amounts of electricity generation. The total amount of generation by region (in 2002) is presented on Table 1 and graphically on Figure 1.

Table 1: Electricity Generation by Region TWh, 2002 [2]

Region	TWh (2002)
Central	197
Siberia	191
Volga	174
Urals	132
Northwest	86
South	67
Far East	42
Total	*889*

Figure 1: Percentage Electricity Generation by Region, 2002 [2]



Most of the generating stations are located near the highly populated areas along the west and southern parts of the country, with some hydro and combined heat and power stations in northern Siberia.

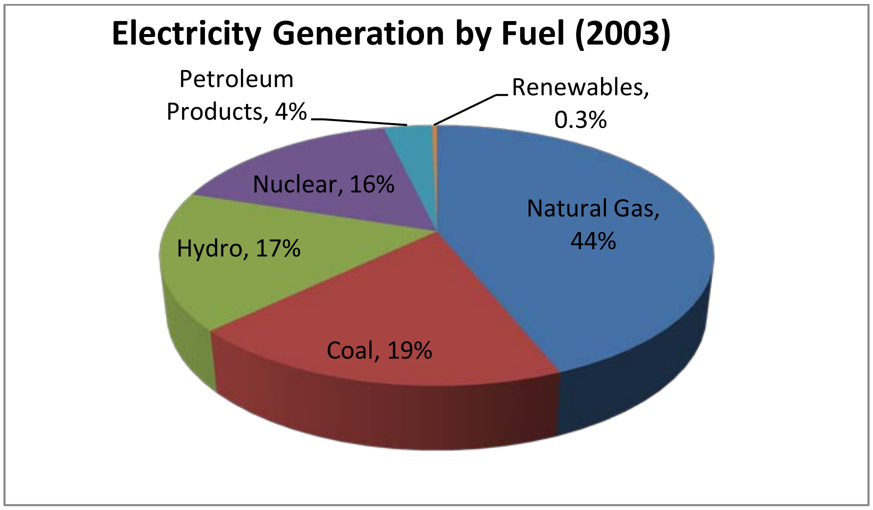
The fuels used for electricity production are summarized in Table 2. By far the largest source is natural gas, followed by coal and hydro power. Nuclear power in 2003 contributed nearly as much energy as hydro.

Table 2: Electricity Generation by Fuel (TWh per year, 2003) [2]

Fuel	TWh
Natural Gas	402
Coal	174
Hydro	157
Nuclear	149
Petroleum Products	31
Renewables	3
Total	916

A graphic representation of fuel usage in 2003 is presented on Figure 2.

Figure 2: Percentage Electricity Generation by Fuel [2]



The contribution levels changed somewhat as nuclear power production increased between 2003 and 2007, as indicated on Table 3.

Table 3: Installed Electricity Generation Capacity by Type [2]

Types of Electricity Generation	Installed Capacity (GW) 2003	Percent of Total power generated in 2003	Percent of Total power generated in 2007
Thermal (incl. combined heat & power)	148	69%	63%
Hydroelectric	64	21%	21%
Nuclear	22	10%	16%
Total	214	100%	100%

2.2 Electrical Energy Consumption

Figure 3 presents the top 10 economies in electricity consumption in the world. Electrical energy consumption in Russia is ranked 4th in the world.

Figure 3: Top Ten Electricity Consuming Economies in the World[1]

Rank	Country	**Electricity - consumption** (TWh, 2012)	
1	China	4,693	
2	United States	3,741	
3	Japan	859.7	
4	Russia	857.6	
5	India	600.6	
6	Canada	549.5	
7	Germany	544.5	
8	France	460.9	
9	Brazil	455.7	
10	Korea, South	455.1	

Electric power in the Russian Republic is supplied by an integrated power grid composed of seven regions. The regions are listed in descending order of installed generating capacity on Table 4.

Table 4: Installed Generating Capacity & Peak Demand (winter peak) by Region [2]

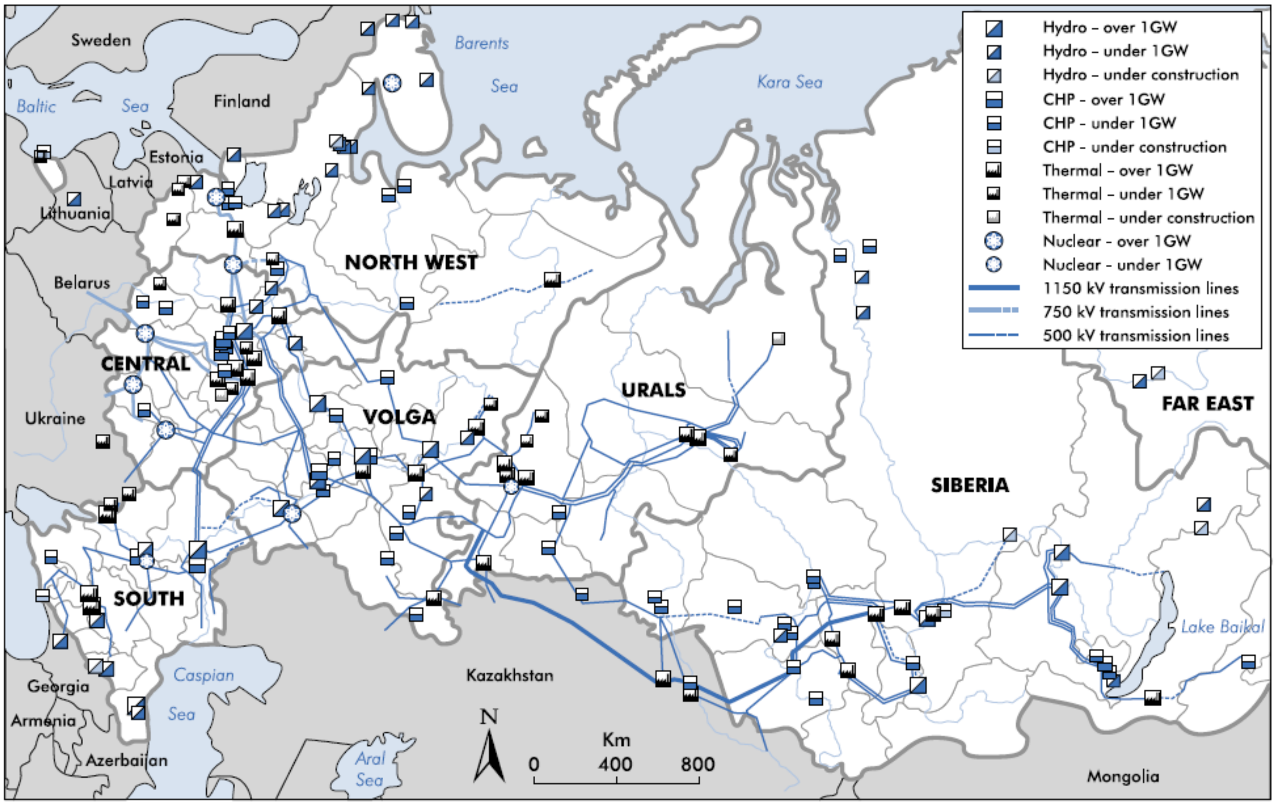
Region	**Installed Capacity** (GW)	**Estimated Peak Demand (February, 2005)** (GW)
1. Central	49	38
2. NW	40	32
3.South	45	28
4. Urals	23	13
5. Volga	19	12
6. Siberia	11	8
7. Far East	11	6
Overall Russia	**198**	**134**

Russia is a winter peaking country, with the highest demands for electricity occurring during the heating season. For comparison, the overall peak demand for electricity during the cooling season (e.g. July 2004) was about 98 GW [2].

The major electricity plants and bulk transmission system are shown on the map in Figure 4.

[1] http://www.indexmundi.com/

Figure 4: Major Russian Electricity Plants and Bulk Transmission System [2]



The energy consumption of each of the seven distinct power grids that make up the Russian electricity system reflects the total amount of industrial, commercial and residential electricity use in each region.

In order to get an idea of the regions where air conditioning would most likely be used, a review was conducted of the typical types of activities that are taking place in each of the Regions including resource development and manufacturing industries, commercial activities such as hospitality, offices and retail, agricultural activities and concentrated residential housing in the 7 regions of Russia. The results are summarized on Table 5, and are presented in more detail in Annex 1.

Table 5: Main industrial activities in each region [2]

Region	Activities	Standard of living	Population	GDP	National Industrial output
1. Central	Highest standard of living, manufacturing and business	High	25% +	30%	20%
2. NW	wealthiest natural resource area, associated mining and industrial activities	High		10%	12.5%
3.South	Coal, agriculture, transportation, tourism	Low to med.		10%	6%
4. Urals	55% of Russia's oil and gas reserves, mining, machine building	Low			
5. Volga	Transportation, pipelines, manufacturing (ships, aircraft, automobiles)	Med. to high		20%	25%
6. Siberia	Coal, steel, forestry, mining, oil and gas	Low			
7. Far East	High potential for hydro generation; system is isolated	Low			

2.3 Regions where AC Units would Impact Russian Electricity Demand

The most likely Regions that make extensive use of air conditioning are the Central Region (where Moscow is located), the Northwest Region (where St. Petersburg is located), and the Southern Region, where many resorts are located near the Caspian Sea, which attract millions of tourists in the summer time.

The characteristics of the air conditioner load are related to the outdoor temperature and humidity of each region; the demand is highest on the hottest days during the summer months. The following Table 6 presents the number of cooling degree-days, an indicator related to the amount of air conditioning use that is likely required. Heating degree-days indicate the relative amount of space heating required during the heating season.

Table 6: Cooling and Heating Degree-Days in Russian Cities (Base = 15.5ºC)

Region	City	Annual Cooling degree-days (°C-days)	Annual Heating degree-days (°C-days)
Central	Moscow	501	3,665
Northwest	St. Petersburg	317	3,778
Southern	Volgograd	1,047	3,349
Southern	Adler	1,078	1,340

These values were calculated via www.degreedays.net and are based on 15.5°C for both cooling degree-day and heating degree-day calculations, using the average temperatures for the past 5 years.

For comparison purposes, the cooling and heating degree-days in some North American cities are shown in Table 7.

Table 7: Cooling and Heating degree-days in North American Cities

City	Annual Cooling degree-days (°C-days)	Annual Heating degree-days (°C-days)
Winnipeg, Manitoba, Canada	471	4,921
Montreal, Quebec, Canada	639	3,485
Toronto, Ontario, Canada	697	3,065
Los Angeles, California, USA	792	375
Chicago, Illinois, USA	948	2,866
New York City, N.Y., USA	1,188	1,929
Washington, D.C., USA	1,473	1,698
Miami, Florida, USA	3,508	55

A comparison of cooling degree days between Russian cities and North American cities suggests that Moscow and St. Petersburg have temperatures similar to Winnipeg (Canada), while Volgograd and Adler in the southwest resort area are nearly as warm as New York City (USA) in the summer, but have different temperature ranges in winter.

One must keep in mind that air conditioning requirements for comfort in a building depend not only on weather conditions (temperature and relative humidity) but also on the building characteristics including thermal insulation level, fenestration, shading, the availability of natural ventilation and on the amount of interior heat gain (from occupants, equipment such as computers, lighting, etc.) Degree-days of cooling and degree-days of heating provide one way of comparing likely energy requirements for space conditioning systems in various locations around the world. However, they do not provide the complete picture because they do not take into account the impact of other important factors that affect comfort conditions (mentioned earlier), such as outdoor relative humidity and building thermal characteristics.

Power is supplied to the Moscow region by Moscow United Electric Grid Company[2]. Within the past 10 years, 2 x 400 MW combined-cycle gas-fired electrical generating units were installed in the region to supply peak load. Due to the relatively high number of heating degree-days to cooling degree-days in Moscow and in St. Petersburg, it is expected the peak demand in both cities occurs during the winter.

[2] http://moesk.ru/en/

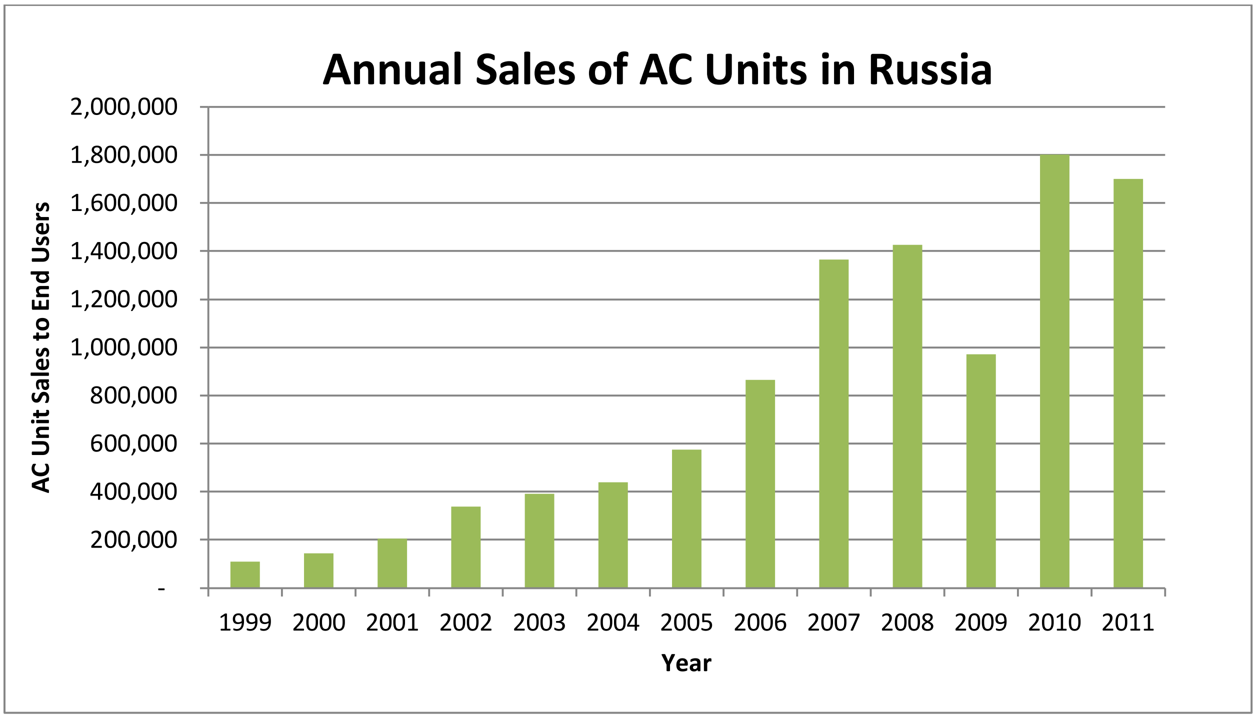
3 Overview of the Russian Air Conditioner Market

The air conditioning market in Russia is a growing market, with a general trend of growth in sales since the mid-1990s, tempered from time to time by general economic down-turns and cool summers. Available data suggests that the Russian market is still below the saturation point and that the stock of AC units will continue to increase beyond 2011.

3.1 Overview of Russian Air Conditioner Sales

In 2011, the annual sales of air conditioning units in Russia is estimated at about 1.7 million units and averaged 1.45 million units per year over the previous 5 years (2007 to 2011) [3]. The trending of AC unit sales for the period 1999 to 2011 is shown in Figure 5.

Figure 5: Annual Sales of AC Units in Russia from 1999 to 2011 [3]



The dip in sales in 2009 to about 0.97 million units is believed to be largely due to the global economic crisis. In 2010 there was a dramatic increase in AC sales to about 1.8 million units due to stored up demand from the previous year and an extremely hot summer, especially in the Moscow region, where the sales volume was 2.4 times that of 2009.

The AC unit sales shown in Figure 5 include both commercial and residential sales. The residential sales fraction has been accelerating since about 1998 [10]. In 1999, AC sector sales were about 22% residential and 78% commercial, reaching about 55% residential sector and 45% commercial sector in 2002 [10]. Market sector trends are discussed in greater detail in Section 3.3.1

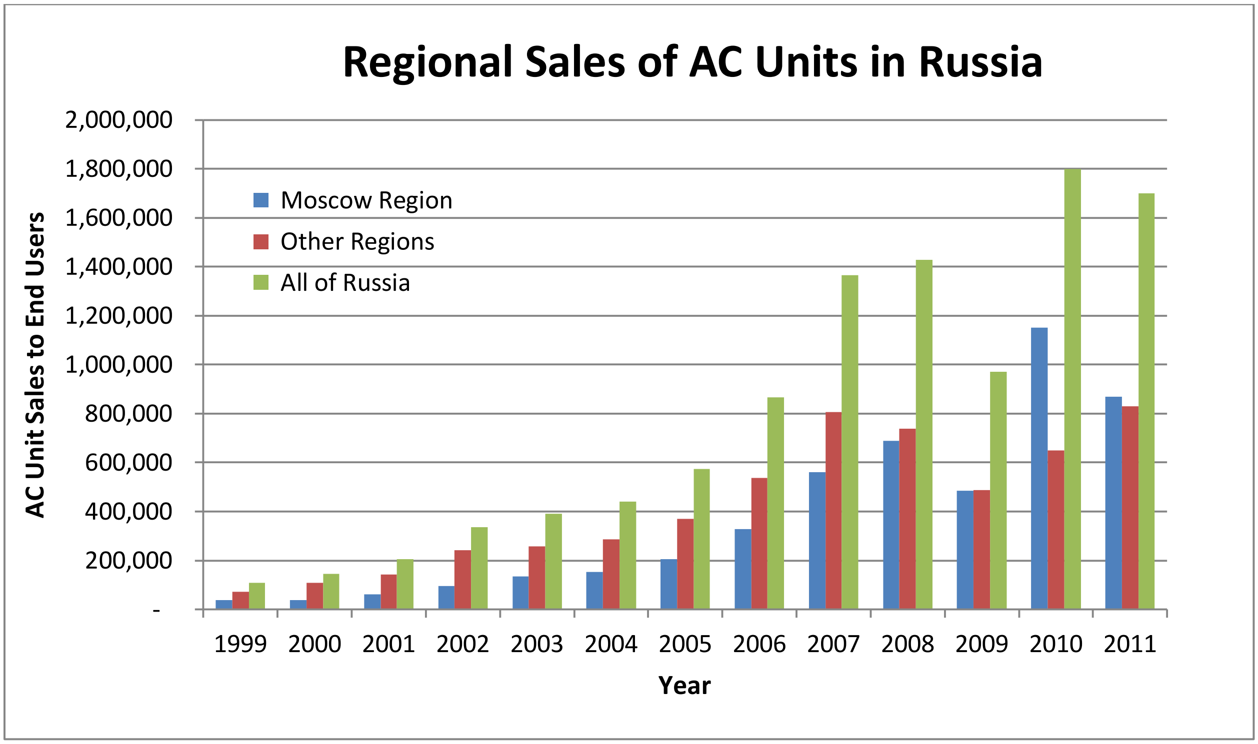
In 2010, it is reported that over 90% of the Russian AC sales were in the 2 kW to 3.5 kW size, with many of these units sold for residential applications [12]. These AC cooling sizes are smaller than the values reported in the 2011 Cooling Benchmarking Study for the EU Region which ranged from 5.6 kW to 6.1 kW in 2011 [17].

Another study reports average residential sector sales between the years 2005 to 2009 at about 480,000 units per year [5]. Projected residential sector sales in 2014 are estimated at about 749,000 units. [5]

3.2 Regional Sales

The regional breakdown of AC sales between the Moscow region and other regions of Russia is shown in Figure 6.

Figure 6: Regional Sales of AC Units in Russia from 1999 to 2011 [3]



Prior to 2007 the Moscow region accounted for about 26% to 38% of AC unit sales in Russia. In 2007, sales in the Moscow region increased to 41% of total sales, and were about 50% in each of the years 2008, 2009 and 2011. In 2010, Moscow sales of AC units more than doubled from the previous year due to an extremely hot summer and accounted for about 64% of all Russian AC unit sales.

In 2011, AC unit sales remained relatively high, due to fears of another hot summer and the prospects of equipment shortages. Climate equipment retailers reported very high “off season” sales of AC units in the first 4 months of 2011 with demand for AC units up by 70 to 100% compared to the same period in 2010 [9], and reported sales of about 800,000 units in the first quarter of 2011[11].

3.3 General Trends in the Russian AC Sales

This section discusses AC sales trends in terms of market sectors and major technology groupings. The following subcategories are considered:

Market Sector Subcategories:

- Residential sector
- Corporate & Commercial Sector

AC Technology Subcategories:

- Window and portable (mobile) ACs
- Split and packaged (PAC) ACs

3.3.1 Market Sector Trends

In the early and mid-1990s, the majority of Russian air conditioner (AC) sales (i.e., 80% to 90%) were to commercial customers. A small number of units (i.e., 10% to 20%) were also sold to residential customers mainly for use in luxury apartment applications [10].

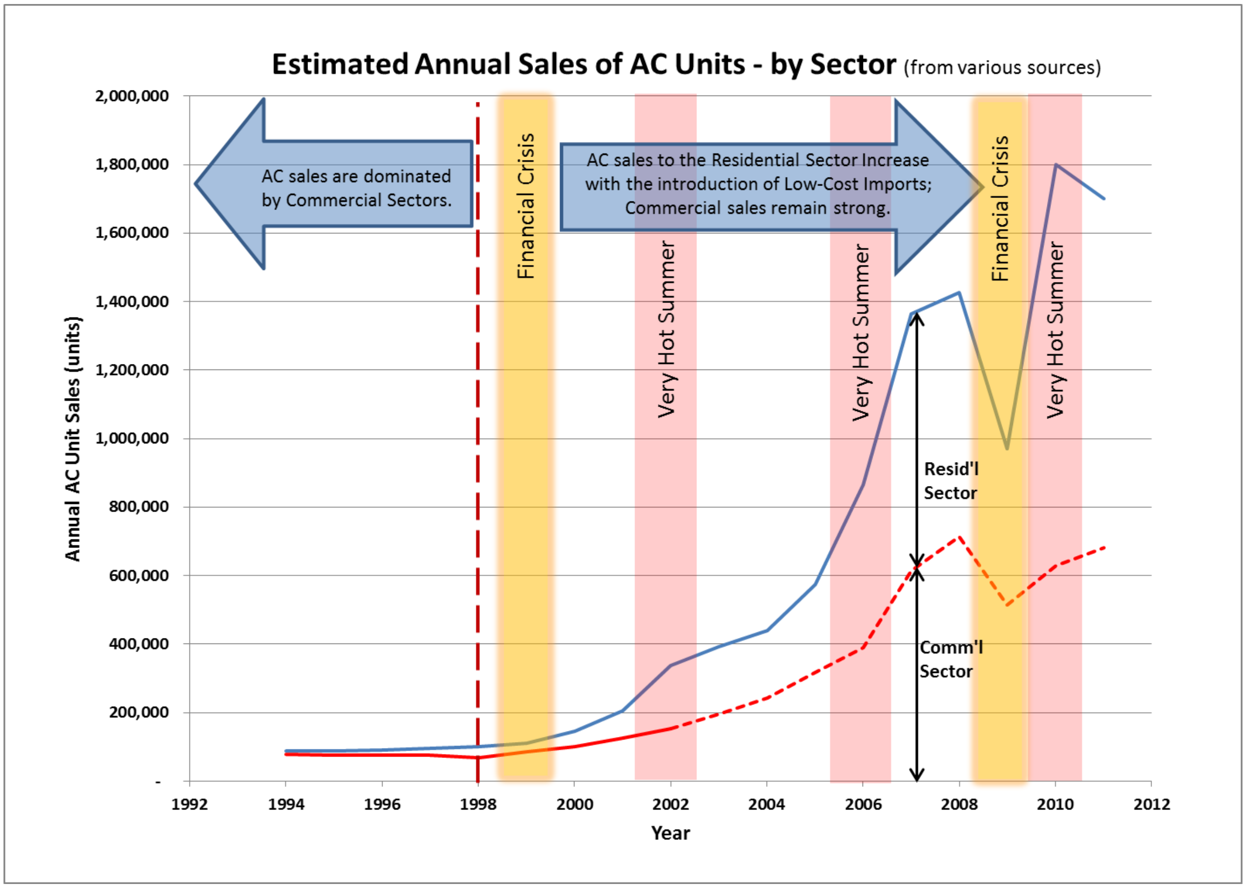
The importance of the residential sector started to change in 1998 when Korean companies introduced inexpensive window air conditioning units to Russia. For the first time, air conditioning was no longer seen as a luxury item and starting to become accessible to average consumers. In 1998, the residential sector was responsible for a significant increase in sales, accounting for about 32% of AC sales, only to collapse to about 22% in 1999 due to a financial crisis that year, which reduced homeowners' spending capacity. Air-conditioning sales to homeowners increased again in 2000, accounting for about 32% of sales that year, and continued to grow year-by-year resulting in a 55% share of all sales in 2002 [10].

Specific market sector data is not readily available after 2002, but anecdotal information concerning sales in 2010 suggests that residential-sector sales have remained strong. In 2010, over 90% of the AC sales were in the 2 kW to 3.5 kW size, and 75% of total sales were inexpensive AC units [12]. This would imply that a high portion of sales were for residential applications, likely in the range of 65% to 70% in 2010.

Air conditioning sales values from various articles and reports were combined to form a unified dataset, and produce an overview of AC sales in Russia for the years 1994 to 2011. Gaps in certain data fields were estimated using trending from adjacent periods. The details are shown in **"Appendix A: Russian AC Sales Estimates".**

Plotting these sales values (see Appendix A for details), Figure 7 illustrates the trending of AC sales for the residential and commercial sectors from 1994 to 2011.

Figure 7: Annual AC Sales by Market Sector



The commercial sector dominated AC sales until about 1998, and was fairly steady at about 80,000 units per year. Commercial AC sales started to climb year after year following the 1999 financial crisis, with little impact on sales by weather factors (e.g. cool or hot summers). Annual sales peaked at over 700,000 units in 2008, but then fell due to another financial crisis in 2009 . Sales volumes rebounded in 2010 and approached 700,000 units in 2011.

Prior to 1998, residential-sector sales of AC units were mainly in niche markets (e.g. luxury apartments and houses) [10], with estimated sales volumes of about 9,000 to 19,000 units annually. In 1998, residential sector sales rose to about 32,000 units [10] due to the introduction of low-cost window AC units from Korea into the Russian market. In 1999, the financial crisis suppressed residential sector sales as homeowners' buying power dropped.

Residential AC sales recovered in 2000 with sales of about 46,000 unitsand showed steady or rapidly-growing sales until the second financial crisis in 2009. Sales in 2007 and 2008 are estimated at 751,000 and 714,000 units respectively. In 2009, residential AC sales dropped to an estimated volume of about 456,000 units due to the financial crisis. Then, in 2010, a year with a record hot summer, residential AC sales set an all-time high with an estimated sales volume of 1,170,000 units, about a 2.5 times increase from the previous year. Residential AC sales in 2011 continued to be strong at over 1 million units.

Unlike commercial-sector sales, residential AC sales are weather dependent. Generally residential sales volumes increase during years with hot summers[3] and sometime the following year, while sales volumes decrease during years with cool summers [3, 11]. Like the commercial sector, residential AC sales are also reduced during periods of financial uncertainty.

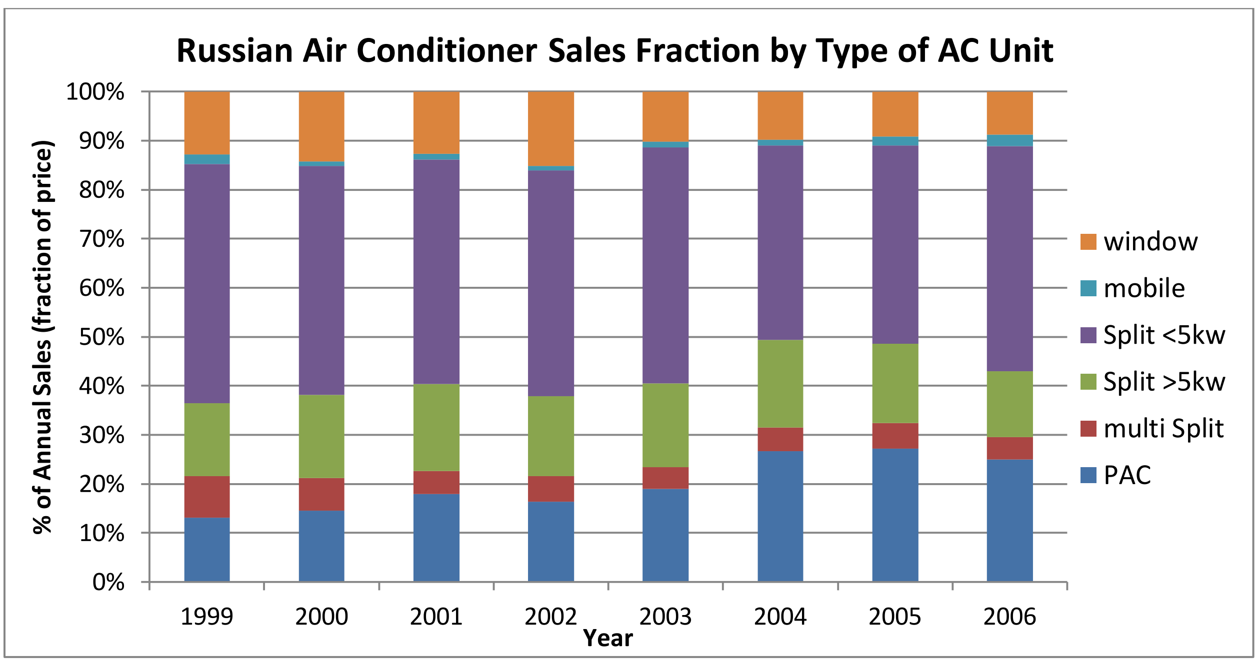
3.3.2 AC Technology Trends

There are primarily six types of AC units sold in the Russian market. These are:

- Window AC units
- Portable or mobile AC units
- Wall-mounted split systems <5kW
- Wall mounted split systems >5kW
- Multi-split systems
- Packaged AC units (PACs)

Figure 8 illustrates the breakdown of AC sales by type for the years 1999 to 2006.

Figure 8: Russian AC Sales Fraction by Technology Type [13]



The window, mobile and wall-mounted splits under 5 kW accounted for about 57% of the sales revenue in 2006, and would include most of the systems sold in the residential sector. Larger wall-mounted splits, multi-splits and PAC units accounted for about 43% and would be predominately sold into commercial applications [13].

[3] For the past 10 to 12 years, Russian summer weather has followed roughly a 4-year pattern: with 1 of 4 years being cooler than average; 1 of 4 years being average, and 2 of 4 years being hotter than average [3]. The years 2002, 2006 and 2010 were the hottest years in this repeating pattern. http://www.apic.ru/images/diagram_01.jpg

For purposes of trending the sales data assembled in Appendix A, these various AC technologies have been grouped into two subcategories on Table 8, namely:

Table 8: Definition of AC Subcategories

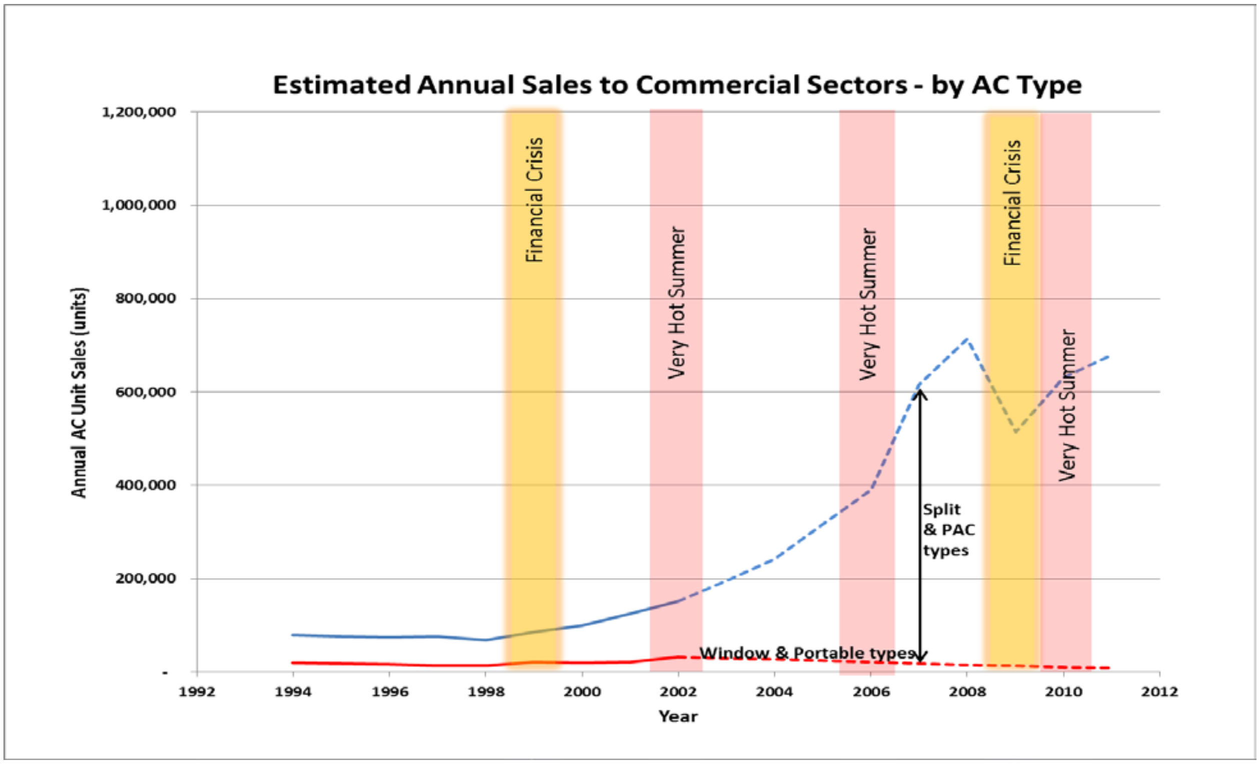
AC Subcategory	*Types of AC units included in the Subcategory*
Window & Portable ACs	• Window AC units • Portable or mobile AC units
Splits & PACs	• Wall-mounted split systems <5kW • Wall mounted split systems >5kW • Multi-split systems • Packaged AC units (PACs) *(both air- and liquid-cooled units)*

The window and portable AC subcategory represent the technologies with lowest cost. These systems are easy to install e.g. often do-it-yourself (DIY) installation, and may be removed and stored during the "off-season". The cooling capacities tend to be smaller and units may be noisier than other types when operating.

Split-systems and packaged AC units (also referred to as PACs or monoblocs) are permanently installed in buildings. These systems may be larger in capacity and are generally installed by trained technicians. Split systems are assembled on site and may require specialized refrigeration training. PACs require ducting to the outside for air cooled units or connection to cooling water source for liquid cooled technologies.

Commercial Sector Air Conditioners: Figure 9 illustrates estimated annual sales of each of the AC subcategories to the commercial sector, with details shown in Appendix A.

Figure 9: Commercial AC Sales by Technology Subcategory

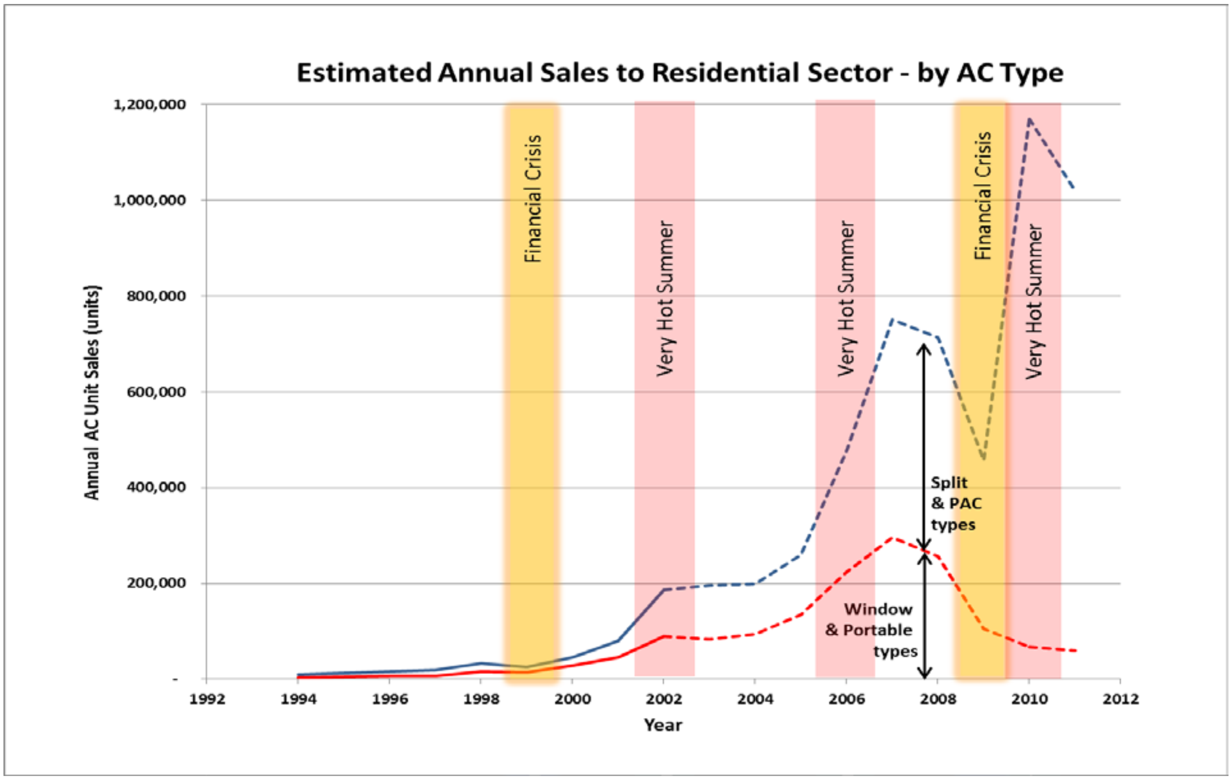


Splits and PACs dominate the sales of AC equipment in the commercial sectors.

Residential Sector Air Conditioners: When the sales of AC units to the residential sector first started to accelerate in about 1998, the most common type of residential AC was the window air conditioner [10]. Over time, the residential market has evolved. In recent years, the most common type of residential AC unit is the wall-mounted split-system type followed by the window AC type [4].

Figure 10 illustrates the estimated annual sales of each of the AC subcategories to the residential sector, with details shown in Appendix A.

Figure 10: Residential AC Sales by Technology Subcategory



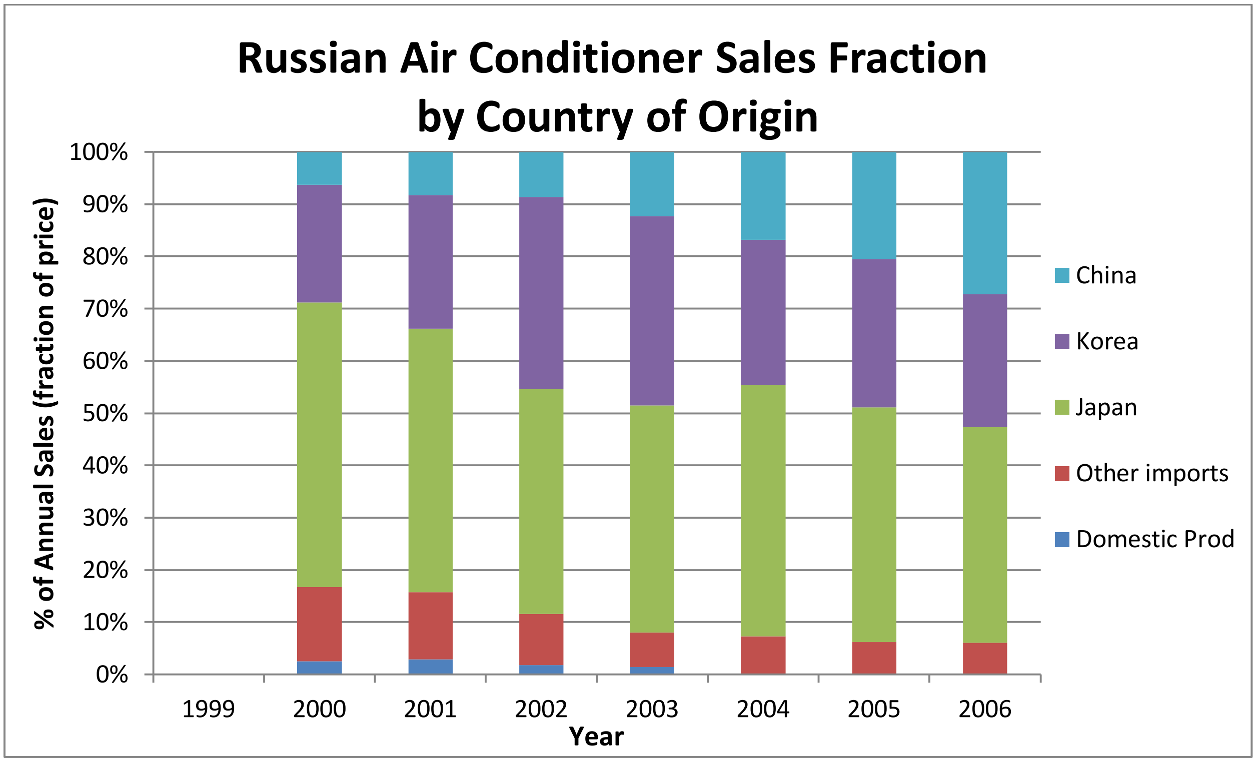
Up to about 2005 both "window & portable", and "splits & PACs" subcategories showed strong market presence in the residential sector. Starting in 2006, windows & portables started losing market share to the splits & PACs, and by 2010 splits and PACs were the dominant technology subcategory in the residential sector. Sales of window and portable AC units are reported at under 80,000 units (to all sectors) in 2010 [12].

4 Domestic Production and Imports of AC Units

The vast majority of AC units (estimated at 97% to over 99%) are imported to Russia [4, 5]. Since 2005, reported domestic production ranges from a low of 732 units to a high of 1,312 units, which is less than 0.1% of the current annual sales. [5]

Figure 11 illustrates the breakdown of Russian AC sales values by the country of origin for the years 2000 to 2006 [13].

Figure 11: Russian AC Unit Sales by Country of Origin [13]



4.1 AC Unit Imports

The imported AC units sold in Russia come mainly from three countries: Japan, Korea and China. The Korean and Chinese products dominate the lower-price segments of the AC market. Japanese units, which are generally higher priced, accounted for about 41% to 47% of the annual AC sales (based on price) between 2002 and 2006.

The Chinese market share is increasing over time, from a low of about 6% in 2000 to over 27% in 2006.

The Korean market share has expanded form about 23-25% in 2000-2001 to about 36% in 2002-2003 by taking market share from Japanese and other importers. In 2004-2006 the Korean market share has contracted back to the 26-28% range, losing market share to Chinese manufacturers.

5 Domestic Stock of Russian Air Conditioners

The domestic stock of Russian AC units was determined in two ways: (1) by searching the literature for estimates of total installed AC units; and (2) by projecting the stock of AC units by integrating the reported annual sales figures and accounting for retirement of older AC units on a year-by-year basis. These results are discussed in the following sections.

5.1 Russian AC Stock – results of literature search

One study [5] reports that the share of residential households using air conditioners grew from 4.88% in 2005 to 5.75% by 2009. Russia has a relatively stable population of about 145 million [5]. This implies a stock of about 2.78 million residential AC units at the start of 2009[4], assuming an average household size of 3 persons [19].

The total number of residential AC units by the start of 2012 will be higher, and the percentage of houses with AC units will be greater due to additional AC sales in 2009, 2010 and 2011. Residential AC sales between 2009 and 2011 are estimated at about 2.65 million units[5]. Ignoring replacement units[6], this suggests a residential stock of about 5.43 million AC units by the start of 2012, and an 11.2% share of houses with air conditioning by the start of 2012.

The literature search did not produce any values on the size of the stock of AC units in the commercial sectors.

5.2 Estimation of the Russian Stock of AC Units from Annual Sales

In order to provide a complete estimate of AC stock for all sectors in Russia, calculations were performed to integrate the detailed sales data (see Appendix A) that was assembled for the years 1994 to 2011. These calculations used the assumptions described in Table 9.

Table 9: Assumptions Used in AC Stock Calculations

Market Sector	AC subcategory	Parameter	Assumed value
Residential Sector	Window & Portable AC Units	AC stock in 1993	30,000 units
		Average replacement cycle	10 yrs
		# of units retired from service in a given year	# of units sold10 yrs prior, or 3,000 units if data not available
	Splits & PACs	AC stock in 1993	70,000 units
		Average replacement cycle	15 yrs
		# of units retired from service in a given year	# of units sold15 yrs prior, or 5,000 units if data not available
Commercial Sectors	Window & Portable AC Units	AC stock in 1993	150,000 units
		Average replacement cycle	10 yrs
		# of units retired from service in a given year	# of units sold10 yrs prior, or 15,000 units if data not available
	Splits & PACs	AC stock in 1993	825,000 units
		Average replacement cycle	15 yrs

[4] 145 million persons divided by 3 persons/household = 48.3 million households x 5.75% with AC = 2.78 million AC units at the start of 2009; Average household size is based on Reference 19.

[5] See Appendix A for details on AC sales estimates.

[6] The number of replacement AC units is estimated at about 110,000 units (~4% of sales) between 2009 and 2011; see Appendix A for details.

		# of units retired from service in a given year	# of units sold15 yrs prior, or 55,000 units if data not available

The details of the domestic stock calculations are shown in Appendix B of this report. A summary of the estimated installed AC stock values at the start of years 2009 and 2012 are shown in Table 10.

Table 10: Estimated Russian Stock of AC Units at the start of 2009 and 2012

Market Sector	AC subcategory	Stock at start of year (units)	
		2009	2012
Residential Sector	Window & Portable	1,261,000	1,405,000
	Splits & PACs	1,714,000	4,107,000
	All Residential	**2,975,000**	**5,512,000**
Commercial Sectors	Window & Portable	228,000	198,000
	Splits & PACs	3,001,000	4,618,000
	All Commercial	**3,229,000**	**4,816,000**
All Sectors	Window & Portable	1,489,000	1,603,000
	Splits & PACs	4,715,000	8,725,000
	All Sectors	**6,204,000**	**10,328,000**

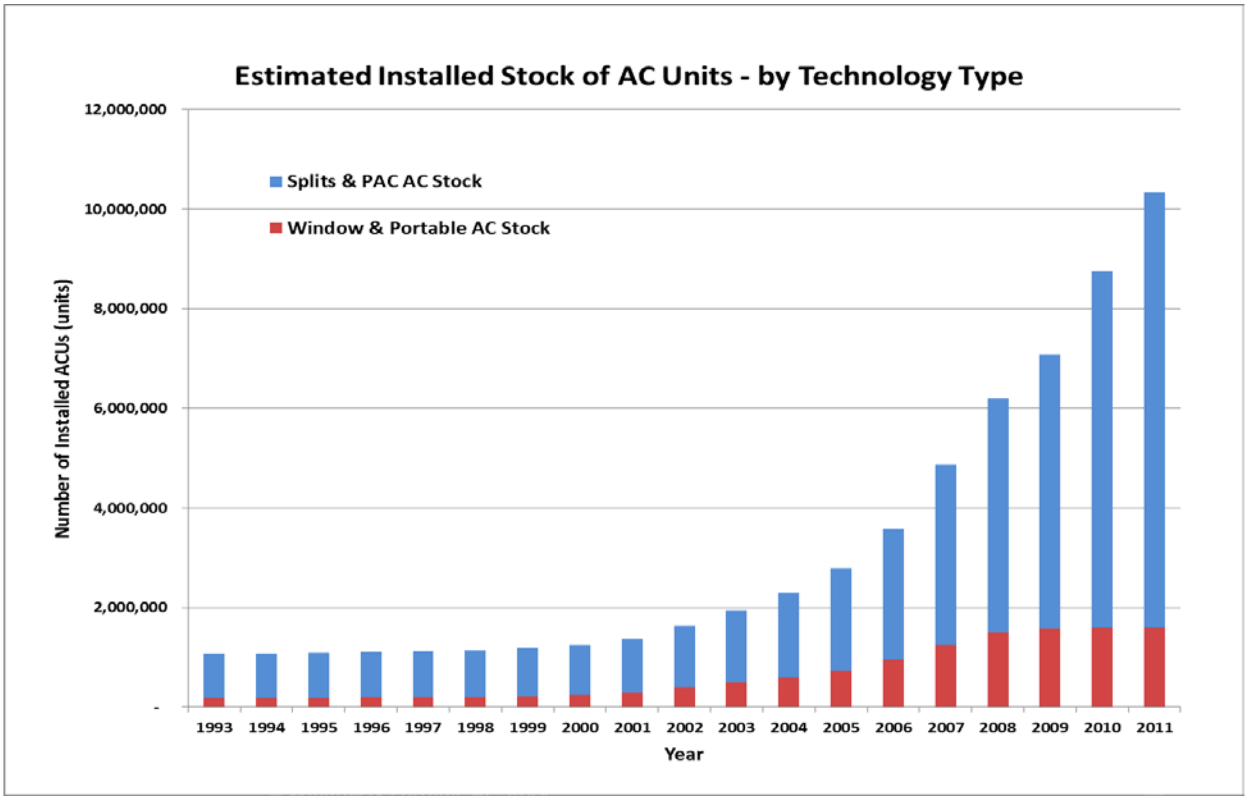
The estimated stock value of 2.98 million residential AC units at the start of 2009 is similar to the value of 2.78 million units estimated from data in Reference 5.

Overall, at the start of 2012, the estimated installed stock of residential AC units is 5.5 million, and the installed stock of commercial AC units is 4.8 million, for a total domestic stock of 10.3 million units. This is made up of 1.6 million window and portable AC units, and 8.7 million split and PAC units.

It is estimated that about 11.4% of Russian households have air conditioning at the start of 2012 based on the assumption of about 48.3 million households.

Growth in the number of installed AC units in Russia over time is illustrated in Figure 12.

Figure 12: Estimated Domestic Stock of AC Units in Russia



The installed stock of AC units was fairly constant until about the year 2000, with a total installed stock of about 1 million units. After 2000, the installed stock of both window & portableand splits & PAC units increased until about 2009, at which time the number of window & portable units leveled off at about 1.6 million units and splits & PACs were at about 5.5 million units. The stock of splits & PACs continued to grow after 2009 and reach about 8.7 million by the end of 2011, for a total installed stock of 10.3 million AC units.

6 Electricity Use and Energy Efficiency Status

The literature search did not produce any information on actual energy usage by installed AC units in Russia.

6.1 Cooling Degree-Days of Major Russian Cities

There will be regional differences in the amount of cooling required based on average temperatures in different regions of the country. Table 6 in Section 2.3 lists the cooling degree-days for some of the largest cities in Russia.

6.2 Estimated Energy Usage by Air-Conditioning Units in Russia

In order to develop a preliminary estimate of annual electricity usage by AC units in Russia, calculations were made based on the installed stock, and assumptions on the average size, average EER values and changes in EER values over time, and average hours of AC unit operation in a typical year.

Table 11 summarizes the key assumptions that were made to allow the calculation of annual energy usage by the installed stock of AC units in Russia.

Table 11: Key Assumptions Used in AC Energy Calculations

Market Sector	**AC Sub-Category**	**Avg. Cooling Capacity** (kW)	**EER of new AC Units** (W/W)	**Avg. Annual Operating hours**[7]
Residential Sector	Window & Portable	2.3	*EER values vary with year* *see Table 12 for assumed values*	500
	Splits & PACs	3.5		500
Commercial Sectors	Window & Portable	3.5		500
	Splits & PACs	7.0		500

6.2.1 Assumed EER values of units sold in Russia between 1999 and 2011

No detailed data on the variation of air conditioning efficiency was found during the literature search other than the values in the 1986 Russian standard [14], which are shown in Table 13 in Section 7.2, and range from an EER of 1.6 to 2.09 (W_{cool}/W_{elect}).

The majority of Russian AC units are imported from China, Korea and Japan. It is reasonable to assume that because of the low minimum energy performance standards (MEPS) requirements in Russia, manufacturers from these countries will export lower efficiency units to Russia than the ones sold in their home markets. Table 12 summarizes the assumed average EER values for AC units sold in Russia between the years 1999 and 2000.

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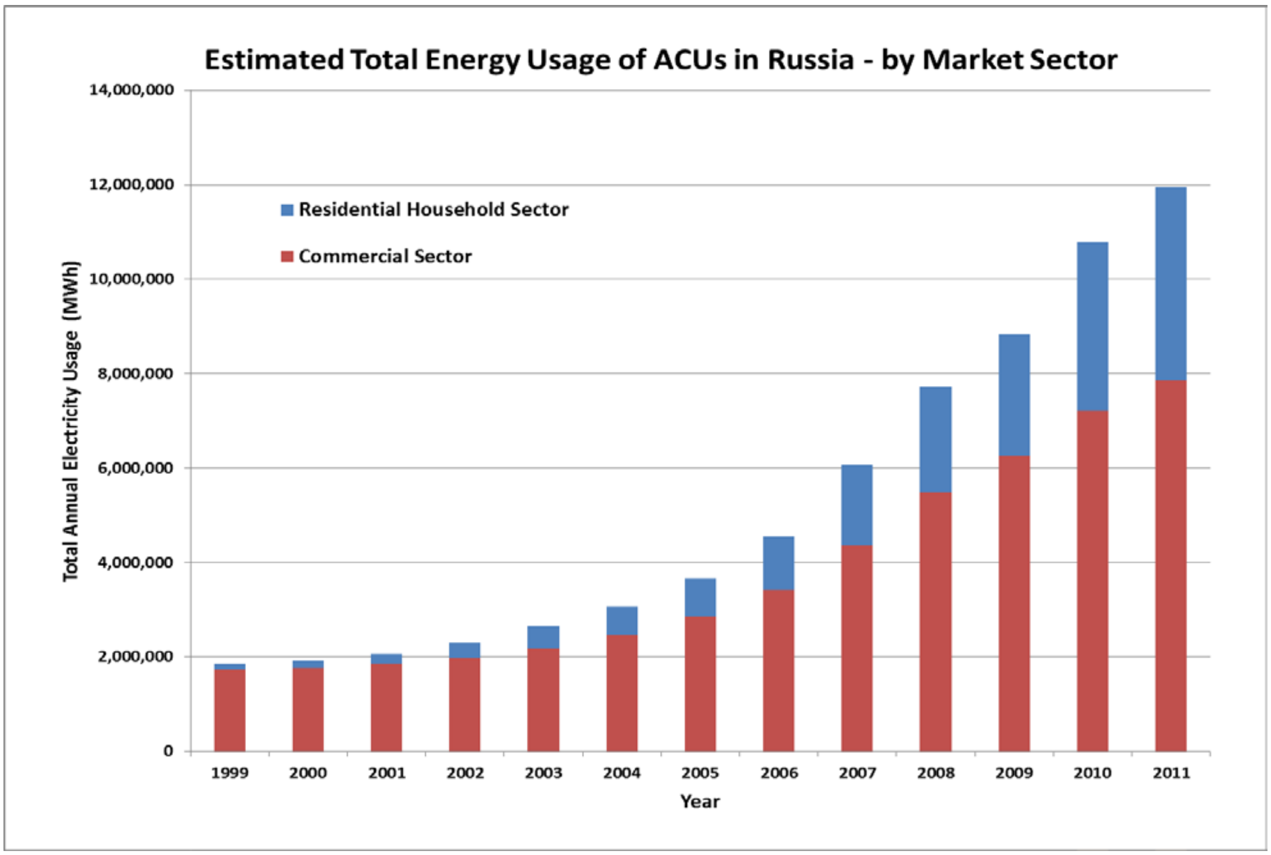
[7] Note: 500 hours is the value used when calculating annual energy usage for AC labelling purposes in Russia [18].

Table 12: Assumed EER Values Used in the Russian AC Energy Estimates

Parameter	Assumed EER (W/W) Values used in Energy Calculations[8]			
Time period >	Avg EER of AC stock in 1998	EER of units sold in 1999	EER of units sold between 2000 & 2010	EER of units sold in 2011
Average EER >	1.90	1.90	2.00	2.75

The details of the AC energy calculations are shown in Appendix C. The resulting energy usage by Russian AC units is shown in Figure 13 by market sector.

Figure 13: Estimated Annual Energy Usage of AC Units by Market Sector



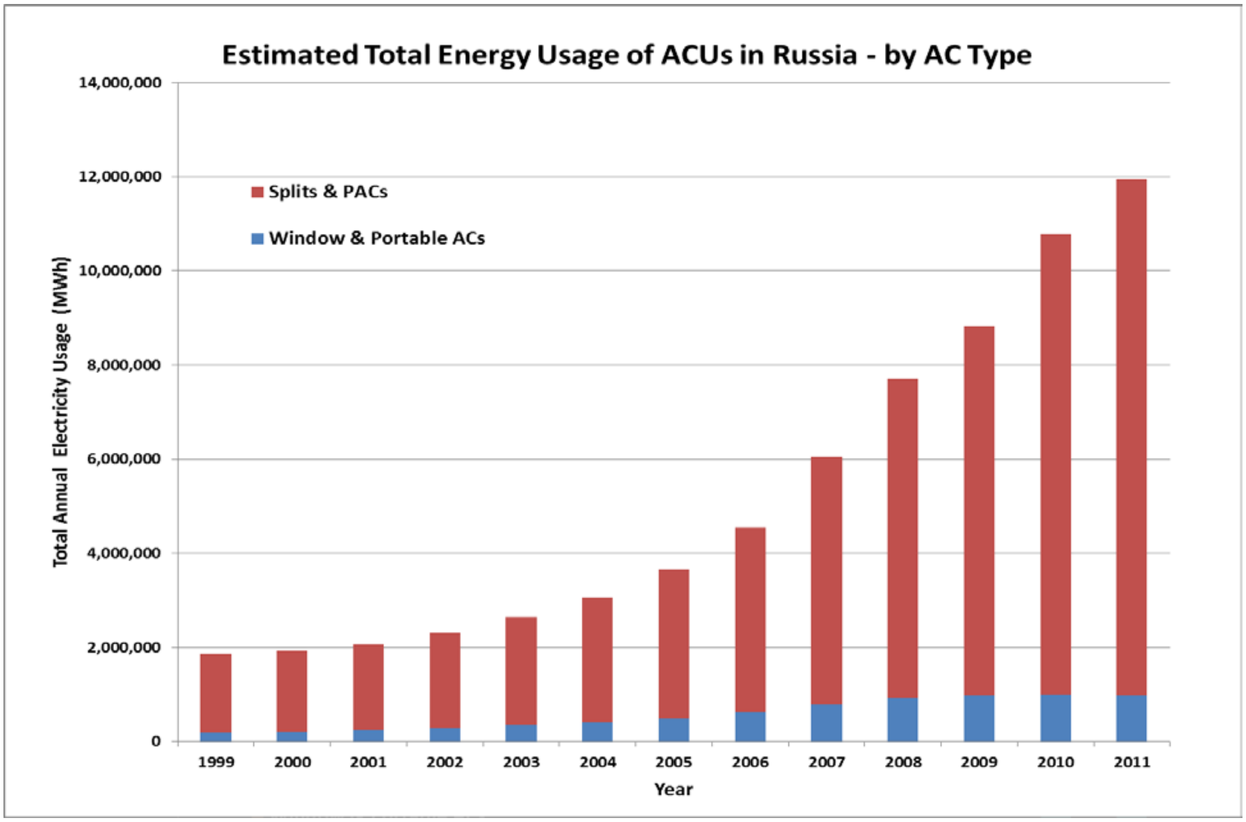
Air conditioners are estimated to use just under 12 TWh of electricity in 2011. This is up from about 1.9 TWh in 1999; an increase of 6.5 times usage in 12 years.

In 2011, the commercial sector used an estimated 7.9 TWh or 66%, while the residential sector used an estimated 4.1 TWh, or 34% of all usage. The residential sector growth is dramatic, increasing from 0.13 TWh in 1999 to 4.1 TWh in 2011; an increase of over 31 times usage in 12 years.

[8] These assumed EER values are similar to 1-Star Efficiency Levels for AC units used in Australia [17]

Figure 14 shows the estimated energy usage by AC technology sub-category.

Figure 14: Estimated Annual Energy Usage of AC Units by Technology Type



The majority of energy is consumed by split and packaged AC units, which used about 11 TWh, or 92% of the total usage in 2011. Window and portable AC unit usage has levelled off since 2008 at just under 1 TWh, or 8% of the total usage.

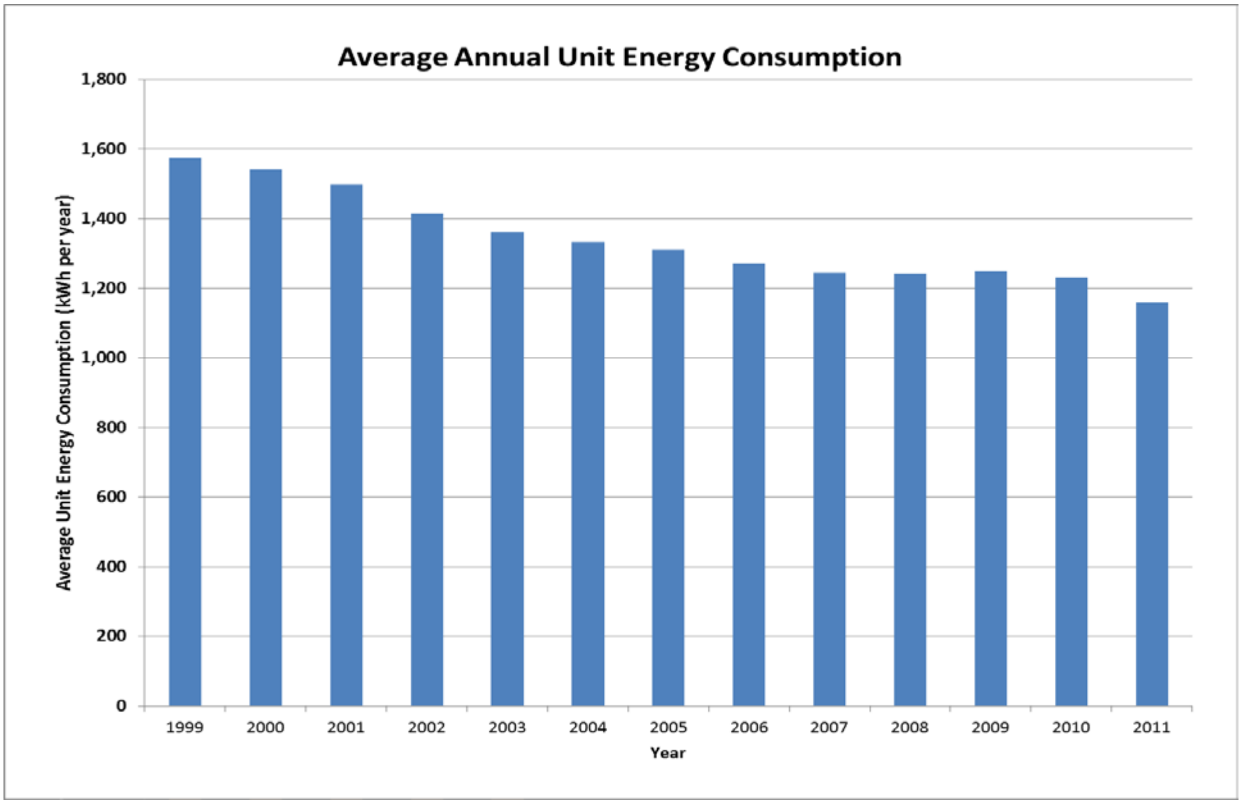
6.3 Estimated Peak Coincident Demand by Air Conditioning Units in Russia

The calculations in Appendix C estimate that there is a total installed air conditioning load of 23.9 GW in Russia in 2011. Assuming that on average 60% of the AC units are running at the time of the electricity-system summer peak (i.e. coincidence factor of 60%) [23], these air conditioners will contribute 14.3 GW to the summer-peak load. Based on the 2004 summer system peak of 98 GW [2], this represents 14.6% of the summer peak load.

6.4 Changes in Average AC Unit Energy Consumption

Figure 15 shows the trending of average AC unit energy consumption (UEC) over time from 1999 to 2011.

Figure 15: Average Annual Unit Energy Consumption - 1999 to 2011



Average annual UEC is trending down from about 1,570 kWh in 1999 to about 1,160 kWh in 2011. Two factors are driving this decrease in UEC: (1) first the average EER is increasing; and (2) the average size of AC units is decreasing as the residential sector becomes a larger fraction of the total AC market and due to the fact that residential AC units are smaller than commercial AC units.

7 Standards & Labeling Program Characteristics

Four agencies were involved in the development of Russia's MEPS program. They are:

- **Minenergo:** Ministry of Energy, formerly known as the Ministry of Fuel and Energy (Mintopenergo);
- **ROSSTANDART:** Federal Agency on Technical Regulation and Metrology. ROOSTANDART is the national standardization body of Russia and is an affiliate of the Ministry of Industry and Trade. It was formerly known as the State Committee of the Russian Federation for Standardization and Meteorology (GOSTANDART);
- **VNIINMash:** Russian Scientific and Research Institute for Standardization and Certification in Mechanical Engineering, an affiliate of ROSSTANDART [24];

GOSTANDART regulations, always prefixed with GOST, contain product energy performance requirements and describe the product's energy test procedure. The mandatory MEPS that were introduced in the 1980's [6, 7] were converted to voluntary requirements in 2002 and were never effectively implemented [20]. New energy-performance labelling requirements have been introduced in 2011 [8, 18].

7.1 Minimum energy performance standards

It appears that minimum energy performance standards (MEPS) for room air conditioners were implemented in 1986 [6, 7].

7.2 Details of 1980's Regulation on Russian Air Conditioners

The following details are reported in the 1999 APEC Study [7] for MEPS regulations covering Russian air conditioners.

Regulation or program (effective date): GOST 26963-86: Self-contained room air conditioners; General specifications (1989). [7]

Product category: Cooling-only and reversible room air conditioners (non-ducted window and split type) in the cooling mode. [7]

Criteria and requirements: Table 13 shows the MEPS requirements for room air conditioners applicable since 1990. [7, 14]

Table 13: MEPS for Room Air Conditioners in Russia [14]

Cooling Capacity (W)	Electrical power demand in cooling mode or heating mode (W)	Implied EER (W/W)	Specific weight (kg/kW*year)
1120	700	1.60	4.01
1400	800	1.75	3.38
1740	900	1.93	2.93
2240	1150	1.94	2.32
2800	1450	1.93	2.22
3550	1800	1.97	2.03
4500	2150	2.09	1.82
5600	2700	2.07	1.57

These standards apply to single-packaged (window) units. Split-packaged units are subject to the same MEPS requirements but with the power demand increased by up to 15% and the specific weight increased by up to 20% for an identical cooling capacity.

Testing standards and procedures: The test procedure is given in the MEPS regulation: *"GOST 26963-86: Self-contained room air conditioners"* [14]. General specifications in this standard are based on, but are not identical to, ISO R859 (now withdrawn; the predecessor to ISO 5151) [7].

No evidence was found in the literature search that these MEPS levels have been updated since 1990. Instead, a 2009 study reports that the mandatory standards were changed to voluntary standards in Russia after the introduction of the Federal law on technical regulations in 2002 [20].

7.3 Energy Efficiency Labelling

In 1999, a standard GOST P 51388-99 *"Provision of Information for consumers about energy efficiency of products for household application"* was developed, setting the framework for an energy-efficiency labelling scheme, which was broadly harmonized with the European one and designed to be implemented across a wide range of products. However, due to its voluntary status, the absence of specific requirements for the energy classes of different products and lack of an implementing government institution, this labelling standard had not been implemented as of 2009 [20].

A renewed attempt to implement energy-efficiency labelling of products, including air conditioners, was introduced at the end of 2010. On September 9, 2010, according to Order 357 issued by the Russian Ministry of Industry and Trade, AC units sold after January 1, 2011, will require energy-efficiency markings. [8, 18]

The labelling requirements for air conditioners are reported [18] as:

1. Perform tests[9]
2. Provide calculations
3. Design the energy efficiency label, including the corresponding class, according to the test results
4. The energy efficiency label should be displayed on the product itself and in the user manual

7.3.1 Energy-Efficiency Class Levels for Air Conditioners in Russia

The energy efficiency labeling of air conditioners is subdivided into 5 different sub-categories of product, including three air-cooled and two water-cooled sub-categories. Within each product subcategory, the cooling-mode efficiency is ranked into seven classes, ranging from "A" (highest efficiency) to "G" (lowest efficiency) according to the measured index of energy efficiency (I_C). The Energy Efficiency Index in the cooling mode (I_C) is calculated by the formula:

where:

Q_C is the cooling capacity of the product, kW;

E_C is the electricity consumption in cooling mode, kW.

Table 14 summarized the Energy Efficiency Index (I_C) requirements for each of the AC sub-categories.

Table 14: Energy-Efficiency Index Levels for Labelling AC Units in Cooling Mode [18]

Energy Efficiency Class	Air-Conditioners Technology Sub-Category				
	Split air conditioners – air cooled	Packaged ACs (PACs) – air cooled	Single & Double Duct ACs – air cooled	Ducted ACs – water cooled	Packaged ACs (PACs) – water cooled
A	$I_C > 3.20$	$I_C > 3.00$	$I_C > 2.60$	$I_C > 3.60$	$I_C > 4.40$
B	$3.20 \geq I_C > 3.00$	$3.00 \geq I_C > 2.80$	$2.60 \geq I_C > 2.40$	$3.60 \geq I_C > 3.30$	$4.40 \geq I_C > 4.10$
C	$3.00 \geq I_C > 2.80$	$2.80 \geq I_C > 2.60$	$2.40 \geq I_C > 2.20$	$3.30 \geq I_C > 3.10$	$4.10 \geq I_C > 3.80$
D	$2.80 \geq I_C > 2.60$	$2.60 \geq I_C > 2.40$	$2.20 \geq I_C > 2.00$	$3.10 \geq I_C > 2.80$	$3.80 \geq I_C > 3.50$
E	$2.60 \geq I_C > 2.40$	$2.40 \geq I_C > 2.20$	$2.00 \geq I_C > 1.80$	$2.80 \geq I_C > 2.50$	$3.50 \geq I_C > 3.20$
F	$2.40 \geq I_C > 2.20$	$2.20 \geq I_C > 2.00$	$1.80 \geq I_C > 1.60$	$2.50 \geq I_C > 2.20$	$3.20 \geq I_C > 2.90$
G	$2.20 \geq I_C$	$2.00 \geq I_C$	$1.60 \geq I_C$	$2.20 \geq I_C$	$2.90 \geq I_C$

[9] Russia establishes a system of procedures and infrastructure for compliance testing and certification of test results by accredited organization. However, compliance testing is mandatory only for safety or electromagnetic compatibility. Energy efficiency of energy consumption equipment is not subject to mandatory testing and a declaration of compliance can be issued by manufacturers.
United Nations Development Program, "Standards and Labels for Promoting Energy efficiency in Russia (Project ID 00070781)," 2004. http://label-ee.ru/eng/Pages/default.aspx

As can be seen on Table 15, the specified EER values in Russia air-cooled models match the current EU EER efficiency class levels [17]

Table 15: Current European Energy Labeling Classes for Air-Cooled ACs [17]

Energy Efficiency Class	Split and Multi-Split Appliances	Packaged (PAC) Appliances	Single Duct and Double Duct Appliances
A	3.2 < EER	3.0 < EER	2.6 < EER
B	3.2 ≥ EER > 3.0	3.0 ≥ EER > 2.8	2.6 ≥ EER > 2.4
C	3.0 ≥ EER > 2.8	2.8 ≥ EER > 2.6	2.4 ≥ EER > 2.2
D	2.8 ≥ EER > 2.6	2.6 ≥ EER > 2.4	2.2 ≥ EER > 2.0
E	2.6 ≥ EER > 2.4	2.4 ≥ EER > 2.2	2.0 ≥ EER > 1.8
F	2.4 ≥ EER > 2.2	2.2 ≥ EER > 2.0	1.8 ≥ EER > 1.6
G	2.2 ≥ EER	2.0 ≥ EER	1.6 ≥ EER

7.3.2 Energy-Efficiency Class Levels for Reversible Air Conditioners in Russia

Reversible air conditioners (i.e. heat pumps) are also labelled in heating mode. The Energy Efficiency Index in the heating mode (I_H) is calculated by the formula:

where:

Q_H is the heating capacity of the product, kW;

E_H is the actual product consumption in heating, kW.

These Energy Class definitions in heating mode are shown in Table 16.

Table 16: Energy-Efficiency Index Levels for Labelling AC Units in Heating Mode [18]

Energy Efficiency Class	Air-Conditioners Technology Sub-Category				
	Split air conditioners – air cooled	Packaged ACs (PACs) – air cooled	Single & Double Duct ACs – air cooled	Ducted ACs – water cooled	Packaged ACs (PACs) – water cooled
A	$I_H > 3.60$	$I_C > 3.40$	$I_H > 3.00$	$I_H > 4.00$	$I_H > 4.70$
B	$3.60 \geq I_H > 3.40$	$3.40 \geq I_H > 3.20$	$3.00 \geq I_H > 2.80$	$4.00 \geq I_H > 3.70$	$4.70 \geq I_H > 4.40$
C	$3.40 \geq I_H > 3.20$	$3.20 \geq I_H > 3.00$	$2.80 \geq I_H > 2.60$	$3.70 \geq I_H > 3.40$	$4.40 \geq I_H > 4.10$
D	$3.20 \geq I_H > 2.80$	$3.00 \geq I_H > 2.60$	$2.60 \geq I_H > 2.40$	$3.40 \geq I_H > 3.10$	$4.10 \geq I_H > 3.80$
E	$2.80 \geq I_H > 2.60$	$2.60 \geq I_H > 2.40$	$2.40 \geq I_H > 2.10$	$3.10 \geq I_H > 2.80$	$3.80 \geq I_H > 3.50$
F	$2.60 \geq I_H > 2.40$	$2.40 \geq I_H > 2.20$	$2.10 \geq I_H > 1.80$	$2.80 \geq I_H > 2.50$	$3.50 \geq I_H > 3.20$
G	$2.40 \geq I_H$	$2.20 \geq I_H$	$1.80 \geq I_H$	$2.50 \geq I_H$	$3.20 \geq I_H$

7.3.3 Label Design

The Russian energy-efficiency (EE) label for air conditioners is based on the European Union design shown in Figure 16 for an electric oven.

For AC units operating in cooling mode only, the Russian EE Label will include the following information:

- Energy-efficiency class (in cooling mode);
- Annual energy consumption in cooling mode (approximately 500 hours/year at full load), kWh;
- Cooling capacity, kW;
- Energy efficiency ratio (i.e. energy efficiency index) in cooling mode at full load;
- Type of air conditioner (a set of operating conditions – cooling, or cooling/heating);
- Cooling method: air or water; and,
- Weighted sound level, dB (if available).

Figure 16: Russian Label Design

For AC units operating in cooling or heating mode, the Russian EE Label will include the following information:

- Energy-efficiency class (in cooling mode);
- Annual energy consumption in cooling mode (approximately 500 hours/year at full load), kWh;
- Cooling capacity, kW;
- Energy efficiency ratio (i.e. energy efficiency index) in cooling mode at full load;
- Type of air conditioner (a set of operating conditions - cooling or cooling/heating);
- Cooling method: air or water;
- Heating capacity, kW;
- Energy-efficiency class (in heating mode);
- Weighted sound level, dB (if available).

UL's Danish subsidiary, DEMKO has begun testing electrical products to Russian standards. DEMKO is one of the first non-Russian, accredited testing organizations to complete a direct agreement with GOSSTANDART, the State Committee of the Russian Federation for Standardization and Metrology, and VNIIS, the Executive Board of the Russian national certification body (NCB) for electrical equipment. Whether or not the lab or their affiliates are certified to test to the Russian or EU standards is not known at this time.

8 Conclusions

8.1 Available AC Data and Limitations

1. The literature review discovered fairly detailed information on overall sales of AC units in Russia up to about 2006. This included information on annual sales volumes to market segments, types of AC units sold and information on the country of origin. Sales information after 2006 was mainly limited to overall annual sales numbers of AC units.

2. Available information on the installed stock of Russian AC units was limited to one reference to the fraction of Russian households with AC units in 2009, which was 5.75% of households.

3. The literature review did not find information on the average size of Russian AC units, average efficiency levels (e.g. energy efficiency ratios (EER), annual performance factors (APF) or season energy efficiency ratios (SEER)), average operating hours, or the average unit energy consumption (UEC) of Russian AC units.

4. Information on minimum energy performance standards (MEPS) for AC units in Russia was limited to activities in the 1980's and 1990's. It appears that the MEPS levels for AC units have not been updated in recent years, and are much lower than current levels in many neighbouring countries such as EU or China. MEPS for AC units were made voluntary in 2002.

5. Current information on AC efficiency labeling in Russia was found. The new labeling regulations were passed into law in 2010 and required efficiency-class labeling of five sub-categories of air conditioners starting January 1, 2011.

6. The labeling categories follow the EU efficiency-classes for single-point EER ratings. It is unclear at this time if the test standard used to measure the EER values is the Russian test standard (GOST 26963-86) or if the EU test standard (ISO 5151-94) has been adopted. Both test standards use similar testing conditions for cooling EER measurements.

8.2 Russian AC Mapping

7. In order to complete the Russian AC mapping exercise it was necessary to augment the available information, gathered from the literature review, with a number of assumptions and calculations. These assumptions are listed in the previous sections in the report.

8. The Russian AC market is in a growth phase, with 2010 sales reported at about 1.8 million units, compared to 145 thousand units in 2000. Residential sector AC sales rose even faster to about 1.17 million units in 2010 compared to 46,000 units in 2000.

9. The total stock of AC units in Russia grew from about 1.37 million units in 2001 to about 10.33 million units in 2011. This represents an average 10-year compounded growth rate of 23% per year.

10. The stock of residential AC units in Russia grew from about 0.20 million units in 2001 to about 5.51 million units in 2011. This represents an average 10-year compounded growth rate of 40% per year. By 2011 it is estimated that over 11% of Russian households are equipped with air conditioning.

11. The 2011 stock of Russian AC units is estimated to have consumed about 12 TWh annually. Residential AC units used about 4.1 TWh or 34%, and commercial AC units used about 7.9 TWh or 66% of the total annual consumption attributed to air conditioners.

12. The 2011 stock of Russian air conditioners is estimated to represent a connected electric load of about 23.9 GW. The AC units are estimated to have contributed about 14.3 GW to the summer system peak assuming a seasonal coincidence factor of 60%. This load component is estimated to represent over 14% of peak demand on the power system in the summer.

13. The estimated average annual unit energy consumption (UEC) for AC units in Russia is estimated to have dropped from 1,500 kWh in 2001 to 1,160 kWh in 2011. Most of this change is due to the reduction in average size of AC units over time as higher residential-sector sales increase the percentage of residential units versus commercial units in the installed AC stock. On average, residential AC units are smaller than commercial AC units. Commercial units represented 80% of the AC stock in 2001, but only 47% of the stock in 2011. Small improvements in average EER over time as AC units are replaced will also contribute to the reduction in UEC. The assumed average EER values used in the analysis were 1.81 to 1.92 in 2001 versus 2.03 to 2.11 in 2011.

9 Recommendations

It is recommended that an "on the ground" survey be undertaken for gathering field data to improve the accuracy of energy use data associated with AC use in representative Russian cities. Such a survey would contribute towards improving the accuracy of the benchmarking study in the following phase of this study.

It is also recommended that a marketing study be conducted to determine the actual performance level and growth rate of the market of each type of air conditioner. This information is essential for determining the potential for saving energy via energy efficiency regulations and for establishing a base from which to track results.

Because of the lack of energy use data on other residential/commercial products in Russia, it is recommended that the two surveys be broadened to include other electricity using products that are expected to be the major contributors to energy use in Russia, such as refrigerated appliances, lighting, TVs, washers, dryers, air handlers, etc.

Contact with and cooperation of the local electricity retail companies would be required in order to facilitate the energy end-use surveys.

With the introduction of mandatory efficiency labeling of AC units sold after January 1, 2011, it is recommended that Russian government consider the implementation of programs to:

- Develop consumer outreach and education programs for to both residential homeowners and commercial procurement departments in order to promote the advantages of purchasing higher efficient AC units..
- Establish an MV&E regime to verify the performance of products in order to ensure the collection of annual data, as well as to verify the efficiency ratings of different types of AC units imported for sale in Russia and compile efficiency trending and compliance information to support future policy decisions, such as regulating the minimum energy performance of AC units imported or manufactured for sale in Russia.

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11 Appendix A: Russian AC Sales Estimates

See attached Excel data sheet

12 Appendix B: Russian ACs – Installed Stock Estimates

See attached Excel data sheet

13 Appendix C: Russian AC Energy-Use Calculations

See attached Excel data sheet

14 Annex 1: Description Russia's Seven Regional Grids

Electricity in the Russian Federation is distributed by a system consisting of 7 regional grids. Generating resources are distributed throughout all regions; 6 out of the 7 grids are interconnected. A brief description of each region is presented in the following excerpts obtained from Reference 2 *(shown in italics).*

14.1.1 1. Central Region

The Central region is the most economically developed region of Russia in terms of standards of living and wealth of the country. Making up just under 4% of Russia's land mass, over 25% of Russia's population lives there. It contributes to over 30% of national GDP, over 40% of federal budget revenues and over 20% of the country's industrial production. The Moscow oblast (region) plays the leading role, accounting for almost 70% of the region's GDP, 45% of its industrial output and almost 85% of the region's contribution to the federal budget. The Central region has also the widest divergence between rich and poor regions with about a tenfold difference between the city of Moscow and the poorest sub-region.

The industrial sector of the Central region focuses mainly on added value activities such as machine building (including car manufacturing), metallurgy, petrochemicals, refining, construction and building materials (accounting for over half of industrial production), food industries (about 20%) and electricity generation (about 20%). In contrast to its major contribution to Russian economic development and growth, the Central region is not well endowed with natural resources. It imports its natural gas needs (which makes up about 65% of regional thermal power electrical supply) to fuel its electricity needs. It generates the most electricity of all Russian regions, accounting for over 20% of total Russian generation. Electricity in the Central region is produced mainly from thermal centralized heat and power plants (CHP) as well as nuclear power plants.

14.1.2 2. Northwest Region

The Northwest region is very diverse in terms of the economic development of its 11 oblasts and autonomous okrug(s). The main economic activity is focused on development of the region's natural resource base and related industrial processes. The northern and northeastern parts of the region are industrial-based in terms of production and refining of various natural resources (forestry and related products, oil, coal, rubber, steel, etc.). The trading port of Murmansk, which is ice-free, plays an increasingly important role in the Northwest region's economic development. The southwestern part of the region is the key industrial part, specializing in machine-building, petro-chemicals and forestry-based industrial production. Just over 10% of Russia's GDP is generated in this region as well as about 12.5% of its industrial output. It ranks second among regions in terms of attracting foreign investment and fourth in terms of contributions to the federal budget.

St. Petersburg is the key city in this region, contributing about two fifths of the region's GDP, just over 30% of the region's industrial production and about half of the region's contribution to the federal budget. Four of the region's 11 sub-regions (St. Petersburg, Murmansk, Vologda and the Komi Republic) *account for about 80% of the region's GDP, 70% of its industrial output and about three-quarters of its contribution to the federal budget. St. Petersburg is supplied by LenEnergo with installed capacity of almost 10 GW including the nuclear power plants discussed earlier. Within the city itself are several large thermal plants mostly fuelled by natural gas. The city is dependent on supplies from the surrounding Leningrad Oblast as it generates only half of the electricity it consumes.*

The Northwest region is one of Russia's wealthiest in terms of mineral resource base. It encompasses huge resources of heavy and precious metals, a well as a significant part of Russia's oil and gas resources, almost 90% of which are situated in the Komi Republic and the Nenets Autonomous Okrug. The Barents and Pechora Sea are key in terms of the region's oil and gas potential. This is where the Shtokman and Prirazlomnaya oil and gas fields lie.

The Northwest electricity system is characterized by a heavy dependence on nuclear-based electricity generation. About 40% of total generation comes from the region's nuclear power plants (5.8 GW out of the region's total installed capacity of 18.7 GW). A significant part of electricity comes from decentralized heat and diesel electric power stations with capacities ranging from 1 to 2500 MW. Over the 1990s electricity generation dropped almost 20% given the lack of demand, although exports to Finland continued. Some parts of the Northwest system, lying closer to the Central region, import their electricity needs from the Central region.

14.1.3 3. The South Region

The Southern region is very diverse in terms of the economic development of its 13 oblasts and republics. Of major importance to this region's economic development and stability, are the key oil and gas pipelines as well as railway lines which link it to the countries of the Caucasus, the Middle East and southern Europe, by way of the Black, Azov and Caspian Seas. This also raises the region's strategic importance. The region focuses on large-scale agricultural production, as well as the production of coal and machines for the energy, transportation and agricultural sectors.

The Southern region is also known for its tourism-business with resorts attracting millions of tourists in the summer months. However, it is one of the poorer regions of Russia, contributing less than 10% to the nation's GDP and to only about 6% of its industrial output.

The region is relatively well endowed with natural resources, however, its coal resources are mostly anthracite and much of its oil fields (high in sulfur and wax) are highly depleted (averaging over 80%). Its natural gas resources are estimated at 11 trillion m^3*, with some major fields still undeveloped. The region's hydro potential is estimated at almost 15 GW with only about 4 GW of capacity in place.*

14.1.4 4. The Urals Region

The Urals region encompasses 6 sub-regions and is renowned for its natural resource base including major oil and gas fields on which most of its economy is based. The region holds 55% of Russia's discovered oil and natural gas reserves. Almost 80% of the region's oil reserves are found in the Khanty-Mansiisk autonomous okrug (key fields include the Samatlor, Mamontov, Fedeorov and Priobskoye). Over 95% of the region's natural gas resources are located in the Yamalo-Nenets and Khanty-Mansiisk autonomous okrugs, a third of which are offshore in the Karsky Sea. Russia's largest producing natural *gas fields are located in this region, including Urengoy, Yamburg, Medvezhe, Zapolyarnoye and the Komsomols fields. The Urals' industry focuses on oil and gas production and petrochemicals as well as heavy and precious metals, machine building and metal works. Major industrial centres include Ekaterinburg (known for its heavy machine building) and Chelyabinsk (known for its production of heavy metals and military industrial complex), with over 1 million inhabitants, each. The region produces almost 15% of Russia's GDP, ranking it the third most important in terms of regional industrial output and economic strength. It generates about 14% of overall Russian electricity while it consumes about 15%, the deficit supplied from the Volga region. Electricity production decreased dramatically over the 1990s in the Urals. About 70% of demand is industrial-based. Most generation is thermal (Reftinskoykaya, Troitskaya, Iriklinskaya, and Permskaya GRES.*

14.1.5 5. The Volga Region

The Volga region is very diverse in terms of the economic development of its 14 oblasts and republics and one autonomous okrug. Although not especially wealthy in natural resources, its position between two rich regions – Siberia to its east and the Central region to its west – brings with it important economic links to both regions and multiplier effects in terms of human resources and industry. Key transport routes cross the Volga region – the Volga River itself, a key transport route, rail and the major oil and gas pipelines from Siberia.

The Volga region ranks as Russia's leading region in terms of industrial output, contributing almost 20% to the nation's GDP and about 25% of its industrial output. Over two-thirds of the Volga region's industrial output comes from five oblasts and republics: Republics of Tatarstan and Bashkortostan as well as the oblasts of Samara, Perm and Nizhniy-Novgorod). Machine-building and metal works are the key industrial activities of the region, accounting for almost 30% of industrial output. This includes automobile manufacturing, ship building and construction of airplanes. Oil refining and petrochemical industries are also very important.

14.1.6 6. The Siberia Region

The region of Siberia encompasses 16 sub-regions and is renowned for its natural resource base including major coal mines, huge river systems on which major hydroelectricity facilities have been constructed or are in the planning stage, heavy and precious metals, and forestry. The region's oil and natural gas resource potential is still unclear, with the need for major investments in exploration to understand the recoverability of rough estimates. To date, it is Russia's leading region in terms of coal and steel and the second most important region in terms of forestry products.

About 80% of Russia's discovered coal reserves are located in Siberia, over half in West Siberia in the Kuznetz (Kemerovsky oblast) and the Gorlovsky (Novosibirsk oblast) hard coal basins and the Kansko-Achinsk (Kemerovsky oblast) brown coal basin. Estimated oil resources are in the order of 12 billion tonnes, of which barely 2 billion tonnes are under development mainly in the Tomsk oblast where 18 of the region's 21 oil fields are located. Estimated total natural gas resources are in the order of 30 trillion cubic meters, located mainly in the eastern part of the region. The largest discovered fields include the Kovikta, Yurubcheno-Takomsky, Sobinsky and

Yaraktinsky fields in the southeast part of the region, as well as the Pelyatkinsky and Deryabinsky fields in the Taimir autonomous okrug.

14.1.7 *7. The Far East System*

The electricity system of the Far East is isolated from the Unified Energy System of Russia and has become increasingly dependent on expensive imported coal, transported sometimes thousands of kilometres for this region's electricity needs. For this reason, the construction of the Bureyskaya hydro facility has been given the highest priority within RAO UES and the Russian government at both the federal and regional levels. In July 2003, at the opening ceremony of the first hydroelectric unit, the Russian President stated that this hydro facility should become the fundamental element of the Far East's economy – the foundation for constructing new plants and creating new jobs in the region. Total capacity of the Bureyskaya hydro plant is expected to be 2 GW, thus increasing the region's installed capacity by 20% to 13 GW. The expected average annual generation from this new hydro facility will be in the order of 7 TWh and will add to current total regional annual generation of almost 40 TWh.