POLITECHNIKA GDAŃSKA
WYDZIAŁ ELEKTROTECHNIKI I AUTOMATYKI

NUCLEAR POWER
LECTURE 2

Gdańsk 2018

NUCLEAR POWER – LECTURE 2

1. Units
2. Energy transformations
3. Energy in the energy sector
4. Primary energy resources
5. Energy demand
6. The energy system and its subsystems

UNITS


SI International System of Units
base units
cd
mol
K
A
kg
m
s
defining constants
K_{cd}
N_A
k
e
h
c
$\Delta\nu$

UNITS

International System of Units (SI)

SI Base Units

Base Quantity	Name	Symbol
Length	meter	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

SI Derived Units

Derived Quantity	Name	Symbol	Equivalent SI units
Frequency	hertz	Hz	s^{-1}
Force	newton	N	$m \cdot kg \cdot s^{-2}$
Pressure	pascal	Pa	N/m^2
Energy	joule	J	$N \cdot m$
Power	watt	W	J/s
Electric charge	coulomb	C	$s \cdot A$
Electric potential	volt	V	W/A
Electric resistance	ohm	Ω	V/A
Celsius temperature	degree Celsius	°C	K*

*Unit degree Celcius is equal in magnitude to unit kelvin.

SI Prefixes

Factor	Name	Symbol	Numerical Value
10^{12}	tera	T	1 000 000 000 000
10^{9}	giga	G	1 000 000 000
10^{6}	mega	M	1 000 000
10^{3}	kilo	k	1 000
10^{2}	hecto	h	100
10^{1}	deka	da	10
10^{-1}	deci	d	0.1
10^{-2}	centi	c	0.01
10^{-3}	milli	m	0.001
10^{-6}	micro	μ	0.000 001
10^{-9}	nano	n	0.000 000 001
10^{-12}	pico	p	0.000 000 000 001

- Adapted from NIST Special Publication 811
- SI rules and style conventions recommend using spaces rather than commas to separate groups of three digits.

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UNITS OF ENERGY

	Joule	Calorie	BTU	Foot-pound	Kilowatt-hour	Megawatt-day	Electronvolt
Joule	XX	0.2390	0.000948	0.7375	2.77778E-07	1.15741E-11	6.2383E+18
Calorie	4.184	XX	0.00397	0.3238	1.16279E-06	4.85437E-11	2.61097E+19
BTU	1055	252	XX	778.2	0.000293	1.221E-08	6.57895E+21
Foot-pound	1.356	0.3238	0.001285	XX	3.84615E-07	1.60256E-11	8.47458E+18
Kilowatt-hour	3.6E6	8.6E5	3412	2.6E6	XX	4.16667E-05	2.24719E+25
Megawatt-day	8.64E10	2.06E10	8.19E7	6.24E10	24000	XX	5.40541E+29
Electronvolt	1.603E-19	3.83E-20	1.52E-22	1.18E-19	4.45E-26	1.85E-30	XX

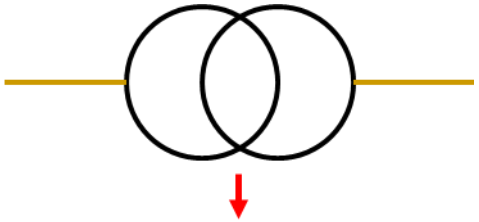
tpu - ton of contracted fuel – 29,3 MJ
toe – ton of equivalent oil – 42 MJ

ENERGY TRANSFORMATIONS

http://www.plcnib.pl/pl/images/icon_152.jpg

TRANSFORMATION AND CONVERSION ENERGY

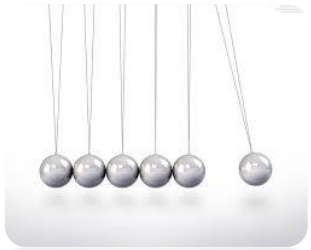
Energy transformation - changing the parameters of the same medium energy

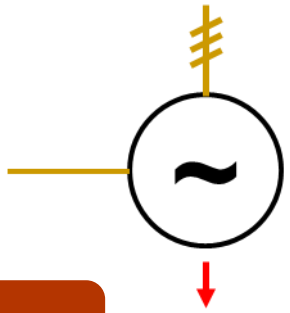


Example: increase or decrease in the value of energy in a given form

TRANSFORMATION AND CONVERSION ENERGY

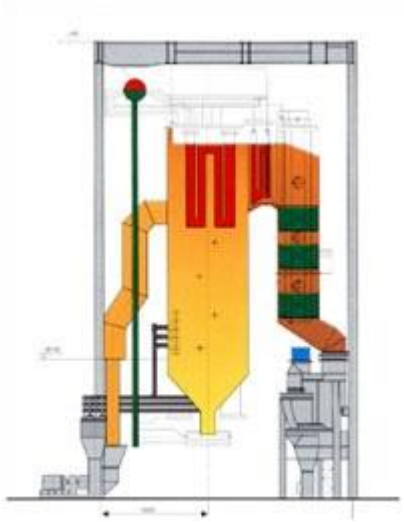
Energy conversion - changing the type of media (characters) energy from one to the other





PENDULUM	POTENTIAL ENERGY	KINETIC ENERGY
HEAT &POWER PLANT	CHEMICAL ENERGY OF FUEL	HEAT ENERGY

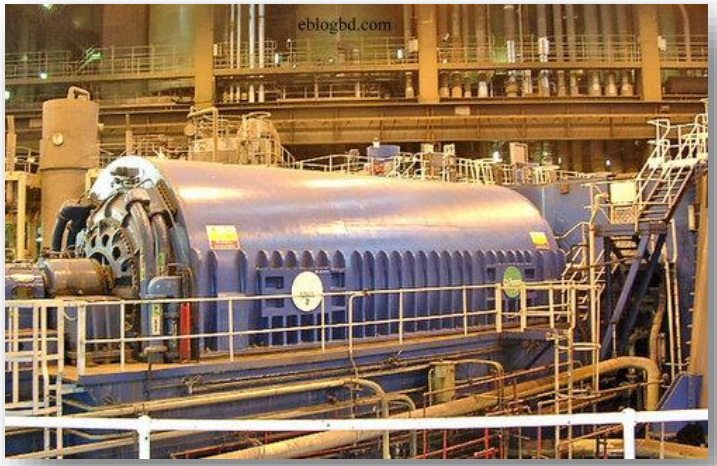
EXAMPLES OF ENERGY CONVERSION



heat boiler
CHE => HE

gas turbine

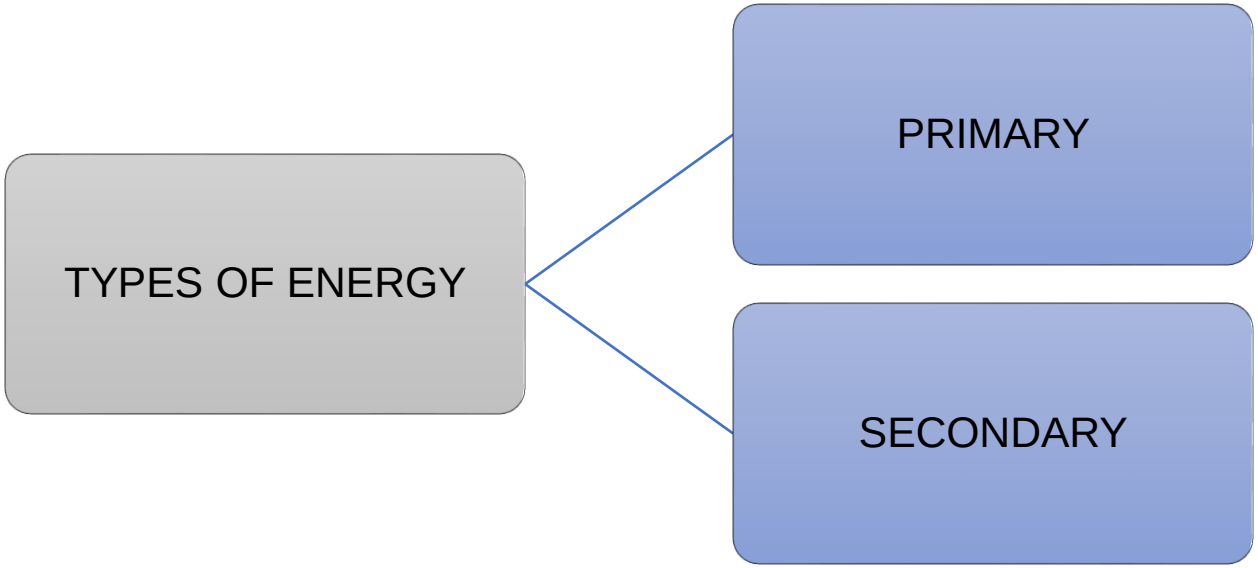
steam turbine
HE =>ME



generator
ME =>EE

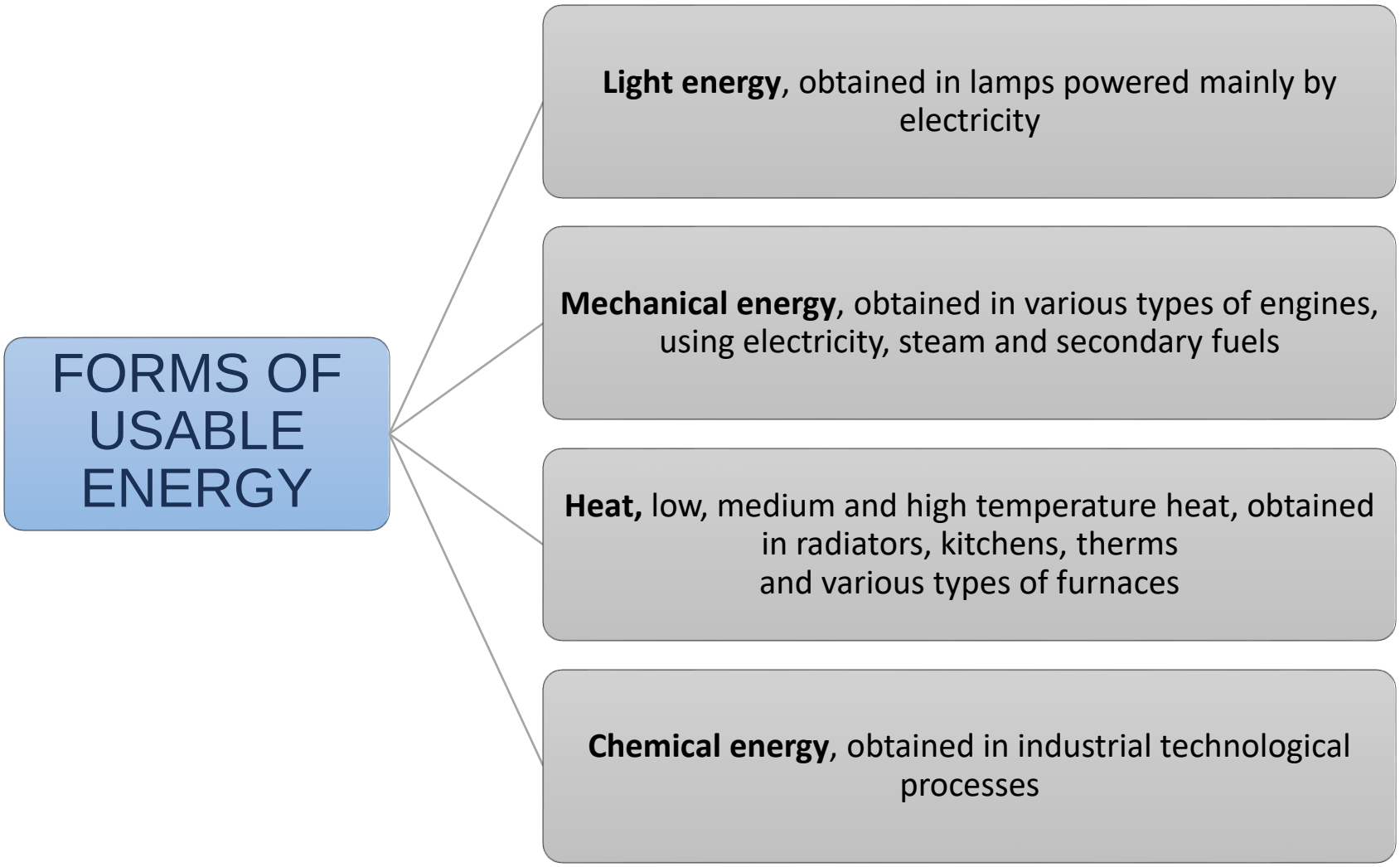
electric motor
EE=> ME

TYPES OF ENERGY



- **Primary energy** - energy that was not subject to any changes
- **Secondary energy** - energy obtained as a result of primary and secondary energy transformation
- **Final energy (final, direct)** - energy in a form, to which the receivers are adapted
- **Usable energy** - energy after transformation in receivers at the end user

FORMS OF USABLE ENERGY



RESOURCES OF PRIMARY ENERGY

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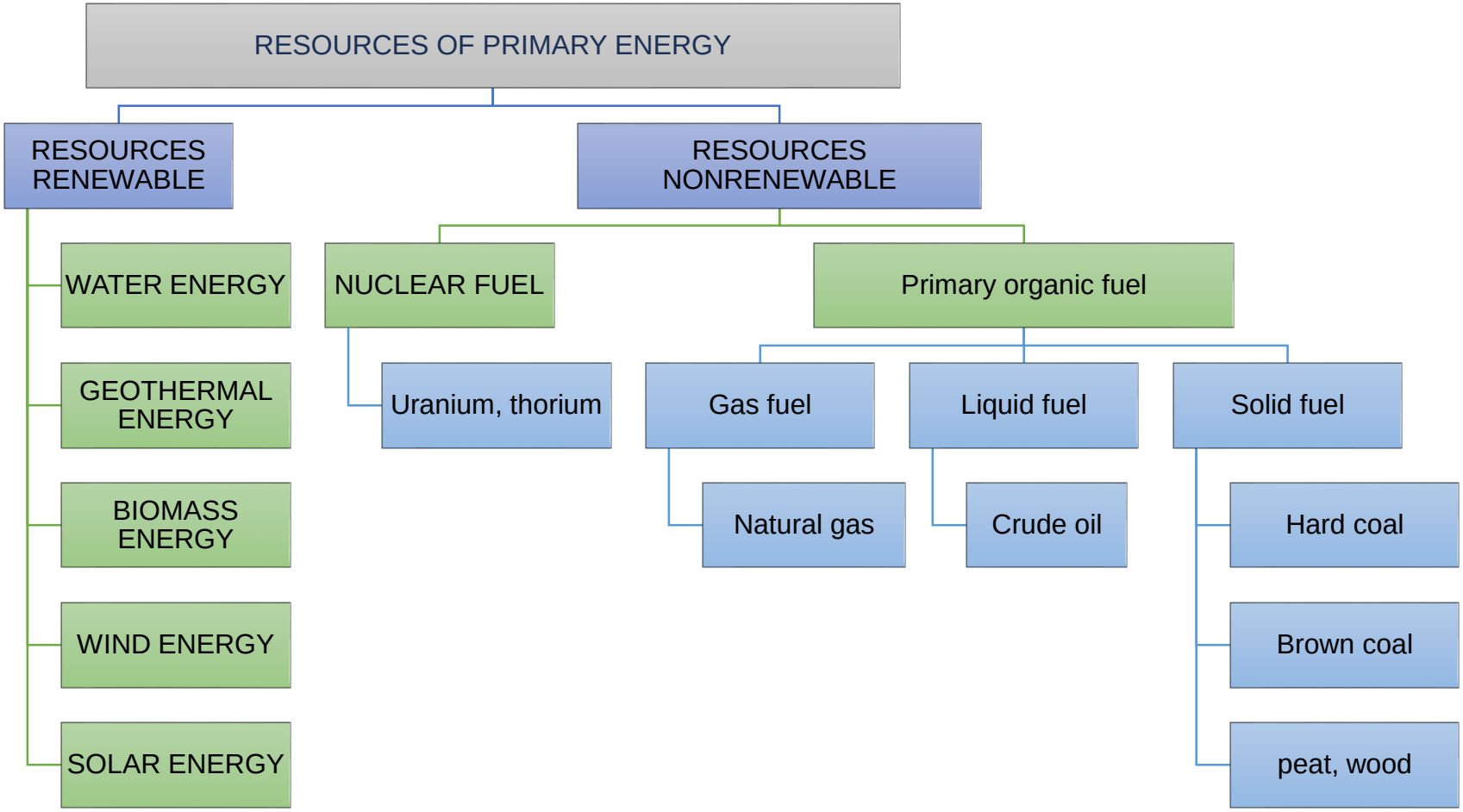
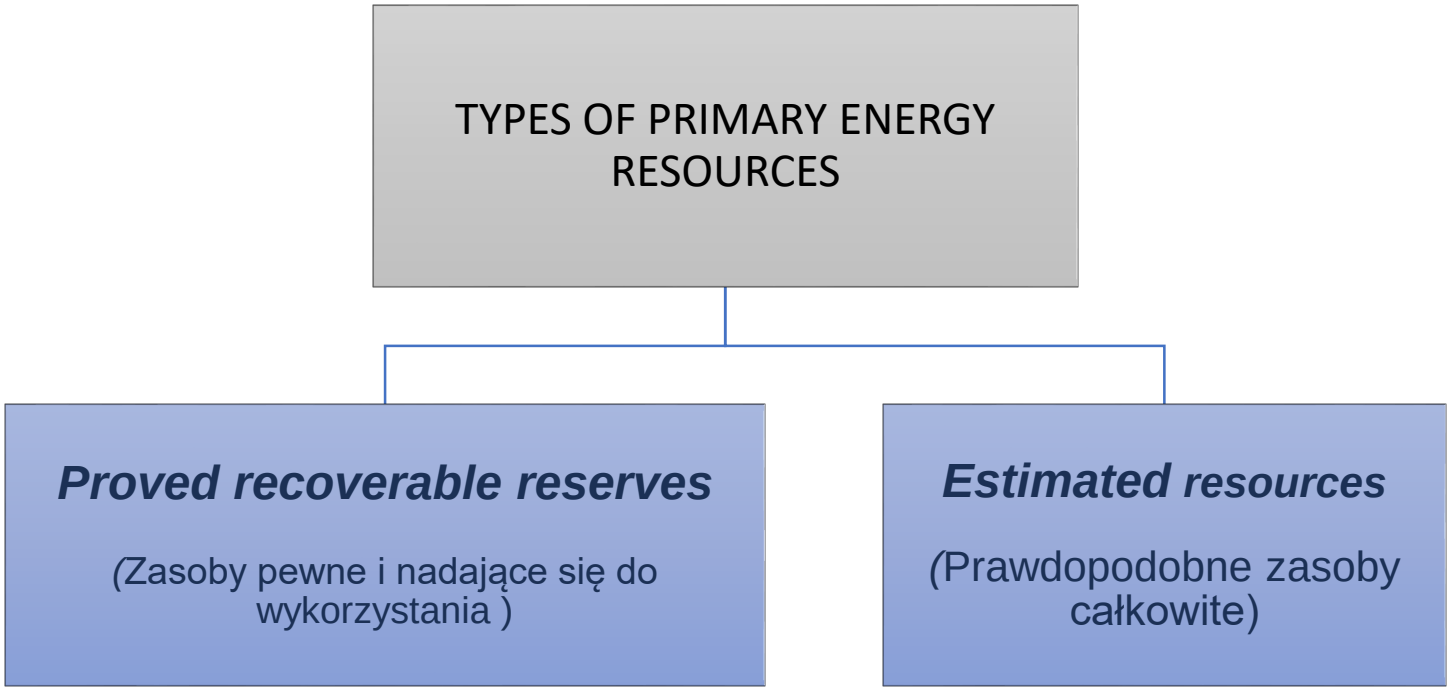


TYPES OF PRIMARY ENERGY RESOURCES



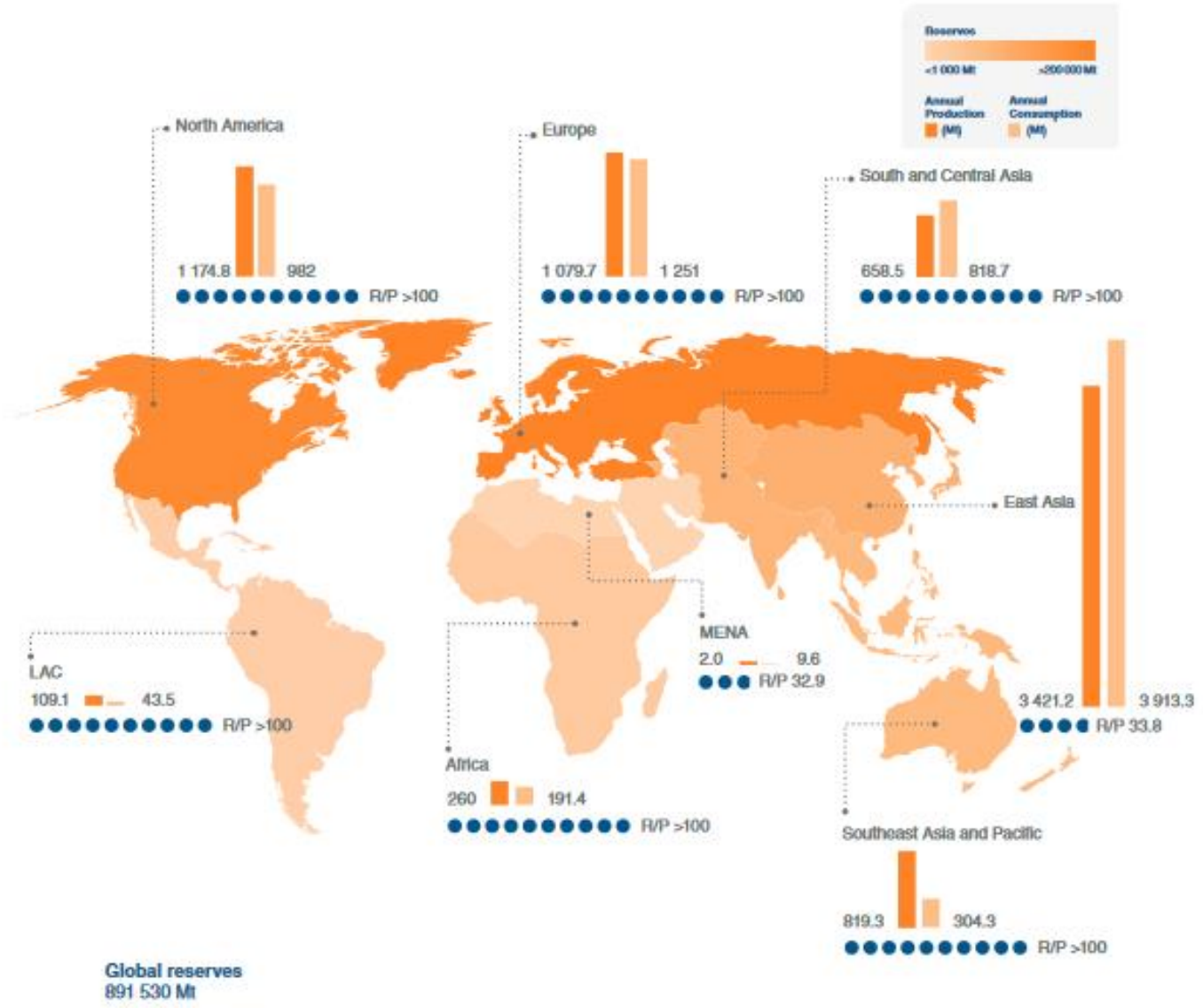
WORLD RESOURCES OF PRIMARY ENERGY - IN NONRENEWABLE SOURCES, ACCORDING *World Energy Council*

Medium of primary energy	Energy value	***Proved recoverable reserves***				***Estimated* resources**			
		quantity	Resources of energy			quantity	Resources of energy		
		unites	10^3EJ	%	%	unites	10^3EJ	%	%
HARD COAL	28 MJ/kg	795 ·10^9 t	22,2	63,1	53,1	7400 ·10^9 t	207	83,5	62
BROWN COAL AND PEAT	8 MJ/kg	190·10^9 t	1,5	4,3	3,6	2000 ·10^9 t	16	6,5	4,8
CRUDE OIL & OIL SHALE	42 MJ/kg	142·10^9 t	6,0	17,0	14,3	320 ·10^9 t	13	5,2	3,9
NATURAL GAS	36 MJ/m^3	152·10^{12} m^3	5,5	15,6	13,2	330·10^{12} m^3	12	4,8	3,6
TOGETHER ORGANIC FUEL:	X	X	35,2	100	84,2	X	248	100	74,3
NUCLEAR FUEL: uranium do 130 USD/kg	2÷ 8 TJ/kg	3,3·10^6 t	6,6	x	15,8	10,7·10^6 t	86	X	25,7
TOGETHER IN THE WORLD	x	x	41,8	x	100	x	334	X	100

WORLD RESOURCES OF PRIMARY ENERGY - IN RENEWABLE SOURCES, ACCORDING *World Energy Council*

Type of renewable energy	Sources (for eksploatation)			Theoretical potential of energy		
	PWh/a	EJ/a	%	PWh/a	EJ/a	%
WATER ENERGY	14,4	52	15	40	140	1,4
WIND ENERGY	2,6	10	3	480	1730	17,6
BIOMASS ENERGY	X	270	77	X	2900	30
GEOTHERMAL ENERGY	X	18	5	X	5030	51
TOGETHER IN THE WORLD	x	350	100	x	9800	100

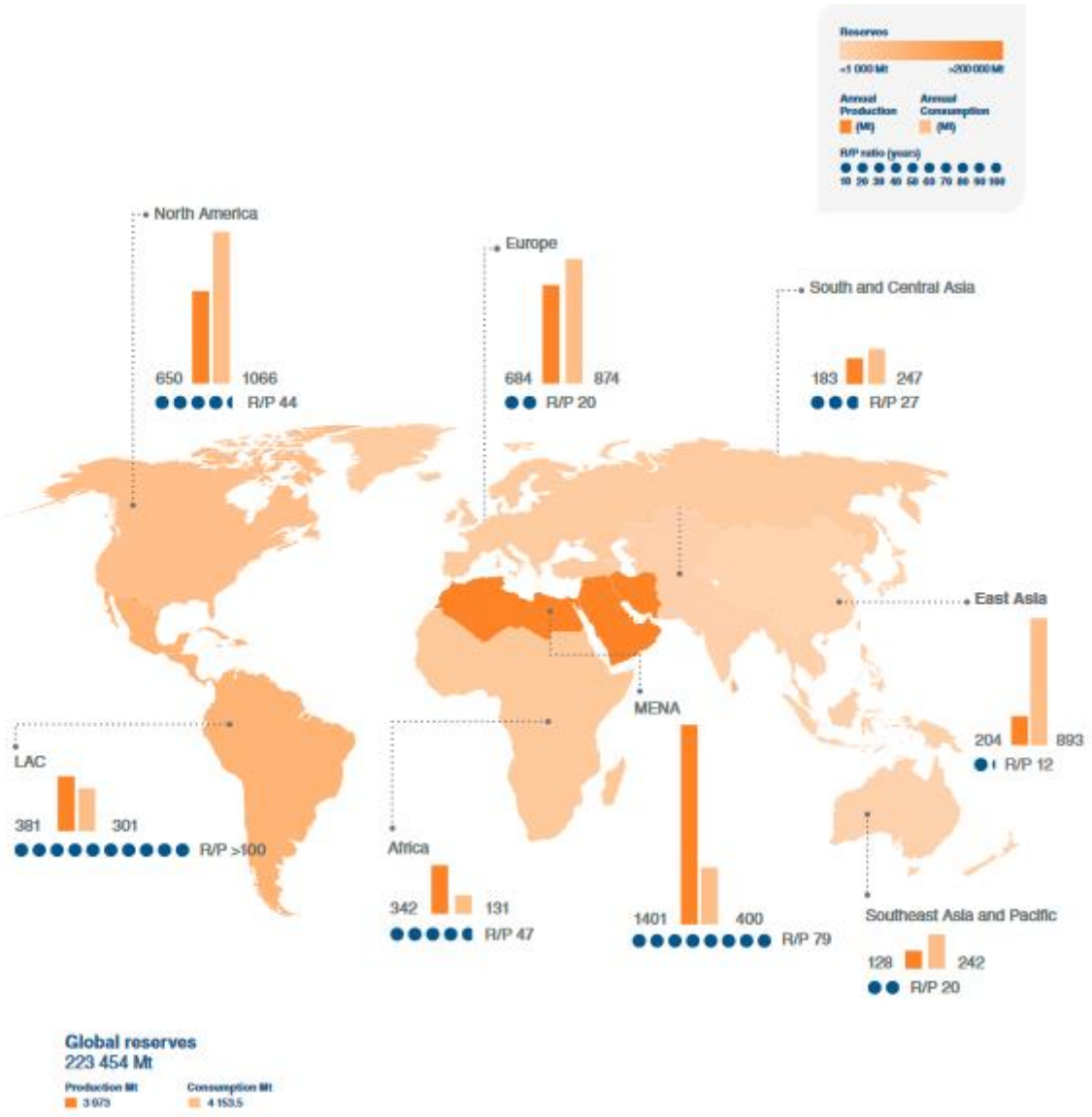
DISTRIBUTION OF WORLD CARBON RESOURCES, CARBON PRODUCTION (*according World Energy Council)*



DISTRIBUTION OF WORLD CARBON RESOURCES, CARBON PRODUCTION (*according World Energy Council)*

country	resources (Mt)		production (Mt)	
	2 011	1993	2 011	1993
USA	237 295	168 391	1 092	858
Russia	157 010	168 700	327	304
Chinya	114 500	80 150	3 384	1 150
Australia	76 400	63 658	398	224
India	60 600	48 963	516	263
Rest of the world	245 725	501 748	1 805	1 675
Together	891 530	1 031 610	7 520	4 474

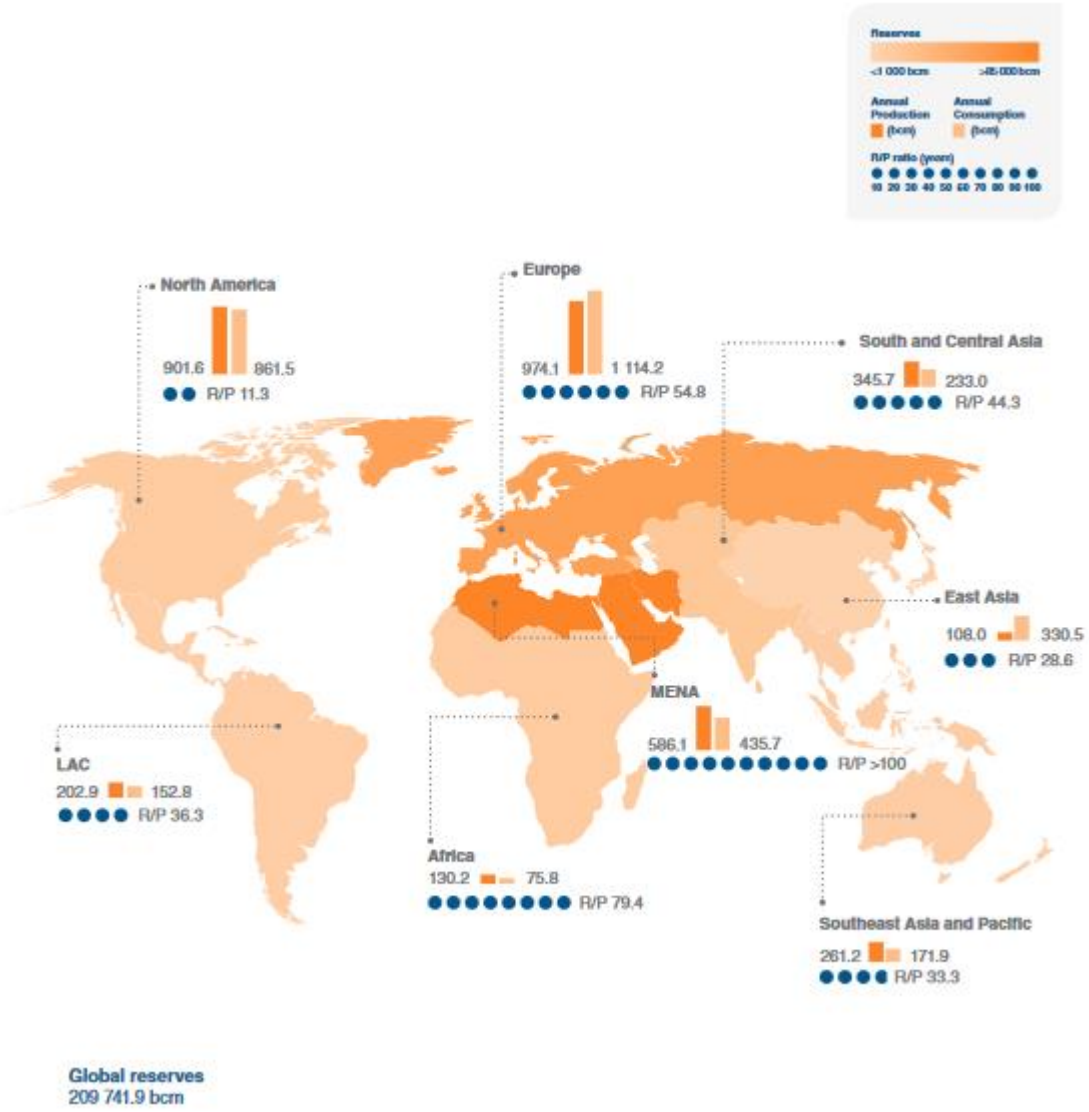
DISTRIBUTION OF WORLD FUEL OIL RESOURCES, FUEL OIL PRODUCTION (*according World Energy Council)*



DISTRIBUTION OF WORLD FUEL OIL RESOURCES, FUEL OIL PRODUCTION (*according World Energy Council)*

country	resources (Mt)		production (Mt)	
	2 011	1993	2 011	1993
Wenezuela	40450	9842	155	129
Saudi Arabia	36500	35620	526	422
Canada	23598	758	170	91
Iran	21359	12700	222	171
Irakq	19300	13417	134	29
Rest of the world	82247	68339	2766	2338
Together	223454	140676	3973	3179

DISTRIBUTION OF WORLD NATURAL GAS RESOURCES, NATURAL GAS PRODUCTION (*according World Energy Council)*



ROZ DISTRIBUTION OF WORLD NATURAL GAS RESOURCES, NATURAL GAS PRODUCTION (*according World Energy Council*

country	resources (Mt)		production (Mt)	
	2 011	1993	2 011	1993
Russia	47750	48160	670	604
Iran	33790	20659	150	27
Qatar	25200	7079	117	14
Turkmenistan	25213	2860	75	57
Saudi Arabia	8028	5260	99	36
Rest of the world	69761	57317	2407	1438
Together	209742	141335	3518	2176

DISTRIBUTION OF WORLD NATURAL GAS RESOURCES, NATURAL GAS PRODUCTION (*according World Energy Council)*

COUNTRY	POWER INSTALLED (MW)		PRODUCTION (GWh)	
	2 011	1993	2 011	1993
USA	98903	99041	799000	610000
France	63130	59032	415480	350000
Japan	38009	38038	162900	246000
Russia	23643	19843	122130	119000
Korea	20718	7615	98616	58100
Rest of the world	119675	116726	787777	722900
Together	364078	340295	2385903	2106000

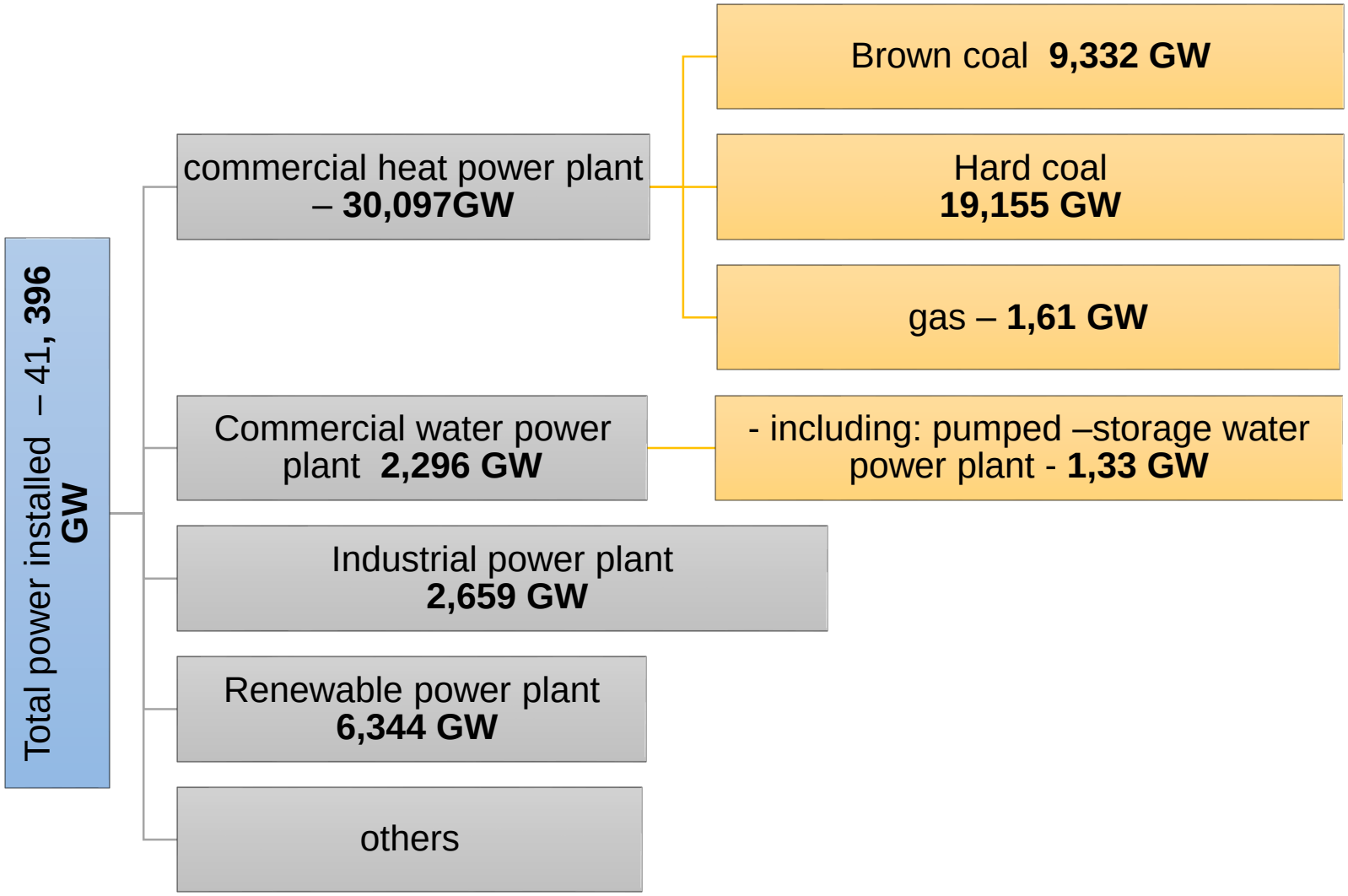
POWER INSTALLED AND ENERGY PRODUCTION - WATER RESOURCES
(according World Energy Council)

COUNTRY	POWER INSTALLED (MW)		PRODUCTION (GWh)	
	2 011	1993	2 011	1993
China	231000	44600	714000	138700
Brasil	82458	47265	428571	252804
USA	77500	74418	268000	267326
Canada	75104	61959	348110	315750
Russia	49700	42818	180000	160630
Rest of the world	430420	338204	828437	1150750
Together	946182	609264	2767118	2285960

POWER INSTALLED AND ENERGY PRODUCTION – WIND RESOURCES
(according World Energy Council)

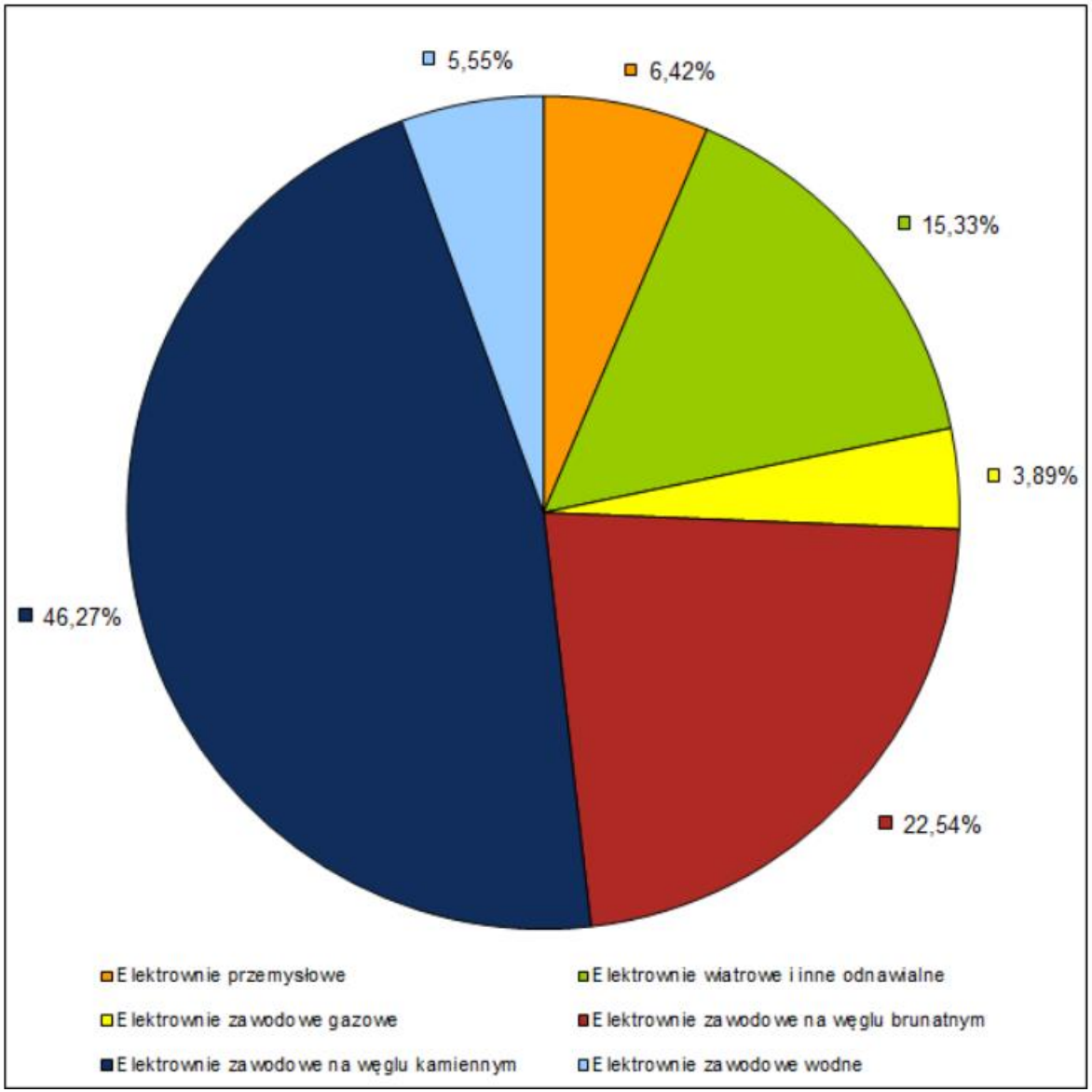
COUNTRY	POWER INSTALLED (MW)		PRODUCTION (GWh)	
	2 011	1993	2 011	1993
China	62364	15	73200	-
USA	46919	1814	120177	3042
Germany	29071	650	48883	-
Italy	21673	52	41790	117
India	15880	40	19475	45
Rest of the world	62142	-	74087	-
Together	238049	-	377613	-

POWER INSTALLED IN POLISH ELECTROENERGETIC SYSTEM (31.12.2016 R.)

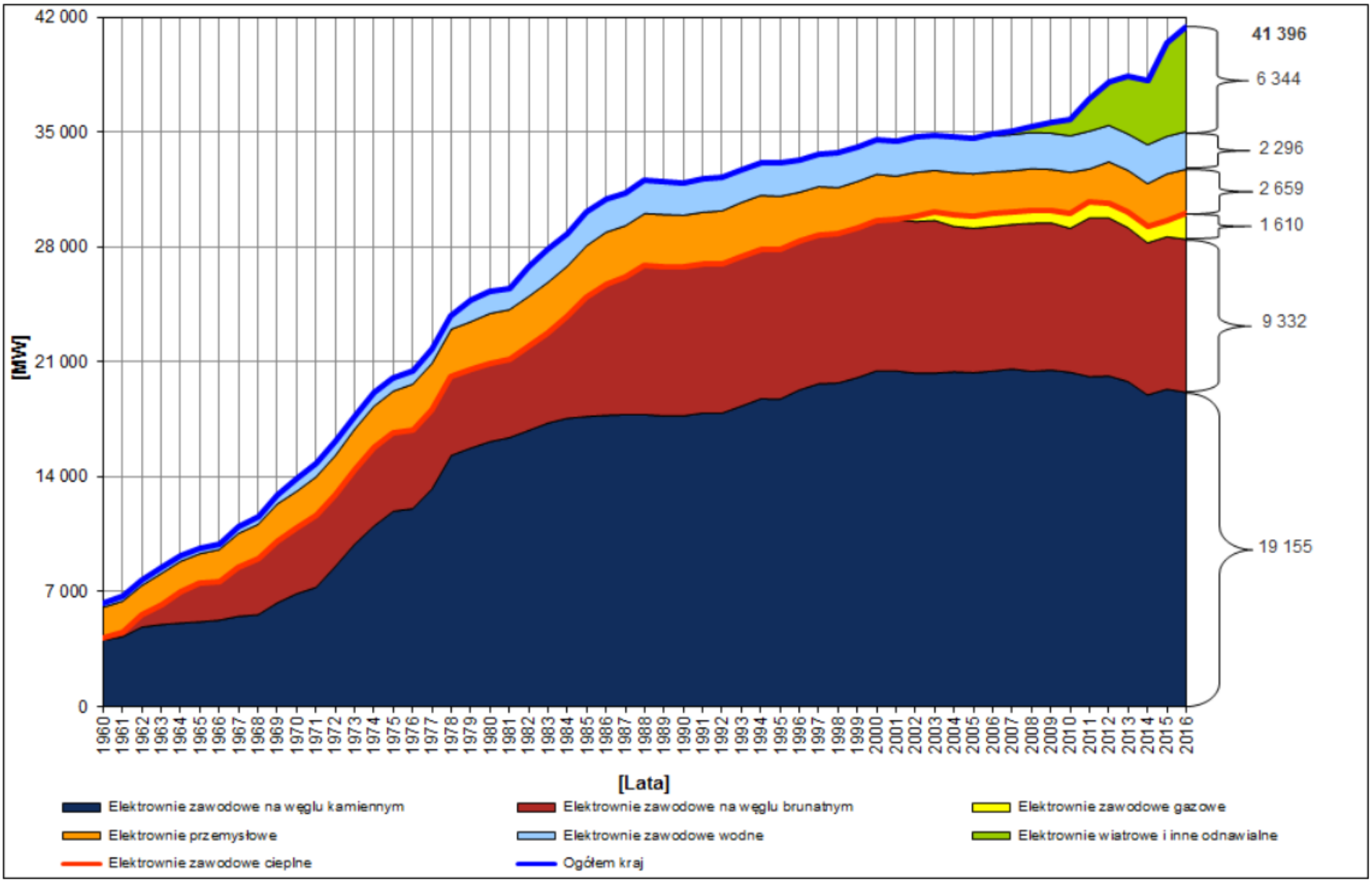


Dane wg Kwartalnika Agencji Rozwoju Regionalnego, portal CIRE.pl

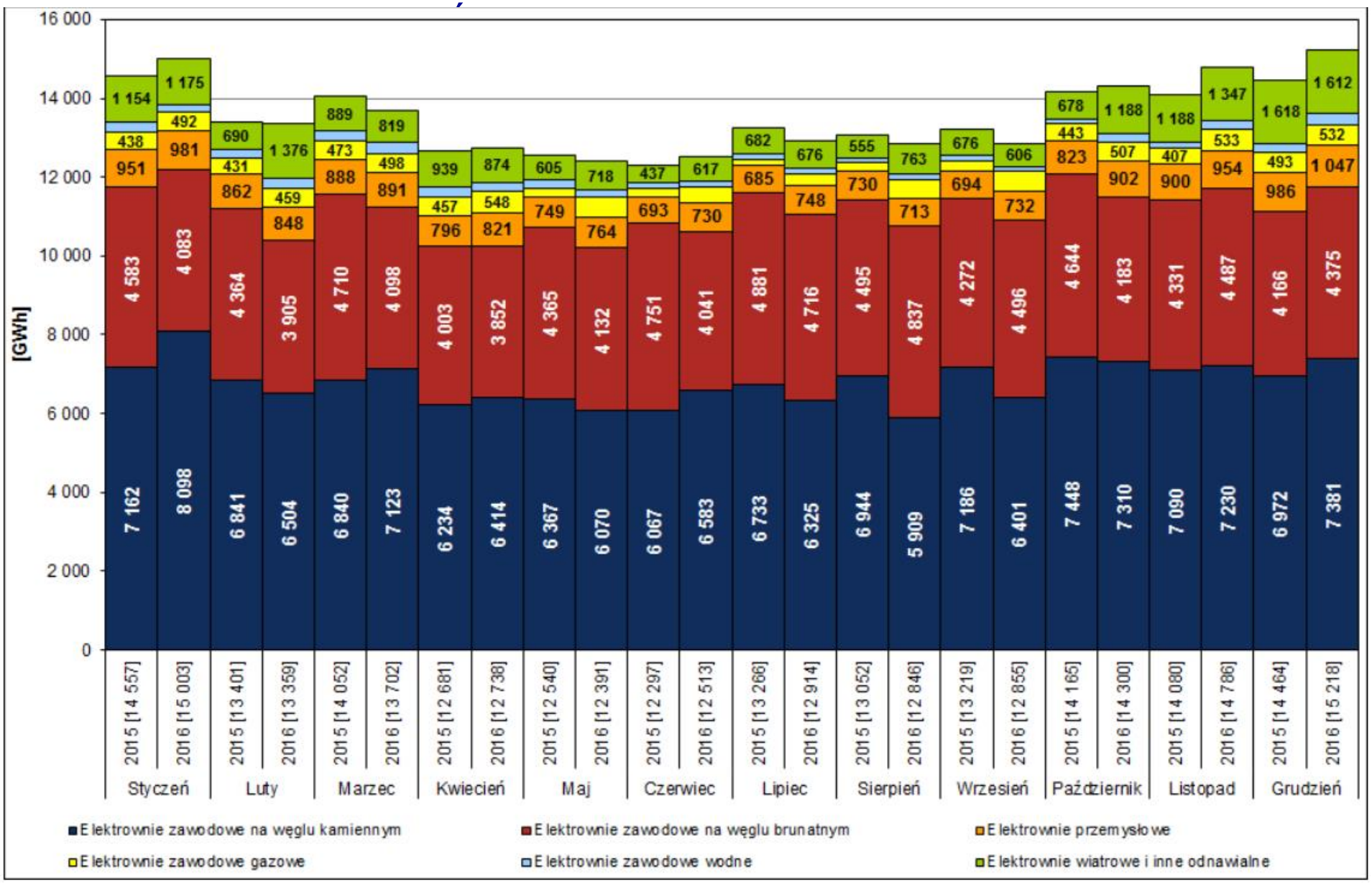
STRUCTURE OF THE PERCENTAGE OF THE POWER INSTALLED IN POLISH ELECTROENERGETIC SYSTEM (according to PES data 31.12.2016)



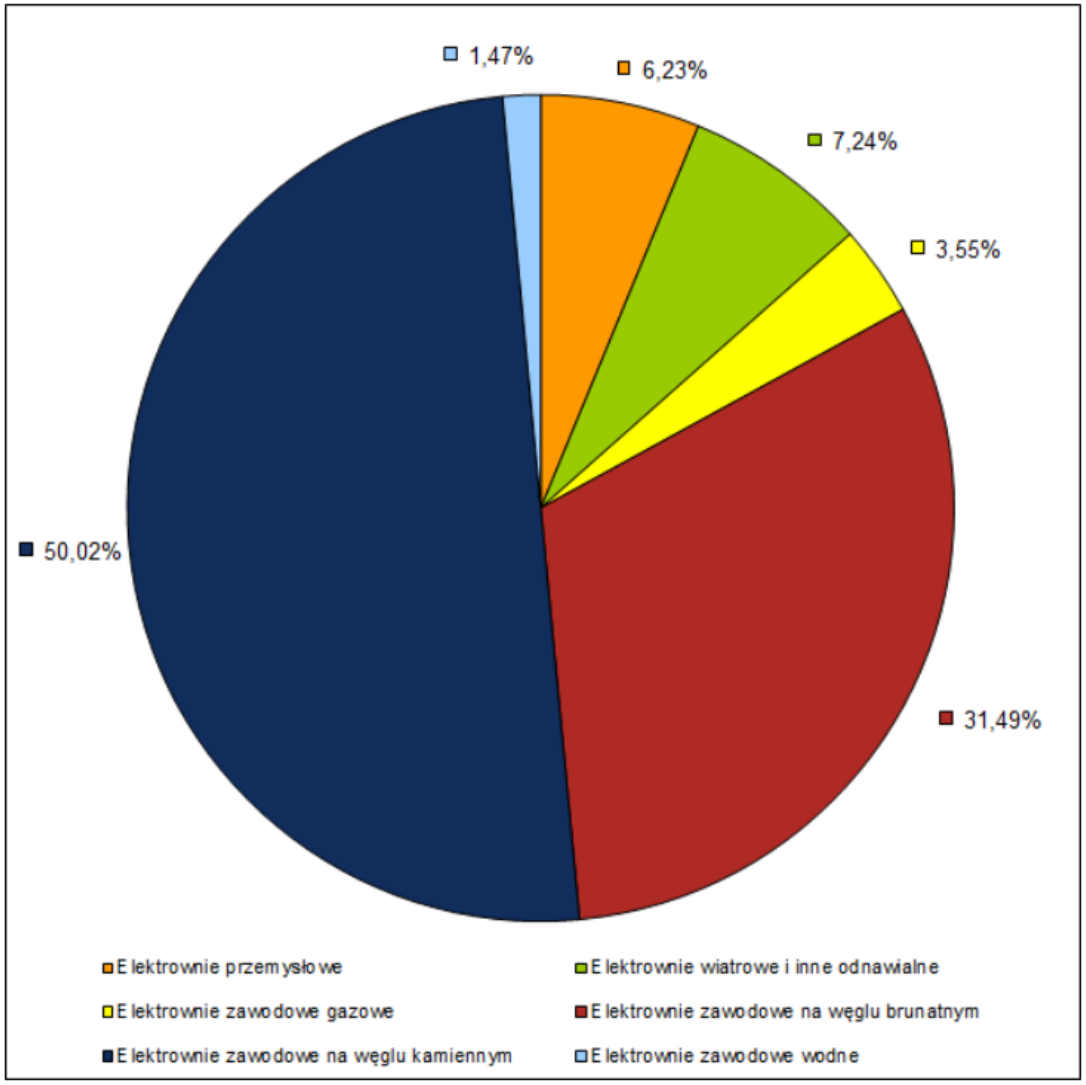
INCREASE OF POWER INSTALLED IN POLISH ELECTROENERGETIC SYSTEM 1960 ÷ 2016 (according to PES data)



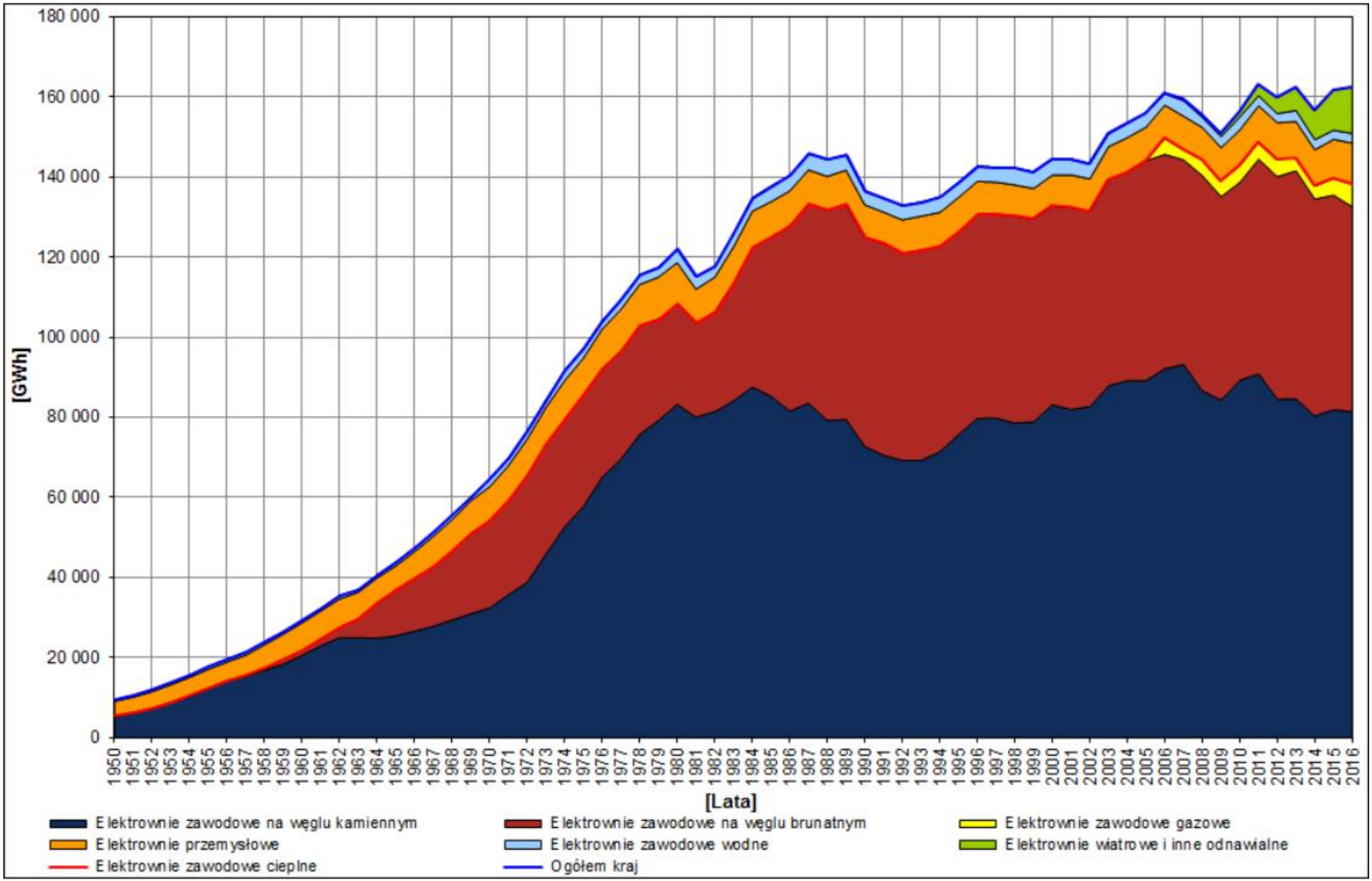
PRODUCTION OF ELECTRICAL ENERGY IN POLISH POWER PLANTS (according to PES data)



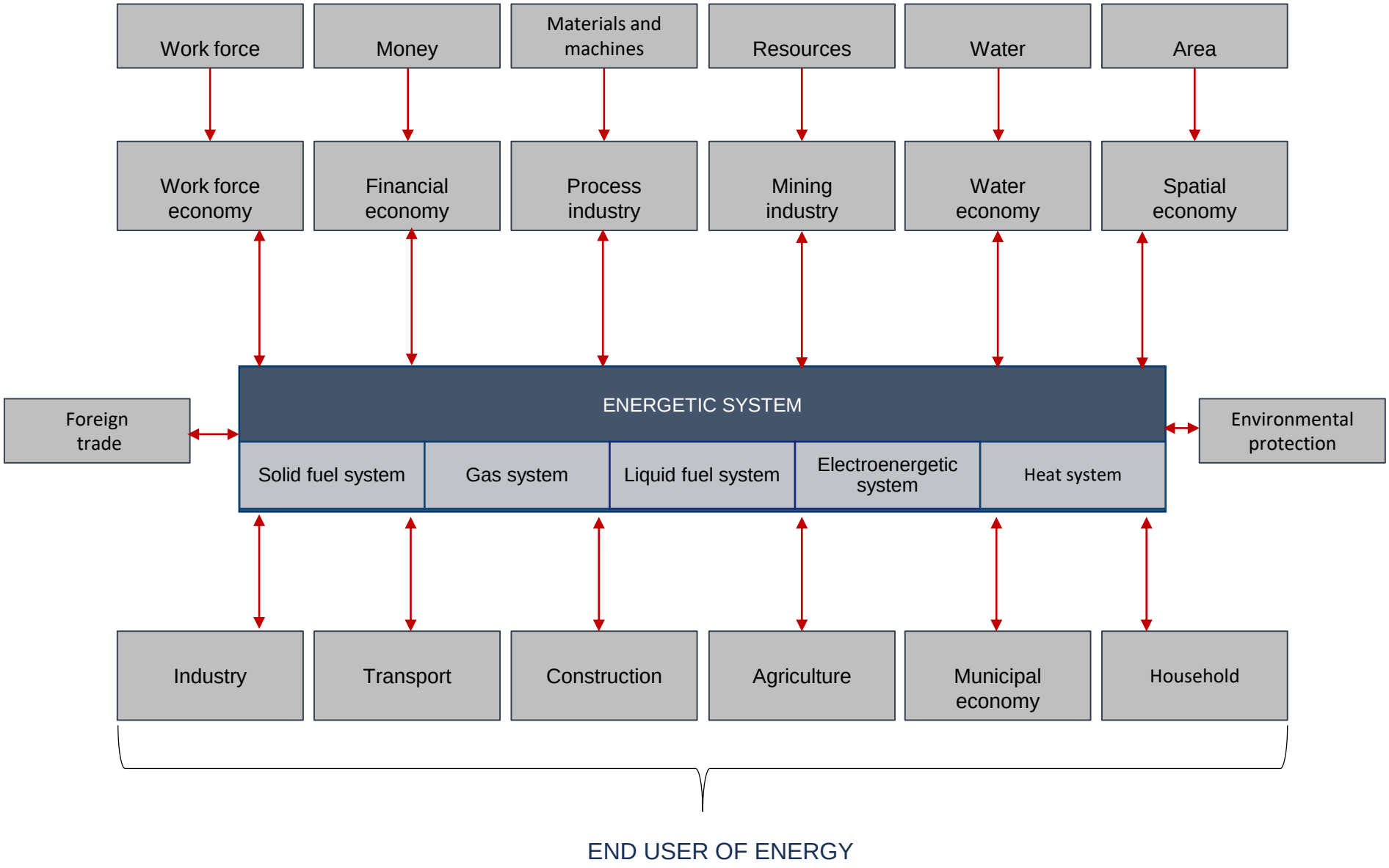
PERCENTAGE SHARE IN NATIONAL ELECTRICAL ENERGY PRODUCTION OF INDIVIDUAL POWER PLANT BY TYPE OF FUELS IN 2016 *(according to PES data)*



PRODUCTION OF ELECTRICAL ENERGY 1950÷2016
(according to PES data)



SCHEMAT POGLĄDOWY OGÓLNOKRAJOWEGO SYSTEMU ENERGETYCZNEGO



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Thank you for your attention