Energy efficiency P&S modeling challenges

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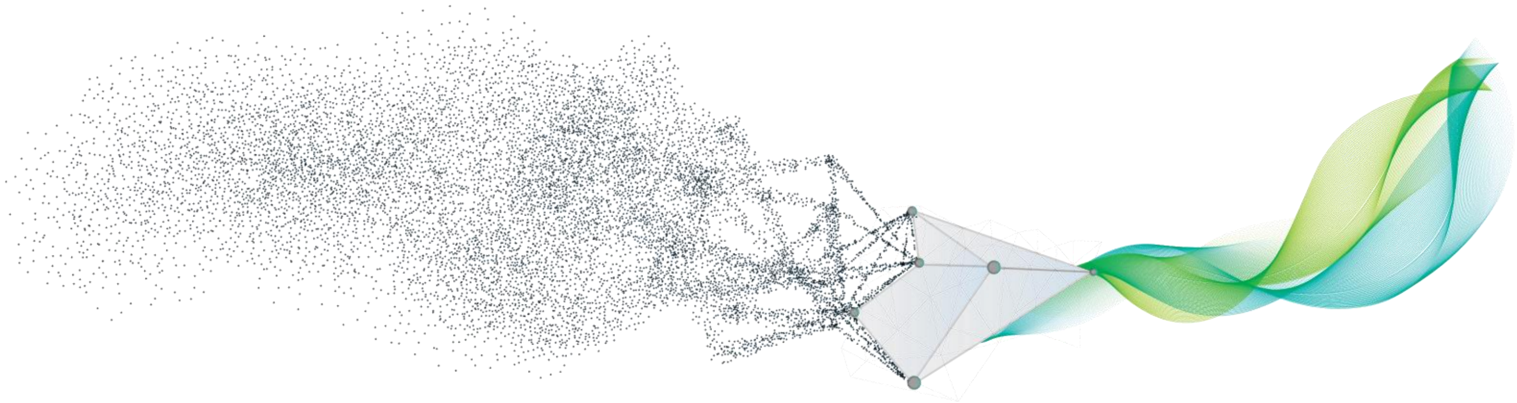

specialized methodologies including stock-turnover modeling for areas such as transport planning. On the supply side, LEAP provides a range of accounting, simulation and optimization methodologies that are powerful enough for modeling electric sector generation and capacity expansion planning, and which are also sufficiently flexible and transparent to allow LEAP to easily incorporate data and results from other more specialized models.

LEAP's modeling capabilities operate at two basic conceptual levels. At one level, LEAP's built-in calculations handle all of the "non controversial" energy, emissions and cost-benefit accounting calculations. At the second level, users enter spreadsheet-like expressions that can be used to specify time-varying data or to create a wide variety of sophisticated multi-variable models, thus enabling econometric and simulation approaches to be embedded within LEAP's overall accounting framework. The newest versions of LEAP also support optimization modeling: allowing for the construction of least cost models of electric system capacity expansion and dispatch, potentially under various constraints such as limits of CO_2 or local air pollution.

Ukupni energetski bilans, BiH, 2015*

*Total energy balance, BiH, 2015**

BILANS 2015 / BALANCE 2015	Ugalj *Coal*	Sirova nafta *Crude oil*	Derivati nafte *Oil products*	Prirodni plin *Natural gas*	Hidro *Hydro*	Biomasa *Biomass*	El. energija *Electricity*	Toplota *Heat*	UKUPNO *TOTAL*
	000 toe								
Primarna proizvodnja energije / *Primary production*	3.165	-	-	-	477	755	-	-	4.397
Uvoz / *Import*	958	947	901	177	-	1	333	-	3.317
Saldo zaliha / *Stock changes*	-195	-2	-71	-	-	-12	-	-	-281
Izvoz / *Export*	-313	-	-239	-	-	-250	-517	-	-1.319
Međunarodna skladišta / *Bunkers*	-	-	-	-	-	-	-	-	-
Bruto domaća potrošnja energije / *Gross inland consumption*	3.615	944	590	177	477	494	-184	-	6.114
Energetska transformacija - ulaz / *Transformation input*	3.952	944	39	45	-	-	-	-	4.980
Termoelektrane / *Thermal power plants*	2.560	-	7	-	-	-	-	-	2.566
Samoproizvođači / *Autoproducers*	227	-	6	10	-	-	-	-	243
Toplane / *District heating plants*	21	-	26	35	-	-	-	-	82
Prerada uglja (briketi, koks) / *Patent fuel, briquetting and coke-oven plants*	1.145	-	-	-	-	-	-	-	1.145
Rafinerije / *Rafineries*	-	944	-	-	-	-	-	-	944
Energetska transformacija - izlaz / *Transformation output*	621	-	924	-	-	-	867	134	2.546
Termoelektrane / *Thermal power plants*	-	-	-	-	-	-	825	79	904
Samoproizvođači / *Autoproducers*	-	-	-	-	-	-	42	17	59
Toplane / *District heating plants*	-	-	-	-	-	-	-	38	38
Prerada uglja (briketi, koks) / *Patent fuel, briquetting and coke-oven plants*	621	-	-	-	-	-	-	-	621
Rafinerije / *Rafineries*	-	-	924	-	-	-	-	-	924
Izmjene i transferi, povratni tokovi / *Exchanges and transfers, returns*	-	-	-	-	-477	-	477	-	-
Potrošnja grane energetike / *Consumption of the energy branch*	3	-	140	-	-	3	123	1	270
Gubici prenosa i distribucije energije / *Losses*	-	-	-	0	-	-	120	9	129
Raspoloživo za finalnu potrošnju / *Available for final consumption*	281	-	1.335	132	-	491	918	125	3.282
Finalna ne-energetska potrošnja / *Final non-energy consumption*	-	-	70	-	-	-	-	-	70
Finalna energetska potrošnja energije / *Final energy consumption*	281	-	1.265	132	-	491	918	125	3.212

Finalna energetska potrošnja energije / *Final energy consumption*	281	-	1.265	132	-	491	918	125	3.212
Industrija / *Industry*	114	-	104	73	-	27	344	1	662
Industrija željeza i čelika / *Iron & steel industry*	0	-	0	23	-	-	66	-	90
Obojeni metali / *Non-ferrous metal industry*	42	-	3	40	-	-	147	-	233
Hemijska industrija / *Chemical industry*	0	-	3	1	-	-	10	-	14
Nemetalni minerali / *Glass, pottery & building mat. industry*	62	-	13	1	-	-	14	-	90
Vađenje rude i kamena / *Ore-extraction industry*	1	-	18	-	-	-	7	-	27
Prerada hrane, pića i duhana / *Food, drink & tobacco industry*	6	-	27	5	-	-	20	-	57
Tekstil i koža / *Textile, leather & clothing industry*	2	-	3	1	-	-	10	-	15
Papir, celuloza i štampanje / *Paper and printing*	0	-	7	1	-	-	17	-	25
Mašine i oprema / *Engineering & other metal industry*	1	-	6	0	-	-	21	-	29
Ostala industrija / *Other industries*	0	-	24	0	-	27	30	-	82
Saobraćaj / *Transport*	-	-	1.030	-	-	-	8	-	1.038
Ostali sektori / *Other sectors*	167	-	131	59	-	464	566	124	1.512
Domaćinstva / *Households*	55	-	77	33	-	437	406	97	1.106
Poljoprivreda / *Agriculture*	0	-	12	-	-	0	5	-	17
Ostali potrošači / *Other*	111	-	42	26	-	27	155	28	389
Statistička razlika / *Statistical difference*	-	-	-	-	-	-	-	-	-

Universal question that permeates through all the sectors is:

„HOW WE ARE GOING TO FINANCE THIS?!”

or how to link overal EE based growth with overal eoncomic parameters

Total final energy intensity is defined as total final energy consumption (consumption of transformed energy, i.e. electricity, publicly supplied heat, refined oil products, coke, etc., and the direct use of primary fuels such as gas or renewables, e.g. solar heat or biomass) **divided by** GDP at 2010 prices.

- EI **of households** = FEC OF HHs/population or m2.
- EI **transport** = FEC transport/GDP at 2010 prices.
- EI **industry** = FEC Industrije/industry gross value added (GVA) at constant 2005 prices
- Energetski intenzitet **usluga** = FEC/services GVA at constant 2005 prices.
- Sevices VA is a sum of 7 subsectors

Energy efficeincy in industry

- Money making clear motivator
- Creating new jobs, improving productivity, competitiveness and economic development.
- Energy security at the local and national level through the reduction of energy imports and the burden on the system of production and distribution of electricity.
- Improving air quality.
- Energy efficiency is the main way to reduce greenhouse gas emissions.
- Energy efficiency should be considered an energy resource

The EEI approach estimates the EEI of country for sector *x* with *i* production processes as follows:

$$EEI_{j,x} = \frac{TFEU_{j,x}}{\sum_{i=1}^{n} P_{i,j} \times BPT_{i,x}} \qquad (1)$$

where, TFEU is the actual energy use of sector as reported in Energy Balances prepared by International Energy Agency (IEA) (in petajoules (PJ) per year), P is the production volume of product *i* in country *j* (in mega tonnes (Mt) per year), BPT is best practice technology energy u for the production of product *i* (in GJ per tonne of output) and *n* is the number of products to be aggregated. On this basis, a country is the most

Table 4. Selected industry energy benchmark data

Source: UNIDO, 2010

Sectors	Units	Developed Countries	Developing Countries	Global Average	Lowest Found	BAT
Petroleum refineries	EEI	0.7 - 0.8	1.3 - 3.8	1.25	-	1.0
High value chemicals	GJ/t	12.6 - 18.3	17.1 - 18.3	16.9	12.5	10.6
Ammonia	GJ/t	33.2 - 36.2	35.9 - 46.5	41.0	31.5	23.5
Methanol	GJ/t	33.7 - 35.8	33.6 - 40.2	35.1	30.0	28.8
Alumina production	GJ/t	10.9 - 15.5	10.5 - 24.5	16.0	7.8	7.4
Aluminium smelting	MWh/t	14.8 - 15.8	14.6 - 15.0	15.5	14.2	13.4
Copper	GJ/t	-	-	13.8	7.4	6.3
Zinc	GJ/t	15.2 - 19.7	16.7 - 37.2	23.6	15.2	-
Iron and steel	EEI	1.2 - 1.4	1.4 - 2.2	1.5	1.16	1.0
Clinker	GJ/t	3.3 - 4.2	3.1 - 6.2	3.5	3.0	2.9
Cement	kWh/t	109 - 134	92 - 121	109	88	56
Lime	GJ/t	3.6 - 13.0	5.0 - 13.0	-	3.2	-
Glass	GJ/t	4.0 - 10.0	6.8 - 7.8	6.5	3.6	3.4
Brick making	MJ/kg	1.5 - 3.0	0.8 - 11.0	-	0.8	-
Tiles	GJ/t	1.9 - 7.3	3.1 - 8.3	-	1.9	-
Sanitaryware	GJ/t	4.2 - 11.3	4.4 - 20.0	-	4.2	-
Pulp and paper	EEI	0.9 - 1.7	0.4 - 2.3	1.3	-	1.0
Textile spinning	GJ/t	3.5 - 3.6	3.5 - 3.6	-	3.4	-
Textile weaving	GJ/t	11.0 - 65.0	5.0 - 43.0	-	-	-
Brewery	MJ/hl	-	-	229	156	-
Cheese	GJ/t	4.3 - 35.2	-	-	1.8	-
Fluid milk	GJ/t	3.1 - 6.5	-	-	0.3	-

- **economic potential -** the potential that is possible by applying available technologies that are cost-effective. It should be noted that the problem with this definition is that it is cost-effective to define in relation to the individual economic definitions of the investor and therefore the standard definition is usually used.
- **technical potential -** potential that is technically possible with the best available technologies, but not taking into account the economy.
- **theoretical potential -** potential that is possible by using theoretical constraints regardless of whether the technology really exists.

IEA – EE production industry potential is between 18 i 26% based on commerically available technologies (IEA 2007).

Table 3. Savings from Adoption of Best Practice Commercial Technologies (Primary Energy Equivalents)

Source: IEA, 2007. Tracking Industrial Energy Efficiency and CO_2 Emissions.

	Low – High Estimates of Technical Savings Potential	
Sectoral Improvements	**Mtoe/year**	**Mt CO_2/year**
Chemicals/petrochemicals	120 – 155	370 – 470
Iron and steel	55 – 108	220 – 360
Cement	60 – 72	480 – 520
Pulp and paper	31 – 36	52 – 105
Aluminium	7 – 10	20 – 30
Other non-metallic minerals & non-ferrous	12 – 24	40 – 70
System/life cycle Improvements		
Motor systems	143 – 191	340 – 750
Combined heat and power	48 – 72	110 – 170
Steam systems	36 – 60	110 – 180
Process integration	24 – 60	70 – 180
Increased recycling	36 – 60	80 – 210
Energy recovery	36 – 55	80 – 190
Total	**600 – 900**	**1,900 – 3,200**
Global improvement potential – share of industrial energy us and CO_2 emissions	**18 – 26%**	**19 – 32%**
Global improvement potential – share of total energy use and CO_2 emissions	**5.4 – 8.0%**	**7.4 – 12.4%**

Table 6. Shortlist of sector specific energy efficiency opportunities – chemicals and petrochemicals
Source: Adapted from Neelis et al., 2008

Sub-Sector/Product	Energy efficiency opportunities	
Ethylene	• More selective furnace coils • Improved transfer line exchangers • Secondary transfer line exchangers • Increased efficiency cracking furnaces • Pre-coupled gas turbine to cracker furnace • Higher gasoline fractionator bottom temperature • Improved heat recovery quench water	• Reduced pressure drop in compressor inter-stages • Additional expander on de-methanizer • Additional re-boilers (cold recuperation) • Extended heat exchanger surface area • Optimisation of steam and power balance • Improved compressors
Aromatics	• Improved product recovery	
Polymers	• Low pressure steam recovery • Gear pump to replace extruder • Online compounding extrusion • Re-use solvents, oils and catalyst	
Ethylene oxide / ethylene glycol	• Increased selectivity catalyst • Optimal design EO/EG-sections • Multi-effect evaporators	• Recovery and sales of by products • Process integration
Ethylene dichloride / Vinyl Chloride Monomer	• Optimise recycle loops • Gas-phase direct chlorination of ethylene • Catalytic cracking EDC	
Styrene	• Condensate recovery and process integration	
Iron ore and ferrous reverts Iron ore and preparation (Sintering)	• Heat recovery from sintering and sinter cooler • Reduction of air leakage • Increasing bed depth	• Emissions optimised sintering • Use waste fuel in sinter plant improved charging method • Improve ignition oven efficiency

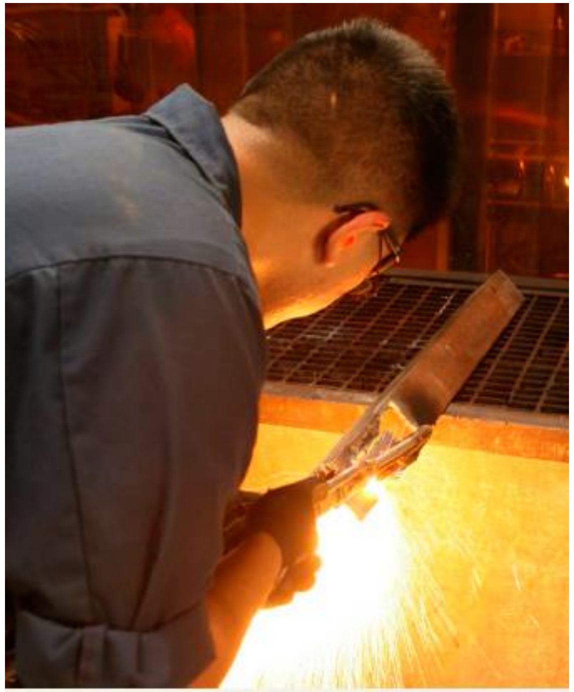

Table 7. Shortlist of sector specific energy efficiency opportunities – iron and steel
Source: Adapted from Worrell et al., 2010

Sub-Sector/Product	Energy efficiency opportunities	
Iron making – blast furnace	• Injection of pulverised coal • Injection of natural gas • Injection of oil • Injection of plastic waste • Injection of coke oven gas and basic oxygen furnace gas • Charging carbon composite agglomerates • Top pressure recovery turbines	• Recovery of blast furnace gas • Top gas recycling • Improved blast furnace control • Slag heat recovery • Pre-heating of fuel for hot stove • Improvement of combustion in hot stove • Improved hot stove control
Steelmaking – Basic oxide furnace	• Recovery of BOF gas and sensible heat • Variable speed drive on ventilation fans • Ladle pre-heating	• Improvement of process monitoring and con-trol • Efficient ladle heating programme
Steelmaking – EAF	• Variable speed drives • Oxy-fuel burners / lancing • Post combustion of flue gasses • Improving process control • Direct current arc furnace	• Scrap pre-heating • Waste injection • Air tight operation • Bottom stirring / gas injection
Casting and refining	• Integration of casting and rolling • Lade pre-heating • Tundish heating	
Metal shaping	• Use efficient drive units • Gate communicated turn off inverters • Installation of automated lubrication system	
Hot rolling	• Recuperative or regenerative burners • Flameless burners • Controlling oxygen levels • Variable speed drives on combustion air fans • Hot charging	• Integration of casting and rolling • Proper reheating temperature • Process control in hot strip mill • Heat recovery to the product • Waste heat recovery from cooling water
Cold rolling	• Continuous annealing • Reducing losses on annealing line	• Reduced steam use in the acid pickling line • Inter-electrode insulation in electrolytic pick-ling line

Table 9. Shortlist of sector specific energy efficiency opportunities – pulp and paper

Source: Adapted from Kramer et al., 2009

Sector	Energy efficiency opportunities
Pulp and paper – raw material preparation	• Cradle debarkers • Automatic chip handling and screening • Replace pneumatic chip conveyors with belt conveyors • Bar-type chip screening • Use secondary heat instead of steam in de-barking • Chip conditioning
Chemical pulping – pulping	• Use of pulping aids to increase yield • Digester blow/flash heat recovery • Optimise the dilution factor control • Heat recovery from bleach plant effluents • Continuous digester control system • Improved brownstock washing • Digester improvement • Chlorine dioxide heat exchange
Chemical pulping – bleaching	• Heat recovery from bleach plant effluents • Chlorine dioxide heat exchange • Improved brownstock washing
Chemical pulping – chemical recovery	• Lime kiln oxygen enrichment • Improved composite tubes for recovery boiler • Lime kiln modification • Recovery boiler deposition monitoring • Lime kiln electrostatic precipitation • Quaternary air injection • Black liquor solids concentration
Mechanical pulping	• Refiner improvements • Increased use of recycle pulp • Refiner optimisation for overall energy use • Heat recovery from de-inking plant • Pressurised groundwood • Fractionation of recycled fibers • Continuous repulping • Thermopulping • Efficient repulping rotors • Drum pulpers • Heat recovery in thermomechanical pulp
Paper making	• Advanced dryer controls • Waste heat recovery • Control of dew point • Vacuum nip press • Energy efficient dewatering – rewetting • Shoe (extended nip) press • Dryers bars and stationary siphons • Reduction of blow through losses • Belt drying • Reduction air requirements • Air impingement drying • Optimising pocket ventilation temperature

Table 12. Shortlist of sector specific energy efficiency opportunities – glass industry

Source: Adapted from Worrell et al., 2008

Sector	Energy efficiency opportunities	
Glass – Batch preparation	• Grinding – new technology • High-efficiency motors • Mixing variable speed drives • Fluxing agents • High efficiency belts • Reduce batch wetting	• Conveyor belt systems • Selective batching • Cullet separation and grinding systems • Optimise conveyor belts • Cullet preparation
Glass – Melting task	• Process control systems • Refractories/Insulation • Minimise excess air/reduce air leakage • Properly position burners • Premix burners • Sealed burners • Variable speed drives on combustion air fans	• Low-NOx burner • Waste heat boiler • Recuperative burners • Bubbler • Vertically-fired furnaces • End-fired furnaces • Regenerative furnaces
Glass – Melting task – Oxy-fuel furnace	• Synthetic air • Heat recovery from oxy-fuel furnace • Oxygen enriched air staging	• High luminosity burners (oxy-fuel) • Oxy-fuel furnace • Tall crown furnace (oxy-fuel)
Glass – Melting task – Electric furnace	• Top-heating • Replace by fuel-fired furnace • Optimise electrode placement	
Glass – Melting task – Cullet use and pre-heating	• Use more cullet and or filter dust • Batch and cullet preheating	
Glass – Forehearths and forming	• Process control • Oxy-Fuel fired forehearth	• High efficiency forehearths • Improved insulation
Glass – Annealing and finishing	• Improve process controls • Improved insulation • Optimise plant lay-out	• Product drying system upgrade • Reduce air leakage • Glass coating

Table 11. Shortlist of sector specific energy efficiency opportunities – pharmaceuticals
Source: Adapted from Galitsky et al., 2008

Sector	Energy efficiency opportunities
Pharmaceutical – R&D	• Fume cupboard controls • Variable speed driven fans • Energy efficient clean rooms
Pharmaceutical – Primary manufacturing	• Close-system sterilisation • Variable flow control for process air • Energy efficient agitation
Pharmaceutical – Secondary manufacturing	• Variable speed driven fans • Variable speed driven vacuum • Multiple effect evaporation • Optimise the operation of pharmaceutical water generation • Recover and reuse water from water treatment plant for other applications

https://www.german-energy-solutions.de/GES/Navigation/EN/Energy-Solutions/EnergyEfficiencyInIndustry/energy-efficiency-in-industry.html

Federal Ministry for Economic Affairs and Energy

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Compressed air

Trade and industry frequently require exceptionally large volumes of compressed air, which is one of the most widely used cross-application technologies and is mainly used in industrial processes.

Electrical drives

Trade and industry requires electrical drives worldwide. They consume 64% of all electricity used in industry. Here, there is also great potential for improved efficiencies in trade and industry.

Refrigeration

Refrigeration technology is an inherent part of many production and logistics processes and is widely used in trade and industry.

Solutions

Events

Projects and partners

ECONOMY SECTORS	PERCENTAGE OF INDUSTRIAL ENERGY CONSUMPTION (%)	ESTIMATED ENERGY SAVING (TECHNICAL POTENTIAL) PJ DRAFT NEEAP	ESTIMATED ENERGY SAVING (TECHNICAL POTENTIAL) PJ UPDATED NEEAP	ESTIMATED CO2 SAVINGS POTENTIALS FROM UPDATED NEEAP (1000XTONNES)
Iron and steel, aluminium, basic metals	37.65	1.62	0.63	58.69
Non–metallic minerals (cement, ceramic, salt…)	49.34	2.44	0.95	88.40
Wood and similar processing	3.21	0.08	0.03	2.90
Food and similar production	6.36	0.42	0.16	15.22
Textile, clothing, leather	2.84	0.16	0.06	5.80
Other	0.6	0.07	0.03	2.54
Total	100	4.79	1.86	173.53

By law on regular energy audits in enteprises

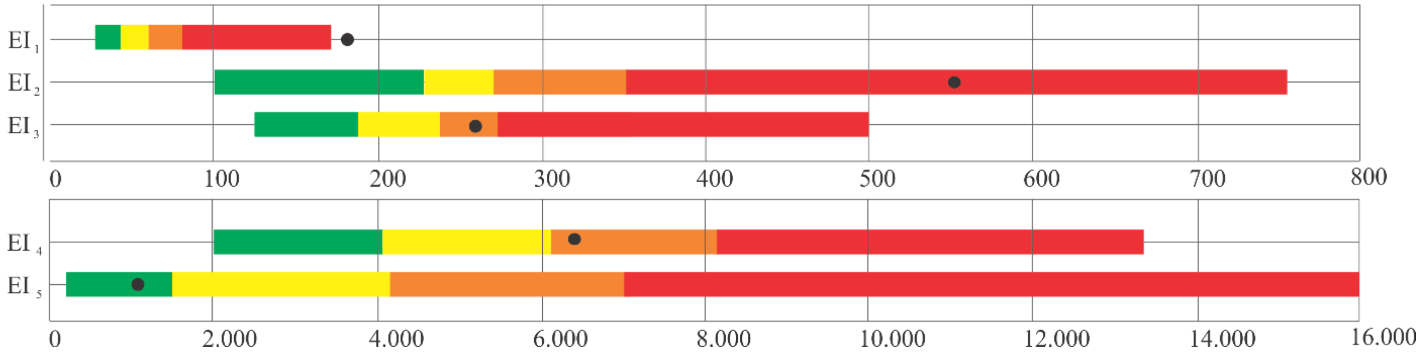
2. Obligated party to conduct energy audits are:
- large enterprises: entities that employ on average less than 250 persons per year, whose total annual income is less than 97,500,000.00 convertible marks and whose total annual balance sheet is less than 84,000,000.00 convertible marks,
- large consumers: an entity with an annual consumption of more than 0.35 GWh of electricity, and / or 30 tons of coal, and / or 150 tons of petroleum products and / and-or total energy and energy consumption in excess of 30 toe.

Naziv teme	Trajanje (h)
Uvod u energijske audite - Zakonska regulativa u FBiH i EU - Koncept energijske efikasnosti preduzeća (razlozi i koristi) - Faze energijskog audita - Sadržaj izvještaja o energijskom auditu	21
Priprema za energijski audit: - Pregled lokacije - Definiranje cilja i obuhvata audita - Priprema upitnika i checklista - Sistem prikupljanja podataka	2
Pregled koraka preliminarne analize Prikupljanje neophodnih podataka (npr. Računa za energente, popis opreme) Razumijevanje tehnološkog/proizvodnog procesa	1
Analiza potrošnje energije i troškova Izrada inventara svih potrošača energije	1
Profil obrazaca korištenja energije Povezanost potrošnje energije i proizvodnje (izrada scatter dijagrama)	3
Potrošnja električne energije, dnevni dijagram i faktor snage, sistem upravljanja, transformatori i kondenzatori	3

No.	Energy indicator	Calculated value
1.	Electricity consumed per square meter work surface, EI_1	180 kWh/m^2
2.	Total energy consumed per square meter of work surface, EI_2	551 kWh/m^2
3.	Total energy consumed per number of working hours, EI_3	265 kWh/h
4.	Electricity consumed per number of workers, EI_4	6.113 kWh/no. work
5.	Total energy consumed per cubic meters of treated wood, EI_5	1.115 kWh/m^3

Based on the data provided from the company, five energy indicators are calculated as it is shown in Table 9.

Table 9. Energy indicators of production plant



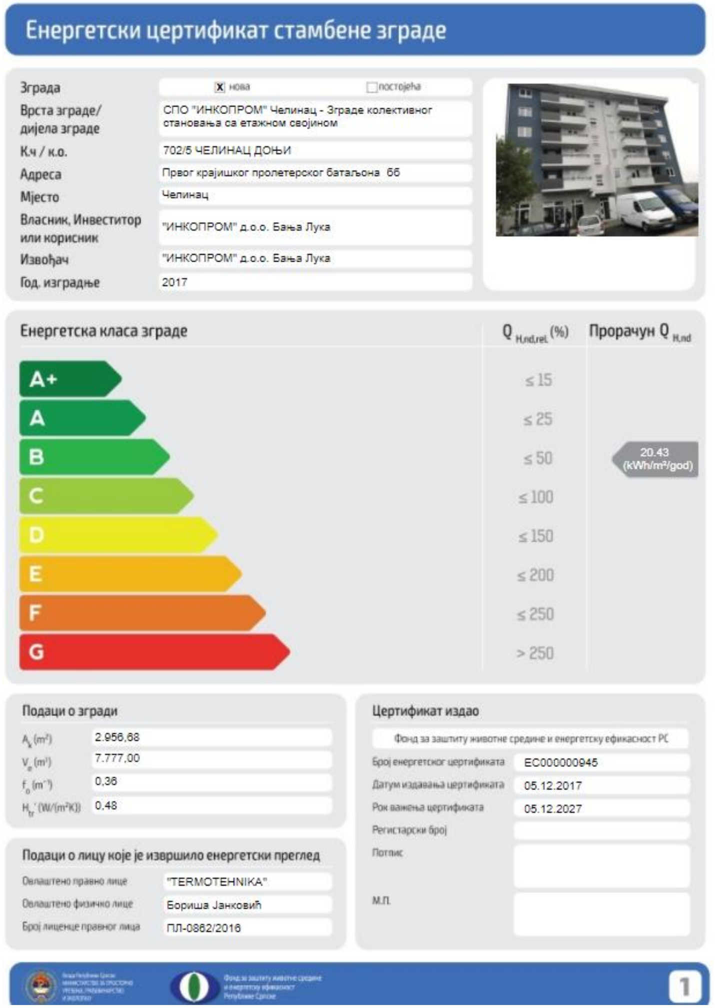


Figure 4. Energy indicators for considered production plant (black dots) and for similar facilities (coloured bars)

THANKS

Esad Smajlović
GIZ Office Sarajevo,
Decarbonisation of Energy Sector of BiH
Senior Advisor

Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH
Ferhadija 19/2
71 000 Sarajevo
Bosnia and Herzegovina

T +387 33 204 895
F +387 33 209 858
M +387 61 486 773
E esad.smajlovic@giz.de
I www.giz.de