



**ALRO industrial policy to
consolidate energy efficiency**

SUMMARY

- **1. Alro policy for energy efficiency**
- **2. ALRO - Vertically integrated operations**
- **3. Technical & innovation results**
- **4. Power management system**
- **5. Increase value added production**
- **6. Programs and directions to act in order to increase the energy efficiency**
- **7. Conclusions**

1. The Alro policy of energy efficiency

The statement of Alro General Director of policy in the following areas : environment, energy, security information, social responsibility, safety and health has a chapter dedicated to energy efficiency :

“ Optimization of processes and technologies to reduce energy consumption and enhancement opportunities to improve energy performance.”



SR EN ISO 50001: 2011 specifies requirements for establishing, implementing, maintaining and improving a system of energy management (EnMS), whose purpose is to create opportunity as an organization to follow a systematic approach to achieve the continual improvement of energy performance, which include energy efficiency, energy usage and energy consumption.

Energy targets are set annually for each areas, namely:

- electricity;
- natural gas;
- industrial water;
- steam;
- compressed air.

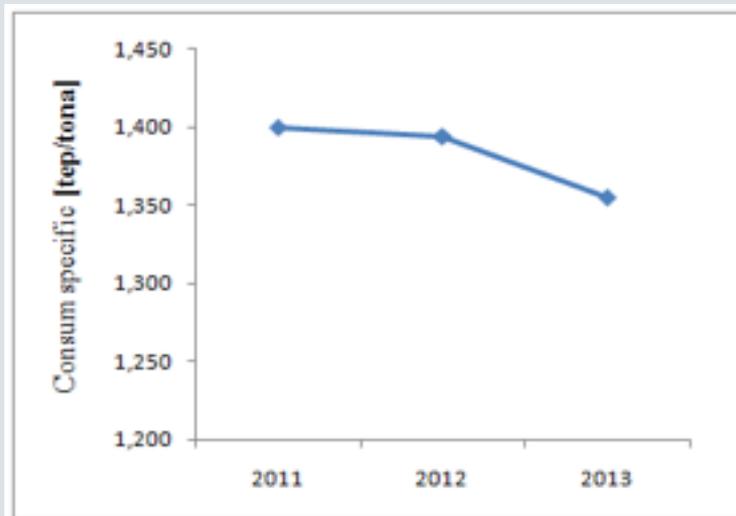
Energy audit

Given that the group ALRO electricity consumption per annum is about 3TWh, the energy audit is one of the most important analysis means used for energy efficiency assessment.

The advantages of energy audit are:

- ✓ assessment of energy efficiency within a specific contour and drawing up an action plan on medium term, containing a series of economically justified concrete proposals for improving the existing situation;
- ✓ continuous monitoring of energy and utilities consumption, to assess and improve the energy efficiency and ultimately minimize the specific energy consumption and related costs;
- ✓ evaluation of the technical solutions and supply conditions for energy & fuel in order to minimize the energy bill on long term basis;

The measures and actions taken after the energy audit led to a decrease of the specific energy consumption, presented below.



The evolution of specific consumption of energy resources on the industrial ALRO site

Source: The energy audit conducted by ELSACO SA

European benchmarking

JRC-Institute for Energy and Transport in 2015 issued a report to European Commission: “Energy Efficiency and GHG Emissions: Prospective Scenarios for the Aluminium Industry”

Company	City	Technology	Max brownfield efficiency (MWh/t)	Distance-to-target (%)
Aluminium Dunkerque S.A.	Graveline-sur-Loon-Plage	AP30	12.8	95 %
Trimet Aluminium AG	St.-Jean-de-Maurienne	AP18 AP30	13.2	99 %
Hydro Aluminium Deutschland GmbH	Neuss	VAW CA-165	13.2	93 %
Trimet Aluminium AG	Essen	Alusuisse EPT-14	13.5	92 %
Trimet Aluminium AG	Hamburg	Reynolds P19	13.8	98 %
Voerdal GmbH	Voerde	Kaiser P69	13.6	91 %
Aluminium de Grece S.A. (ADG)	St. Nicolas (Distomon)	AP07 AP09	13.2	100 %
Atlantic Aluminium Co.	Keilones	-	13.2	100 %
Alcoa Fjarðal	Reydarfjörður	AP30	12.8	97 %
Nordic Aluminium Company	Grundartangi	VAW CA-180	13.2	96 %
Nordural Helgúvík	Helgúvík	AP36	12.8	100 %
Rio Tinto Alcan Iceland Co. Ltd.	Stremsvík	Alusuisse EPT-10	13.2	88 %
Vimetco Arlo SA	Slabina	AP09	13.2	99 %
SLOVALCO	Zár nad Hronom	Hydro HAL-230	13.2	98 %
Talum, d.d. Kidricevo	Kidricevo	AP18	13.2	94 %
Alcoa Inespal SA Aviles	Aviles	PF-VSS	13.8	98 %
Alcoa Inespal SA La Coruna	La Coruna	PF-VSS	13.8	91 %
Alcoa Inespal San Ciprian	San Ciprian	AP-14	13.2	95 %
Rusal Kubikenborg Aluminium AB	Sundsvall	Kaiser P86	13.5	100 %
Alcan Smelting & Power UK	Fort William	AP18	13.2	99 %

Maximum attainable efficiencies and distance-to-target (energy efficiency) per plant

Alro uses an old technology as compared to other plants, but the energy efficiency performance is 99%

2. ALRO -Vertically integrated operations



- Acquired Sierra Minerals bauxite mine, sole supplier of bauxite to Alum, with roughly 31 mil. t resource base
- 100% of the output is processed internally by ALRO
- Tulcea production facility recently upgraded and fully compliant with EU environmental standards with capacity of 600kt



- Group activity
- External supply
- Location of facility

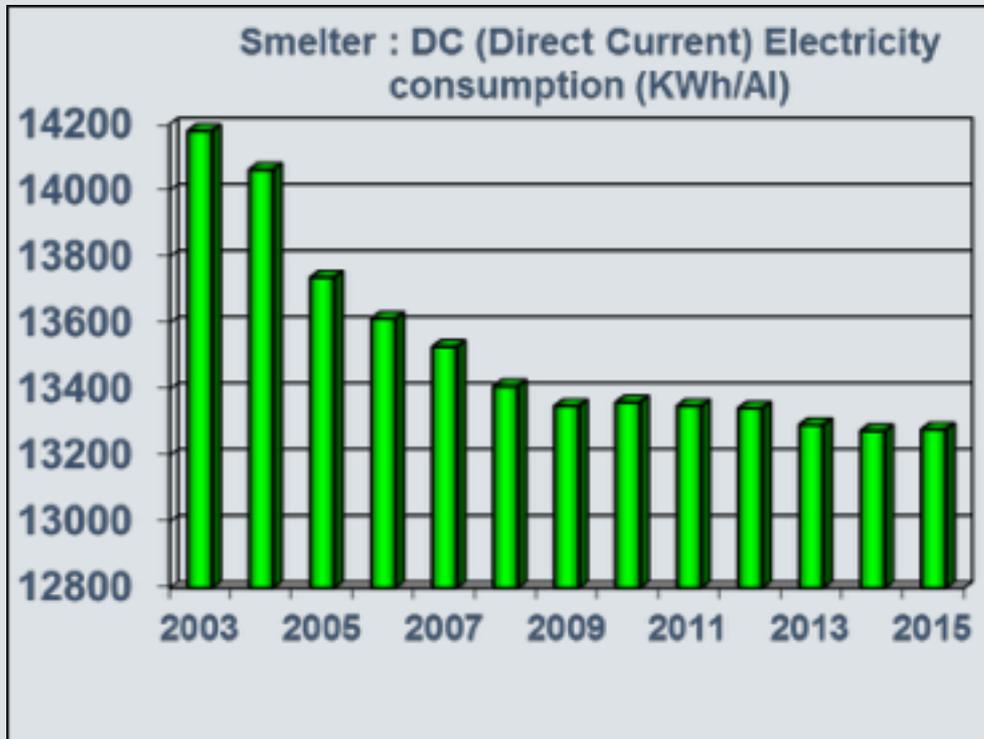
- All carbon anodes required for the electrolysis cells are produced internally
- Slatina production facility, which includes the smelter, anode plant and cast aluminium facility, has total capacity of 265kt of electrolytic aluminium and 340kt of cast aluminium
- Slatina processing facility capacity is 96kt of flat rolled products, depending on product mix; with capacity increase program is going up to 120,000 MT in 2018

Vertical integration advantages: planning, resources control & monitoring increase the usage efficiency.

3. Technical & innovation results

Smelter performance evolution- the biggest electricity consumer:

In the last 10 years the specific power consumption decreased by 1,000 KWh/Mt Al



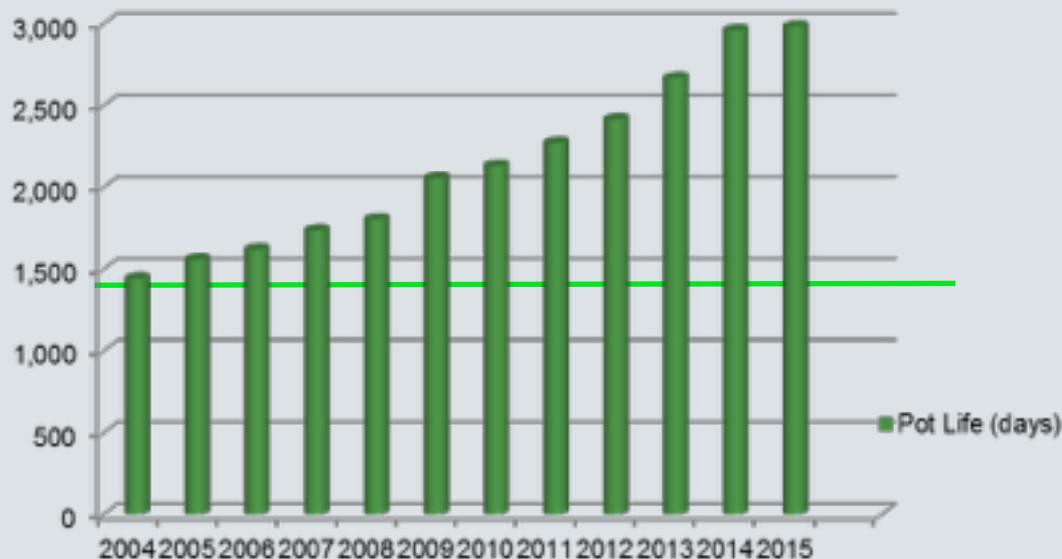
Modernization works performed during last decades included :

- conversion to computer controlled point feeding, hooding and dry scrubbing;
- amperage increase from 85 to 120 kA;
- new design of pot, patented by Alro specialists;
- installation of the hyper dense transport system for alumina designed and patented by Alro specialists;
- controlling of the Anode Effect: decrease its number, energy consumption and decreased PFC (Fluorine and Carbon compounds) emissions by 84 times since 2002;
- increased potlife.

Pot life evolution

During 2004 – 2015, increasing the electrolysis pot life has been a continuous long-term process and the final result of this process – the electrolysis pot life has been doubled in 11 years.

Pot Life (days)

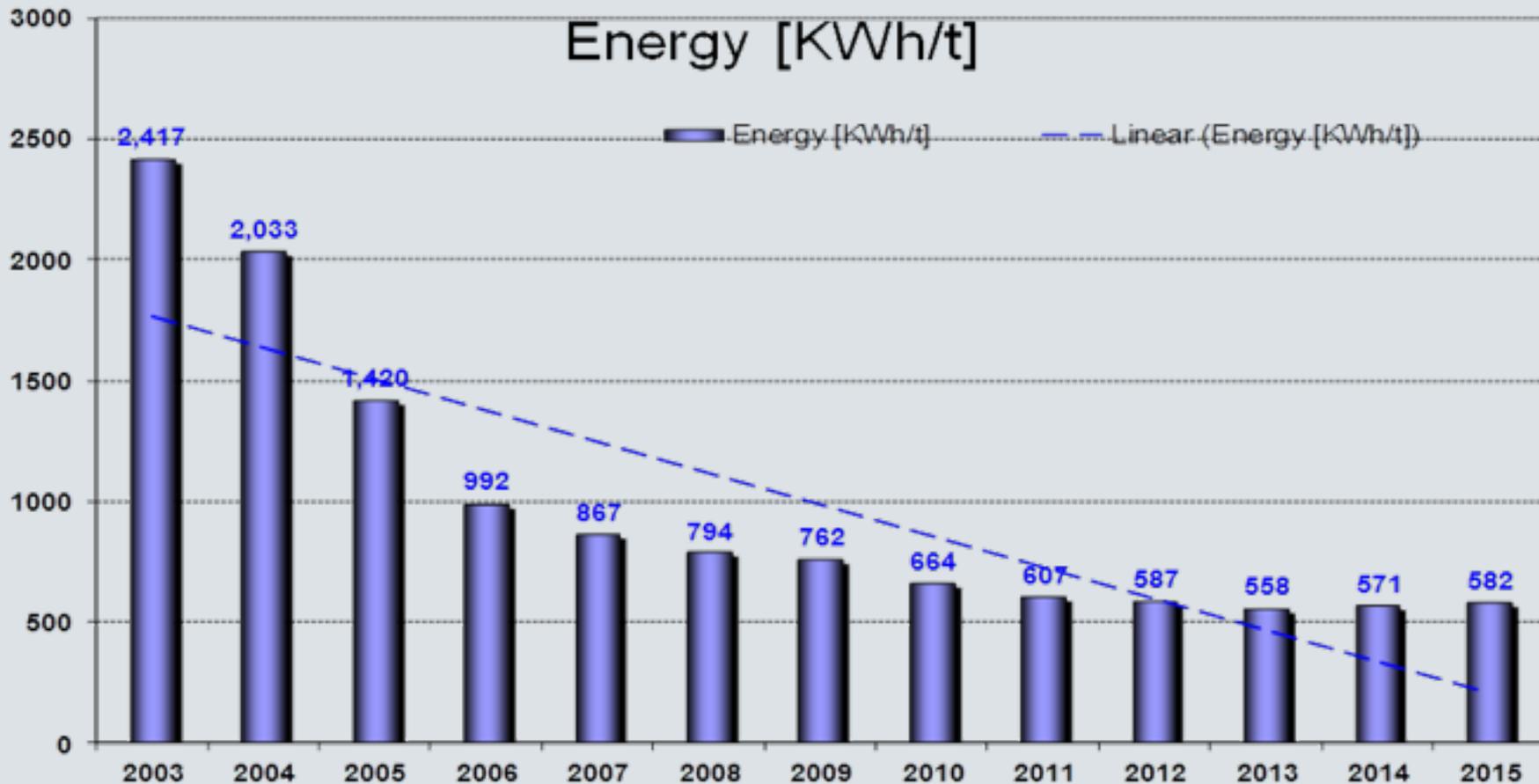


- The raw materials quantity to rebuild one electrolysis cell is around 50 Mt;
- By doubling the pot life the waste generation has been reduced in the same range, saving also the electricity for pot shut down and restart.

The International Congress Non-Ferrous Metals and Minerals , Krasnoyarsk, 14 -17 September 2015 – awarded ALRO for technical & innovation results .

Power specific consumption evolution 2003 – 2015

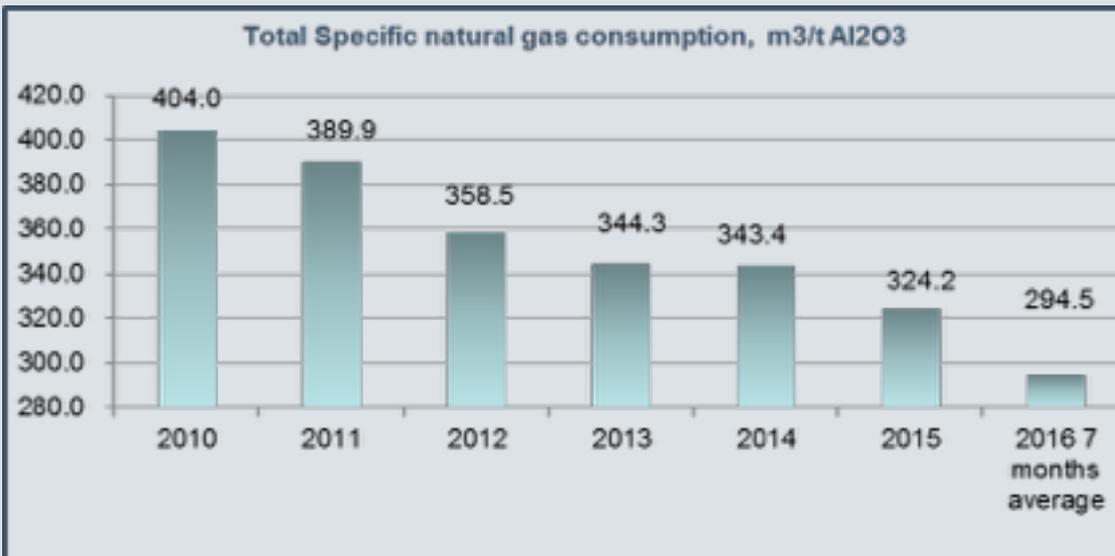
Processed Aluminum Division



Specific consumptions of electricity decreased over 5 times in the last 10 years

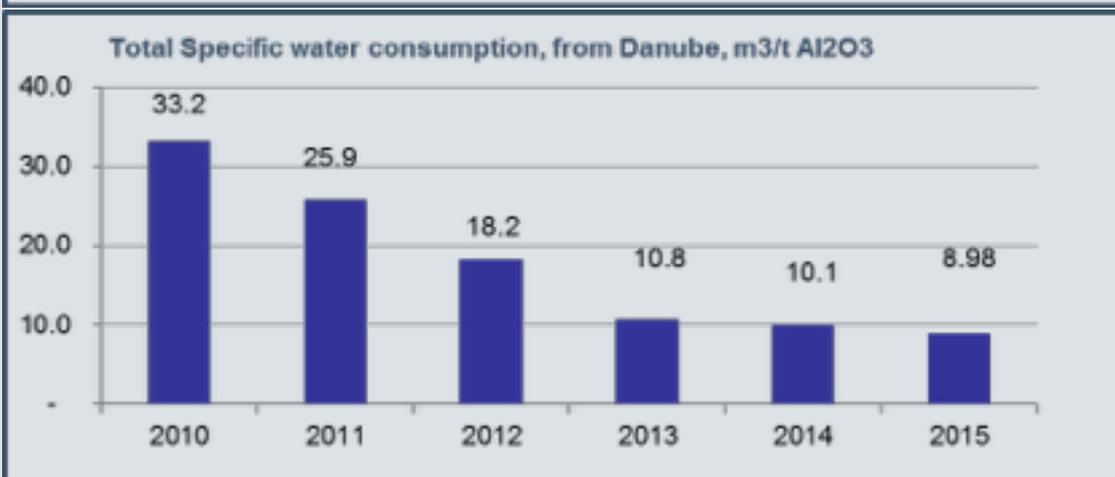
ALUM SA –The energy specific consumption evolution

Alum continued to implement measures during the last time period, in order to reduce the energy specific consumptions.



The main actions & measures taken were :

- Installed heat exchangers to recover the thermal energy from plant liquors
- continued the program for replacing the obsolete thermal insulations in some plant areas
- Improved the refinery parameters according to internal technological improvement planning program.
- adjusting the refinery operation to work in campaigns with some equipment.



4. Power management system

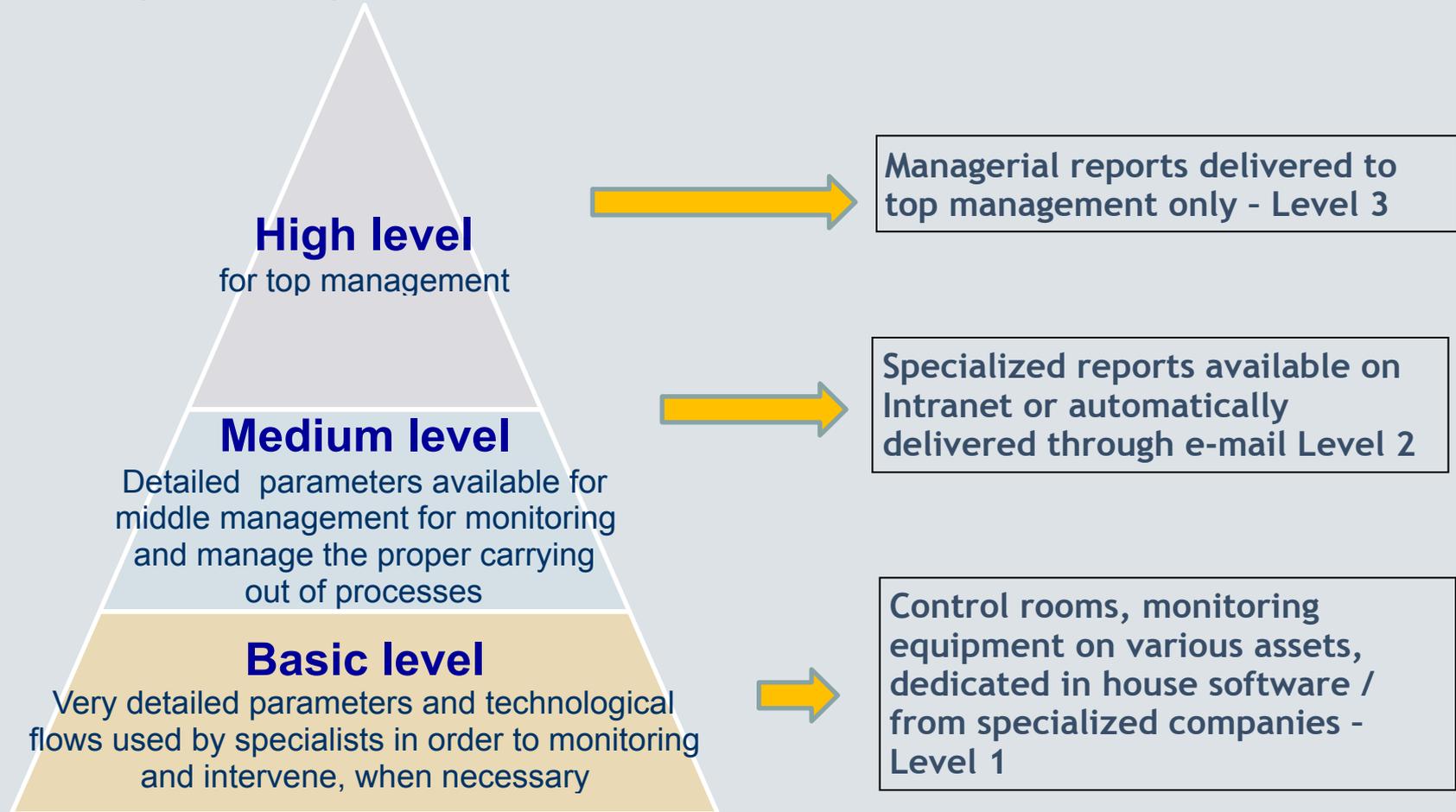
The Alro power management system consists of:

1. Online Monitoring;
2. Maintenance program of production equipment;
3. Energy dispatch – on group of companies level;
4. Continual Improvement Program to improve the specific electricity consumption

- By **online monitoring** at the level of group companies, the electricity consumption for all sectors is managed. Updating is performed online every 15 minutes and the display is intuitive - traffic light colors:
 - yellow** - forecast;
 - green** – within the forecast range;
 - red** - outside (over) forecast range.
- **Maintenance** program of production equipment is very important because the electricity consumption is directly correlated with the operation time of the equipment. A special place has **the predictive maintenance** which lowers the downtime of the equipment and especially estimates the downtime of the machinery for repairs– making possible a more accurate compliance to the power consumption forecast.
- **Energy dispatch** is a working group that manages the next day energy consumption forecast and establishes measures and actions in order to achieve the energy consumption forecast at group of companies level. Complex planning is performed and the work group has the authority (coordinated with company & section management) to turn ON/OFF machinery, decrease /increase the power intake in Electrolysis sectors.

Monitoring

In order to use all the information and parameters delivered by the various monitoring and process control devices, a global system has been implemented. This system is structured on several levels, in accordance with the degree of detail and respectively the hierarchy level to which it is addressed.



Examples of operations overview monitoring with different operating parameters available online, on the internal company network :

Scrap casthouse

- Sinoptic cuptor cu camera dubla
- Grafice cuptor cu camera dubla
- Raport zilnic incarcare cuptoare
- Raport lunar incarcare cuptoare
- Registru predare in turnatorie
- Cuptor de mentinere
- Sinoptic filtru
- Grafice filtru
- Cuptor inductie
- Raport zilnic cuptor inductie
- Raport lunar cuptor inductie
- Raport operativ de productie
- Activitate de productie
- Plan productie
- Consumuri specifice
- Introducere zgura

Monitoring

Examples of synoptic picture with the instantaneous power consumption evolution, available online, on the internal network

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Consumatori orare energie electrice

10:20:50

Extinde contori sectie

- Electr 3 Redr Turnat Transportari
- Electr 4 Anozii cruzi SIR UA APS
- Electr 5 Anozii copti ARCI Adm
- CTG Anozii asamblati THE Turn. deseuri

March 2016						
February	March					April
Sun	Mon	Tue	Wed	Thu	Fri	Sat
28	29	1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31	1	2
3	4	5	6	7	8	9

- Semnificatie culori
- galben prognoza
 - rosu >5% ca prognoza
 - roz > 3% ca prognoza
 - verde in banda de 3%
 - albastru < %3 ca prognoza

Ora	Electr 3		Electr 4		Electr 5		CTG		Redr		Anozii cruzi		Anozii copti		Anozii asamblati		Turnat		SIR UA		ARCI		THE		Transportari		APS		Adm		Turn. deseuri		
P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R	P	R		
1	282.0	266.0	281.0	259.0	142.0	143.0	7600.0	7882.3	450.0	445.6	1636.0	1672.2	736.0	746.2	1216.0	1184.7	2750.0	2452.6	1.0	0.0	0.0	9.7	3500.0	3506.9	17.0	7.0	55.0	39.0	80.0	74.9	1100.0	1735.7	
2	297.0	294.3	278.0	270.6	139.0	142.5	7600.0	7891.5	450.0	448.8	1596.0	1692.8	696.0	723.0	1236.0	1253.9	2410.0	2499.3	1.0	0.0	0.0	8.8	3500.0	3534.9	17.0	7.0	55.0	39.0	70.0	77.1	1200.0	1376.4	
3	272.0	278.5	272.0	276.5	143.0	138.0	7600.0	7848.0	442.0	451.0	1596.0	1602.2	689.0	743.9	1236.0	1230.5	2410.0	1980.2	1.0	0.0	0.0	8.8	3500.0	3407.8	17.0	7.2	55.0	41.0	70.0	76.1	1100.0	1519.4	
4	266.0	262.2	263.0	271.2	139.0	133.7	7600.0	7926.5	442.0	446.9	1596.0	1631.2	689.0	759.5	1236.0	1275.3	2410.0	1982.9	1.0	0.0	0.0	8.8	3500.0	3411.0	17.0	6.9	55.0	40.0	70.0	75.8	1200.0	1676.4	
5	280.0	261.9	267.0	266.0	133.0	133.3	7600.0	7972.9	439.0	443.1	1596.0	1673.3	689.0	679.4	1156.0	1208.1	2740.0	1956.4	1.0	0.0	0.0	9.8	3500.0	3447.9	25.0	7.1	60.0	40.0	70.0	75.1	1100.0	1444.2	
6	258.0	263.3	254.0	259.6	129.0	127.4	7600.0	8035.8	439.0	456.0	1596.0	1483.9	689.0	624.4	850.0	861.8	2730.0	2193.4	1.0	0.0	0.0	9.8	3500.0	3436.9	30.0	7.3	60.0	43.0	70.0	76.1	1100.0	1440.7	
7	266.0	246.8	259.0	252.7	133.0	131.0	7600.0	7756.1	440.0	447.2	1596.0	1561.1	769.0	697.0	618.0	203.8	2740.0	2219.8	1.0	3.9	0.0	9.1	3500.0	3371.6	44.0	46.3	60.0	52.0	90.0	88.0	500.0	193.3	
8	303.0	289.6	289.0	272.4	146.0	142.7	7600.0	7795.9	442.0	449.5	1626.0	1675.3	769.0	726.0	1250.0	1029.4	2140.0	2082.8	20.0	31.0	0.0	17.3	3550.0	3488.8	22.0	57.8	100.0	157.0	120.0	121.8	250.0	226.2	
9	323.0	279.5	245.0	282.3	158.0	150.9	7600.0	7623.6	442.0	462.8	1636.0	1736.0	769.0	654.6	1443.0	1384.2	2150.0	2136.9	20.0	14.0	0.0	10.8	3550.0	3701.1	20.0	66.6	180.0	161.0	180.0	145.1	250.0	204.7	
10	220.0	213.7	211.0	248.9	124.0	133.9	7600.0	7548.3	450.0	459.5	1636.0	1708.3	769.0	737.2	1443.0	1464.7	2140.0	1957.4	20.0	14.2	0.0	14.7	3550.0	3732.9	14.0	62.3	220.0	147.0	160.0	113.7	250.0	193.7	
11	161.0	43.2	215.0	51.8	107.0	27.2	7600.0	1933.1	450.0	114.7	1636.0	419.5	769.0	181.5	1443.0	331.8	2160.0	463.4	20.0	2.8	0.0	4.3	3550.0	940.4	68.0	15.4	110.0	33.0	140.0	30.3	250.0	62.2	
11	161.0	172.6	215.0	207.2	107.0	108.6	7600.0	7730.8	450.0	458.9	1636.0	1677.9	769.0	726.1	1443.0	1327.1	2160.0	1853.6	20.0	11.3	0.0	17.1	3550.0	3761.5	68.0	61.4	110.0	132.0	140.0	121.2	250.0	248.9	
12	170.0	0.0	178.0	0.0	96.0	0.0	7600.0	0.0	450.0	0.0	1636.0	0.0	686.0	0.0	1443.0	0.0	2150.0	0.0	20.0	0.0	0.0	0.0	3550.0	0.0	0.0	12.0	0.0	110.0	0.0	130.0	0.0	250.0	0.0
13	196.0	0.0	174.0	0.0	93.0	0.0	7600.0	0.0	451.0	0.0	1656.0	0.0	686.0	0.0	1443.0	0.0	2160.0	0.0	20.0	0.0	0.0	0.0	3550.0	0.0	10.0	0.0	150.0	0.0	120.0	0.0	500.0	0.0	
14	183.0	0.0	160.0	0.0	83.0	0.0	7600.0	0.0	451.0	0.0	1696.0	0.0	686.0	0.0	1250.0	0.0	2150.0	0.0	20.0	0.0	0.0	0.0	3550.0	0.0	9.0	0.0	230.0	0.0	100.0	0.0	700.0	0.0	
15	166.0	0.0	158.0	0.0	84.0	0.0	7600.0	0.0	450.0	0.0	1696.0	0.0	686.0	0.0	536.0	0.0	2160.0	0.0	20.0	0.0	0.0	0.0	3550.0	0.0	9.0	0.0	90.0	0.0	100.0	0.0	800.0	0.0	
16	198.0	0.0	180.0	0.0	78.0	0.0	6600.0	0.0	450.0	0.0	1696.0	0.0	769.0	0.0	1396.0	0.0	2740.0	0.0	1.0	0.0	0.0	0.0	3550.0	0.0	10.0	0.0	50.0	0.0	80.0	0.0	1200.0	0.0	
17	187.0	0.0	185.0	0.0	76.0	0.0	6600.0	0.0	450.0	0.0	1696.0	0.0	769.0	0.0	1396.0	0.0	2730.0	0.0	1.0	0.0	0.0	0.0	3550.0	0.0	8.0	0.0	55.0	0.0	80.0	0.0	1100.0	0.0	
18	256.0	0.0	255.0	0.0	125.0	0.0	6600.0	0.0	458.0	0.0	1696.0	0.0	769.0	0.0	1396.0	0.0	2740.0	0.0	1.0	0.0	0.0	0.0	3550.0	0.0	8.0	0.0	55.0	0.0	70.0	0.0	1250.0	0.0	
19	271.0	0.0	275.0	0.0	144.0	0.0	6600.0	0.0	457.0	0.0	1676.0	0.0	769.0	0.0	1396.0	0.0	2740.0	0.0	1.0	0.0	0.0	0.0	3550.0	0.0	10.0	0.0	55.0	0.0	70.0	0.0	1250.0	0.0	
20	258.0	0.0	268.0	0.0	136.0	0.0	6600.0	0.0	455.0	0.0	1676.0	0.0	696.0	0.0	1396.0	0.0	2730.0	0.0	1.0	0.0	0.0	0.0	3550.0	0.0	10.0	0.0	55.0	0.0	70.0	0.0	1250.0	0.0	
21	247.0	0.0	273.0	0.0	136.0	0.0	6600.0	0.0	450.0	0.0	1676.0	0.0	696.0	0.0	1396.0	0.0	2740.0	0.0	1.0	0.0	0.0	0.0	3550.0	0.0	9.0	0.0	60.0	0.0	80.0	0.0	1250.0	0.0	
22	257.0	0.0	282.0	0.0	138.0	0.0	6600.0	0.0	445.0	0.0	1676.0	0.0	656.0	0.0	1125.0	0.0	2740.0	0.0	1.0	0.0	0.0	0.0	3550.0	0.0	9.0	0.0	60.0	0.0	70.0	0.0	1000.0	0.0	
23	263.0	0.0	275.0	0.0	138.0	0.0	6600.0	0.0	445.0	0.0	1676.0	0.0	656.0	0.0	618.0	0.0	2730.0	0.0	1.0	0.0	0.0	0.0	3550.0	0.0	9.0	0.0	60.0	0.0	80.0	0.0	700.0	0.0	
24	268.0	0.0	278.0	0.0	135.0	0.0	7600.0	0.0	445.0	0.0	1576.0	0.0	736.0	0.0	1125.0	0.0	2740.0	0.0	1.0	0.0	0.0	0.0	3550.0	0.0	14.0	0.0	60.0	0.0	80.0	0.0	1250.0	0.0	
T	5848.0	2699.0	5775.0	2710.9	2955.0	1407.4	174400.0	80213.8	10743.0	4625.2	39474.0	16855.8	17293.0	7272.8	29043.0	11528.0	60030.0	21925.1	176.0	66.7	0.0	111.9	84850.0	35980.2	418.0	290.9	2100.0	792.0	2250.0	954.0	20800.0	10072.5	

Monitoring

Snapshots of the Control Rooms :



Maintenance

The main directions to act :

- ✓ Planning repair : annually/ monthly /weekly and daily;
 - ✓ Continuing the implementation of predictive maintenance closely connected with TPM practices.
- There are no borders between the two concepts so the modern approaches of predictive investigation techniques will be carried out amid the implementation of the 5S – the base of the TPM philosophy.

That means:

- proper working condition for all assets;
- enhanced efficiency of the predictive activity;
- friendly working environment;
- increased responsibility and commitment of the operators and maintenance personnel, in equal measure ;
- increase of the quality and volume of the achieved production

The results are:

- ✓ Obtain Minimum 80% OEE (Overall Equipment Effectiveness)
- ✓ Rectify customer complaints;
- ✓ Reduce the manufacturing cost;
- ✓ Satisfy the customers needs by 100 % (Delivering the right quantity at the right time, in the required quality);
- ✓ Reduce accidents;
- ✓ Follow pollution control measures.



Continual Improvement Program

- ✓ **Develop awareness programs for enhancing organization intelligence level (Working together in synergy).**
- ✓ **Acquiring the necessary knowledge on Six Sigma and Lean Six Sigma practices at professional level on a large scale in company – already qualified 12 Lean Six Sigma Green Belts.**
- ✓ **Systematic application of specific techniques (TPM, Value Stream Mapping, Loss FMEA, 5S etc) to all relevant processes (production and administrative processes).**
- ✓ **Enforcing the suggestion system and systematically collecting improvement/ development suggestions from all company levels.**
- ✓ **Defining the performance improvement projects. Process variability reduction, lead times and cost reduction, better OTD, higher equipment reliability and better equipment utilization have to be considered as targets**
- ✓ **Deploying project to materialize the improvement opportunities.**
- ✓ **Evaluating the results of the projects through the Performance Monitoring System**

In each department the existing continuous improvement action plans are currently implemented and followed up.

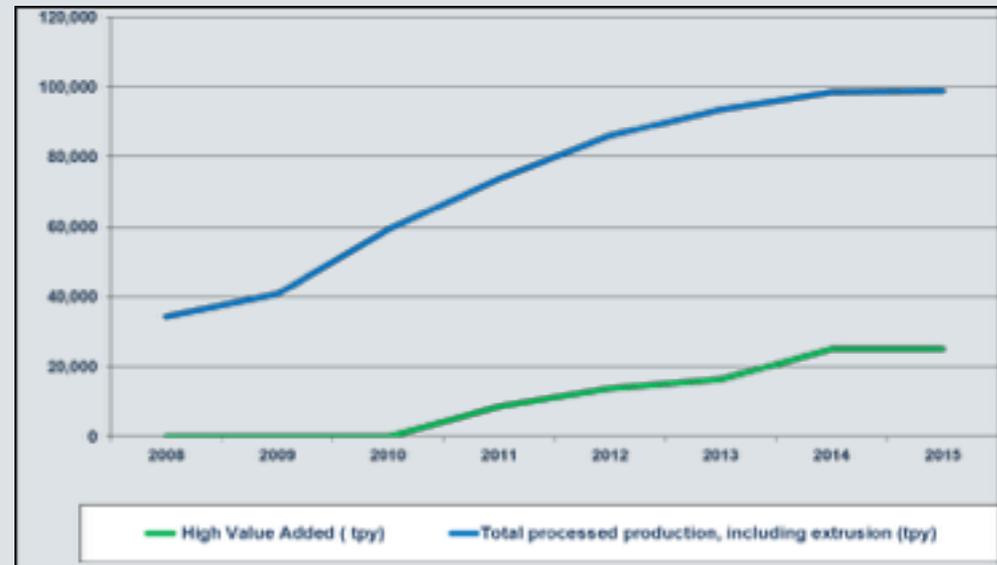
5. High Value Added Product – the another effective way

Due the markets constraints (electricity price increase year on year and LME quotation decrease) in the last years ALRO started to implement a new business strategy :

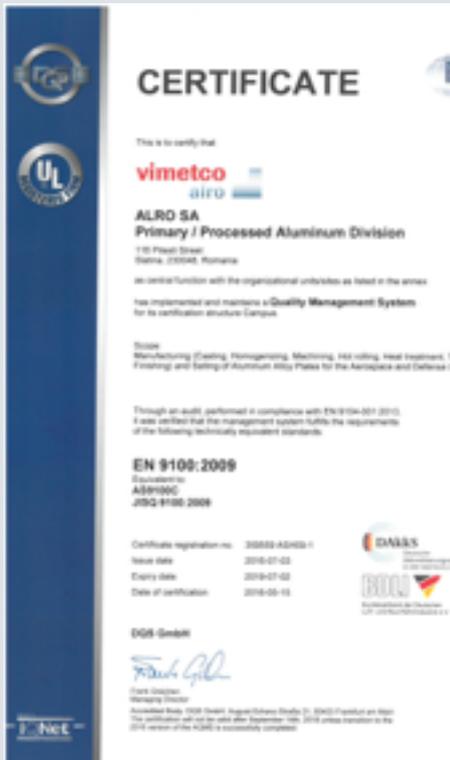
- decrease the quantity of primary products and develop Flat Rolled Products by:
 - increasing the quantity and diversification of flat rolled products;
 - increasing new products with the high value added, including trade mark registration, for example ALRO MultiBraz®;
 - certification in accordance with new market requirements, i.e. for automotive (heat exchangers) and airspace industry (Alro is supplier for airspace industry).
- increase usage of the aluminum scraps from the market;

Production of Processed Aluminum Division, including extrusions, increased:
-from 34,000 to approx. 100,000 tpy;
- High Value Added Products increased in the last year up to 25 % from total production.

HVAP means: aircraft plates; cladding coils & sheets, especially for heat exchangers in automotive industry, Long Life sheets & coils, 6xxx extrusions for automotive



Special processes, aerospace and automotive industries quality certifications



More than common system certifications of ISO 9001, ISO 14001 and OHSAS 18001, ALRO holds these high demanding certifications with specials areas: aircraft supplier EN 9100; automotive supplier ISO/TS 16949, construction products and pressure equipment.

6. Programs and directions to act for improve the energetic efficiency

ALRO is committed to implement measures and actions aiming a continuous improvement of the energetic efficiency.

In this respect, it was set up a system between the units of the Group (Primary Division, Processed Division, Vimetco Extrusion and ALUM Tulcea) which allow to release or take over the balances between the forecast and the actual power energy consumptions, for each unit, based on hourly rate.

Alro investments program, short term, to increase the energy efficiency includes mainly the following:

- Install of electromagnetic stirring device for furnaces in order to increase the efficiency of the re-melt aluminum;
- Industrial water recirculation station for the induction furnaces in Rodding Shop and Paste Plant;
- Choosing efficient burners for industrial installations depending on the intended use, for example:
 - ✓ Oxy-gas- for melting aluminum contaminated scraps;
 - ✓ Regenerative- for melt of aluminum clean scraps, but with a high rate of melting;
 - ✓ Recuperative-for melt of aluminum scrap with high content of magnesium.
- Equipment for slots cutting in the baked anodes;
- Changing the HRM (hot rolling mill) drive system with a superior performance one, in terms of specific consumption of electricity;
- New design of electrolysis pot;
- Replace the 12 NDS pump in the Water stations with pumps driven by variable frequency drive;
- Upgrade of the lighting system, through using LED lamps with much lower energy consumption.

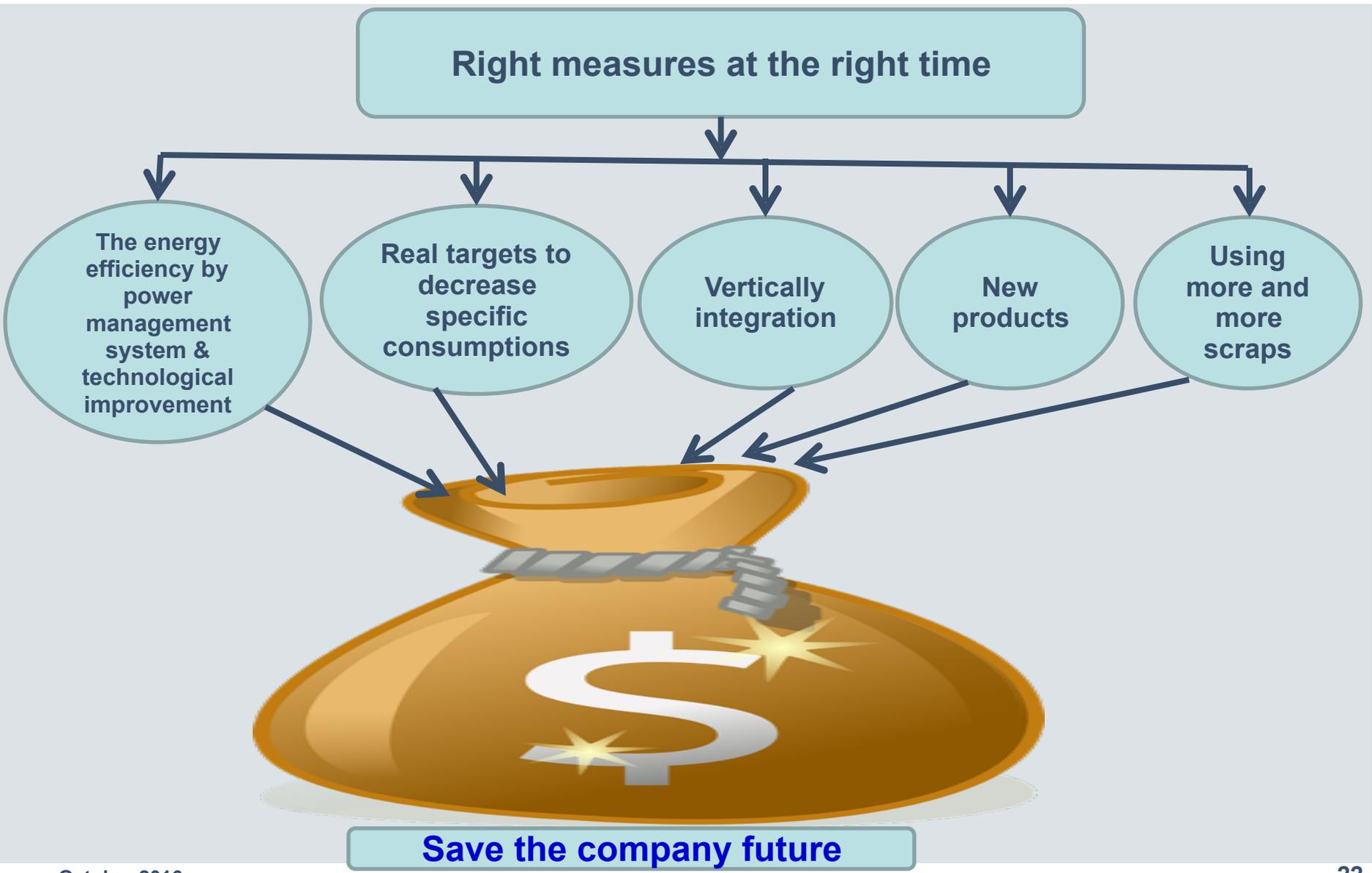
The combination of improving technology with dedicated burners in Alum resulted in lower natural gas consumption by 30% in the last 3 years!

7. Conclusions

1. Every year Alro found solutions to decrease the specific electricity consumption – in last 10 years 1,000 KWh/Mt lower in the Primary Aluminum Division and less 5 times in Processed Aluminum Division ;
2. The electricity consumption decrease has been achieved through investing in "state of art" equipment and continuous improvement of the production management:
 - Production plan;
 - Repair plan& predictive maintenance;
 - Maintained predictive;
 - Use of 5S, TPM, Value Stream Mapping philosophies;
 - Monitored activity online & energy consumption;
 - Use of energy dispatch to achieve the energy consumption forecast;
 - Certified ISO 50001; EN 9100; ISO/TS 16949... compelling at annual improvements in efficiency of all activities, not only at energy efficiency.
3. Vertical integration and orientation toward high value production are the main pillars to preserve the competitiveness of our plant in the present difficult legislative and market conditions;
4. Energy targets are set annually for each areas, each year –less than previous year.

All of these measures outlined above have resulted into a history of more than 50 years of existence of the company, a history full of unrivaled experience and know-how.

Instead of final



Thank you!