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# IMPLEMENTATION OF LOW CARBON TECHNOLOGIES IN THE MACEDONIAN AGRO INDUSTRY

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A b s t r a c t: Introducing new technology in the agro industry in Macedonia at this stage is of paramount importance for the SMEs in order to be competitive on the domestic and international markets. The importance is even greater when that technology is related to environment since that is an area in which the legislation is becoming stricter. The National Cleaner Production Centre – Macedonia is implementing a project that will help companies from the agro industry in Macedonia to adopt low carbon technologies according the UNIDO approach – dematerializing products, increasing process efficiencies, minimizing process emissions, switching to low carbon inputs and closing the carbon loop. This paper presents the challenges and results achieved in the process of implementation of the Low Carbon Technologies in a company from the agro industry in Macedonia. The selected company is a dairy with traditional production processes interested in lowering the environmental burden and improving its competitiveness.

**Key words:** low carbon technologies; cleaner production; sustainable development; agro industry

## ПРИМЕНА НА ТЕХНОЛОГИИ ЗА НАМАЛУВАЊЕ НА ЕМИСИИТЕ НА СТАКЛЕНИЧКИ ГАСОВИ ВО КОМПАНИИ ОД АГРОИНДУСТРИЈАТА ВО МАКЕДОНИЈА

А п с т р а к т: Воведувањето на нови технологии во агро индустријата во Македонија во оваа фаза е од огромно значење за малите и средни претпријатија со цел тие да бидат конкурентни на домашниот и меѓународните пазари. Важноста на новите технологии е уште поголема кога тие технологии се во функција на заштита на животната средина, бидејќи тоа е област во која националното законодавство постојано поставува повисоки критериуми за компаниите. Националниот центар за почисто производство – Македонија спроведува проект кој ќе им помогне на компаниите од агро индустријата во Македонија да ги применат технологиите за намалување на емисиите на стаклени гасови согласно пристапот на УНИДО – дематеријализација на производите, зголемување на ефикасноста на процесите, минимизирање на емисиите од процесите, преминување на влезни суровини кои не базираат на јаглерод и затворање на јаглеродниот круг. Овој труд ги прикажува предизвиците и резултатите постигнати во процесот на примена на технологии за намалување на емисиите на стаклени гасови во една компанија од агро индустријата во Македонија. Избраната компанија е од индустријата за преработка на млеко и млечни производи со традиционални производни процеси чие раководство покажува постојан интерес за намалување на загадувањата на животната средина и зголемување на конкурентноста.

**Клучни зборови:** стаклени гасови; чисто производство; одржлив развој; агроиндустрија

## INTRODUCTION

As a private established company which primary orientation is production and processing of milk and milk products and their distribution, over the past period it has noted a continuous progress on production line mainly of various types of cheese and yogurt, followed by production of pasteurized milk, liquid yogurt, curds and other milk products.

It is positioned as well-known company for milk products in Macedonia and has a good distribution network over all country mainly in leading supermarket stores. It's excellent cheese brands (white cow, mixed, sheep and goat cheese) and yogurt (cow and sheep yogurt) is easily recognized and accepted by customers, giving everybody with it concurrent prices a good choice for fresh and tasty milk product.

Formed in 1991 as a result of existing reforms and optimizations followed by splitting of existing agricultural complex, it is formed as a separate unit, concentrated on cattle growing and production of milk and milk products.

In it's today configuration, we can identify five business sectors:

1. Farming, with main interest production of cattle food. It satisfies 70% of needs for food of cow and goat farms. Main production is wheat, barley, alfalfa, vetch, fodder beet, corn silage and other products.
2. Cow farm with total daily production of milk of 4000–6000 liters.
3. Sheep farm, closed mid of 2015.
4. Dairy, with daily capacity of 20000 liters fresh milk.
5. Administration facility.

Total number of employees at dairy unit is 22 people, working in two shifts. Its main business is processing of milk and milk products and its distribution.

Production program at this moment consists of:

- Production of white cheese (cow, mixed, goat and sheep).
- Production of yellow cheese-kashkaval.
- Production of solid yogurt.
- Production of curds.

Situated in the south and the south-east part of Republic of Macedonia it experiences a Mediterranean climate with fairly little rain, strong winds, and sometimes small amounts of snow during the winter followed by low but acceptable temperatures during winter and high temperatures during summer. The quantity of rain and snow falls during the year is relatively small, around 600–750 mm of rain and 9 days of snow during the whole year. There are around 55 ice days during the year and the winds in the ravine are frequent. The sunny days capture most of the days in the years, around 2540 hours every year. The humidity in average is around 71%, it has lower value in July, and higher in January.

### *The mission*

The management team is proactive and has the vision to understand that implementing a strategic approach can bring return on investment in environment-related measures. Having in mind that the company is one of the bigger milk production companies in Macedonia and also obligated to maintain HACCP procedures, it is obliged to satisfy the high production and environmental standards. However the company is committed to improve its performances continuously and this is the reason why it is part of the Low Carbon Project.

## IMPLEMENTATION

Following practical steps of previous successful implemented projects, a couple of meetings were made as a startup point. Interactive presentation was made about UNIDO, cleaner production and low carbon technologies. Practical results of National Cleaner Product Center – Macedonia were presented through couple of case studies.

During this period top and middle management team of the company showed big interest and devotion for implementing these principles. Practical success of presented projects was starting point for top management to make final decision to accept implementation of low carbon principles in the company. For this purposes LC team was created consisting of 4 people from production, maintenance and management area of the company, and two CP experts from NCPC-Macedonia (Fig. 1).

| Ecological elements |  |  |  |  |
|---|---|---|---|---|
| Use of raw materials | * | | | |
| Energy use | * | | | |
| Water usage | * | | | |
| Fuel / oil usage | * | | | |
| Waste water management | | * | | |
| Pollution prevention | | * | | |
| Solid waste management | | * | | |
| Exhaust air / gases | | * | | |
| Smell | | | * | |
| Waste noise | | * | | |
| Local government | * | | | |
| Local municipality | | * | | |
| Intern relationships (employee-manager) | * | | | |
| Management motivation | | * | | |
| Employee motivation | | * | | |
| Workplace conditions | * | | | |
| Transportation (vehicles) and traffic | | | * | |

**Fig. 1**. Smiley diagram

### *Initial environment assessment*

Following the UNIDO accepted tools and methods like Smiley diagram and environmental questionnaires were prepared before site visit and initial environmental assessment was performed.

During initial assessment several site visits were performed with the main objective to discuss and been introduce with general environmental issues within the company as follows: waste generation and waste management of all types of waste, energy and water consumption, State Environmental Inspectorate's visits, national environmental legislation, etc. (Figure 2).

**Storm water**

Do you know where the storm water drains on your premises are located?

□Yes □**No** □N/A

Do you have any features or procedures in place to prevent storm water pollution?

□Yes □**No** □N/A

Are the storm water drains around your business free of pollution? (litter, sand, metal shavings etc.)

□**Yes** □No □N/A

Do you store all equipment, materials and liquids so that spills or leaks could not enter the storm water system?

□**Yes** □No □N/A

Do you regularly clean up the surface areas around your premises?

□**Yes** □No □N/A

Do you use a broom instead of a hose to sweep and clean up the surface areas around your premises?

□**Yes** □No □N/A

**Waste water**

Do you have a permit from the local water authority (if needed)?

□Yes □**No** □N/A

Do floor drains in the work area drain to either a storage tank or direct to the sewer?

□**Yes** □No □N/A

Do you use a vacuum cleaner (appropriate to the process) to clean up dust and sand?

□**Yes** □No □N/A

**Ground water**

Do you know if your site has groundwater under it?

□**Yes** □No □N/A

If there is groundwater under your site, do you take precautions to prevent pollutants from entering the groundwater?

□**Yes** □No □N/A

**Raw material**

Do you know the composition of your materials?

□**Yes** □No □N/A

If a supplier was willing to take your waste for reuse can you guarantee a regular supply?

□**Yes** □No □N/A

Do you have a licensed waste transporter to transport:

General production waste? **Yes** □No □N/A

Waste chemicals? Yes □**No** □N/A

Liquid wastes? Yes □**No** □N/A

**Air quality management**

Do you take measures to prevent dust from leaving your premises?

□**Yes** □No □N/A

Do you take measures to prevent fumes and vapour (including odorous emissions) from leaving your premises?

□**Yes** □No □N/A

**Hazardous materials**

Do you store all hazardous materials (such as resins, catalysts) in a bunded, covered area that will not allow any spilled or leaked materials to enter the storm water system?

□**Yes** □No □N/A

Do you have a Dangerous Goods Licence, if needed?

□Yes □**No** □N/A

Do you have all the relevant material safety data sheets (MSDS) and keep them in an accessible place?

□**Yes** □No □N/A

Do you have a spill fighting equipment and written procedures?

□Yes □**No** □N/A

**Noise management**

Do you regularly check and carry out maintenance on noisy equipment?

□**Yes** □No □N/A

If you have had complaints about noise, have you identified the source of the noise and taken steps to reduce its effects?

□**Yes** □No □N/A

**Management of premises**

Have you made any changes to your business for environmental reasons?

□**Yes** □No □N/A

Do you have an environmental policy or plan?

□Yes □**No** □N/A

**Fig. 2.** Environmental questionnaire

From filled Smiley diagram and questionaries' it is evident that the company has a mid-level of conscience for environmental impacts [1]. The employees are more or less good educated. The water quality management is not efficient and improvements should be made toward the treatment of the clean and the waste water. Energy consumption is issue too, since the heating of the facility is based on fossil fuels such as diesel fuel [2].

### *Low carbon assessment*

For proper evaluating and implementing low carbon principles valuable data was collected and sorted so proper measures and activities should be given [3]. Most important products, raw and process materials, waste emission, water, electricity and fuel usage (energy consumption data), process equipment data with power consumers list and boiler facility data was collected during low carbon assessment (Tables 1 and 2) [4].

Table 1

*Waste data summary 2012–2015*

| No | 2012 | Yearly qty | unit (m³, kg) |
|---|---|---|---|
| 1 | Plastic waste | 33.137 | kg |
| 2 | Paper and hard paper (carton) waste | 4.810 | kg |
| 3 | Metal waste | 0.331 | kg |
| 4 | Cow manure | 5 245 000.00 | kg |
| No | 2013 | Yearly qty | unit (m³, kg) |
| 1 | Plastic waste | 29.319 | kg |
| 2 | Paper and hard paper (carton) waste | 8.900 | kg |
| 3 | Metal waste | 0.065 | kg |
| 4* | Cow manure | – | kg |
| No | 2014 | Yearly qty | unit (m³, kg) |
| 1 | Plastic waste | 15.360 | kg |
| 2 | Paper and hard paper (carton) waste | 2.460 | kg |
| 3 | Metal waste | 0.211 | kg |
| 4 | Cow manure | – | kg |
| No | 2014 | Monthly qty | unit (m³, kg) |
| 1 | Cow manure | 500 000.00 | kg |

Table 2

*Energy data summary 2012–2015*

| Energy supply | 2012 | 2013 | 2014 |
|---|---|---|---|
| Electricity | | | |
| (A) kWh | | 214716.00 | 156639.00 |
| (C) € | 16512.79 | 9018.07 | 6578.84 |
| Fuel | | | |
| Litres | 99861.00 | 101325.00 | 96325.00 |
| (B) kWh | 1 167 375.00 | 1 184 489.00 | 1 126 039.00 |
| (D) € | 80 887.00 | 75 993.00 | 75 133.00 |
| | | | |
| kWh (A) + (B) = | 1 570 126.00 | 1 399 205.00 | 1 282 678.00 |
| € (C) + (D) = | 97 399.79 | 85 011.07 | 8 1711.84 |

All data was sorted and listed for past 3–4 years depending of it availability for mentioned period. Mainly, data was collected for period 2012–2014 (Figure 3).

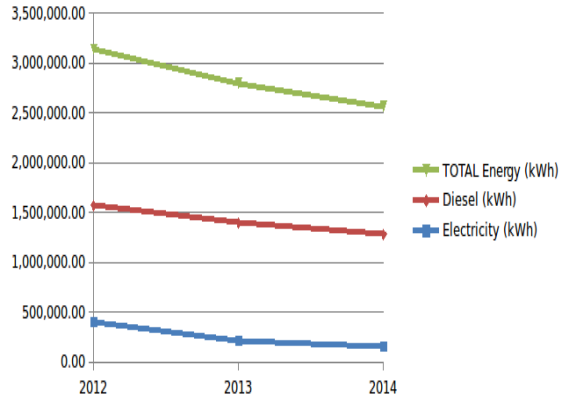


**Fig. 3.** Total energy demand for electricity and fuel 2012–2014

Based on collected data E-sankey diagram was prepared showing the total energy demands (Figure 4).

The LC team also checked for processes optimization but no options were identified since all production processes are according the best available techniques.

For each production process at the company a flow diagram was created showing the flow of materials, the inputs and outputs in each step, as well as the temperatures of the inputs and outputs of each step [4]. This is necessary in order to get a better understanding of the heat and cold demand of all production processes (Figure 5).

The next step after creating the flow diagrams is to translate these information into a single stream list showing the process name, the start and end temperature, the category of the process (hot or cold), the mass flow, the Cp value and the total power quantity (Figure 6) [5].

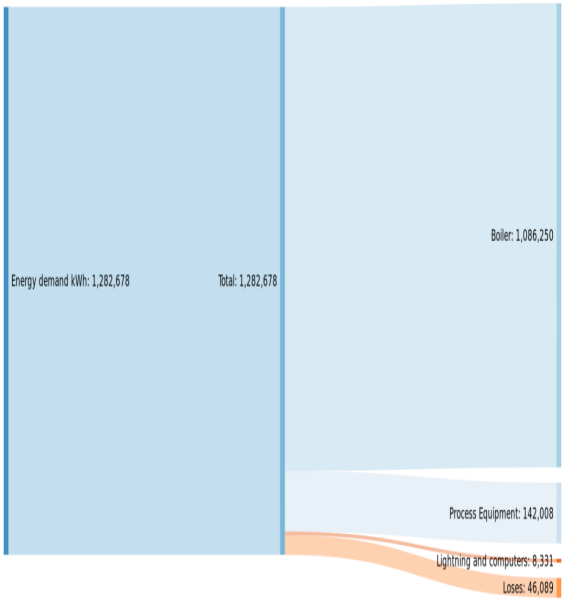


**Fig. 4.** Sankey diagram of the total energy demand for 2014

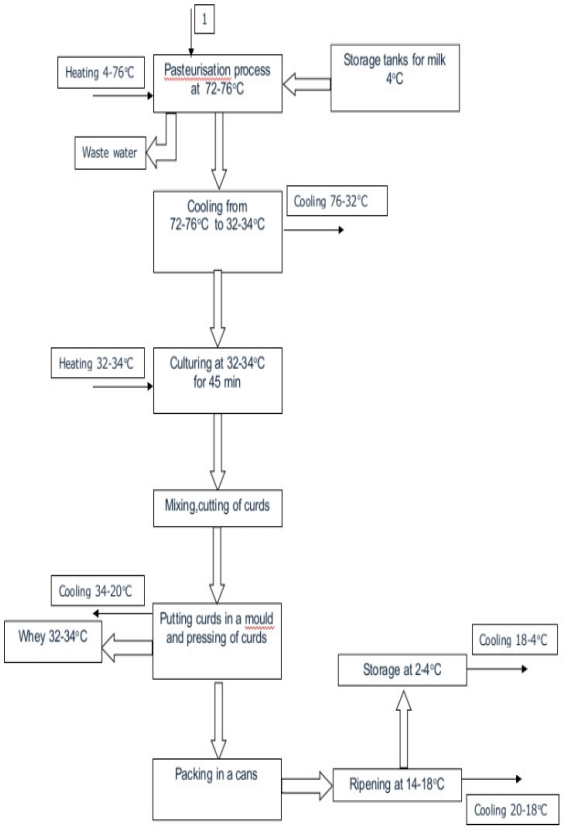


**Fig. 5.** Flow diagram of process in dairy

| **WHITE CHEESE** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| No. | Process name | Start temp. ($^{O}$C) | End temp. ($^{O}$C) | Hot/Cold | Mass flow (ṁ) | Cp | P (kW) | Total power Q (kWh) |
| 1 | Pasteurisation | 4 | 76 | cold | 1.4 | 3.93 | 393 | 261387,444 |
| 2 | Cooling | 76 | 32 | hot | 0.6 | 3.27 | -79,93333333 | -53164,29947 |
| 3 | Culturing | 32 | 34 | cold | 0.6 | 3.27 | 3,633333333 | 2416,559067 |
| 4 | Cooling | 34 | 20 | hot | 0.6 | 3.27 | -25,43333333 | -16915,91347 |
| 5 | Ripening | 20 | 18 | hot | 1.4 | 3.27 | -9,083333333 | -6041,397667 |
| 6 | Final cooling | 18 | 4 | hot | 0.6 | 3.27 | -25,43333333 | -16915,91347 |

**Fig. 6.** Stream list of process in dairy

## BENEFITS

The LC team has identified 5 measures which result in lowering the costs for diesel fuel, electricity and lowering the company's $CO_2$ emissions:

– The **first measure** is implementation of monitoring system for exhaust gases from boilers in order to manage future optimization of generation of steam and better using of waste heat generated from exhaust gases [8]. Although boiler manufacturing date is relatively new, there is no evidence that there is optimized production of steam and good working parameters of boiler.

– The **second measure** is use monthly waste produced from milk cattle (cow manure) for production of bio-gas (Table 3). It is highly suggest due to satisfactory level of generated cow manure and good alternative fuel for steam boilers [7] [9]. Implementation of suggested alternative fuel will result in lowering carbon emission and valuable savings per year.

Table 3

*Biogas calculation*

| | |
|---|---|
| Manure / month in tons | 50 |
| Produced bio gas / month in $m^3$ | 12 500 |
| Daily energy value of used fuel in MJ | 12 250 |
| Daily need values of bio gas in $m^3$ | 556 |
| Total available bio gas in days | 22 |
| Daily consumption of diesel in lit. | 350 |
| Costs for diesel / day in € | 276,5 |
| Fuel savings in €/year | 99 540 |
| Expenses 4% from initial value / year | 30 000 |
| Initial savings in € | 60 540 |
| Incomes from selling fertilizers (min. value) €/year | 76 800 |
| Other expenses 15% of total savings interests rates bills, etc.) | 29 951 |
| Total savings in € | 124389 |

*Note: Energetic values: Diesel 35 MJ/lit, bio gas: 22 MJ/$m^3$

A. Monthly cow manure collected at facility:
500000 kg (500 tons).

B. Boiler daily consumption of diesel fuel:
350tons

C. Monthly consumption of diesel fuel:
350 × 30 = 10500 lit.

D. 1 kg of cow manure = 25 – 30 lit bio-gas
Total produced bio-gas per month:
500000×25 = 12500000 lit biogas
=12500 $m^3$/month.

E. Consumption calculus:

- Energetic value of diesel and bio gas: diesel = 35 MJ/lit; bio-gas = 22 MJ/$m^3$.
- Daily energy value of used fuel: 350×35=12250 MJ/day
- Monthly energy value of diesel fuel: 10500×35 = 367500 MJ/month.
- Daily needed values of bio-gas: 12250 MJ/day: 22 MJ/$m^3$ = 556 $m^3$/day.
- Total available bio-gas for running: 12500 $m^3$/month: 556 $m^3$/day = 22 days continuous work of boiler on bio-gas

  Note: Production of bio gas is only calculated from fresh cow manure. Sludge from waste water management facility and other bio-waste is not taken in this calculation.

F. Costs/savings calculus for replacing diesel fuel with bio-gas:

- Value of diesel fuel at this moment (09.2015): 1 lit = 0.79 €
  350×0.79 = 276.50 €/day for diesel fuel purchase.
  **Fuel savings:** 276.50×360 days = 99540 € savings/year (other costs not included).
- Maintenance, staff, electricity costs/year for bio-gas plant: 4% of starting investment.
  Initial value of bio-gas facility: 750000 €
  750000×4% = 30000 €.
  **Total savings:** 99540 – 30000 = 69540 €/year.

G. Incomes from liquid and solid fertilizer:

- Total created fertilizer per month from 500000 kg fresh cow manure:
  - Solid fertilizer or fiber fraction (80 kg/ton) = 40000 kg/month.
- Price for fertilizers:
  Liquid = 1.4 €/lit, Solid = 0.32 €/kg.
- Total income per month for selling fertilezers:
  - Solid: 0,16 €×40000 kg = 6400 € (min) or 0.32×40000 kg = 12800 € (max).
- Total income from fertilizers for one year (with minimum values):
  - Solid: 6400 €×12 months = 76800 €/year.

H. Investment payback time:

- Incomes: 69540+76800=146340 € / year
- Other costs (interest rates, water bills, etc) 15 % of total income: 21951 €/ year
- **Total income:**
  **146340 – 21951= 124389 €/year**
  **Payback period:**
  **750000 / 124389 = 6,02 years**

I. $CO_2$ savings:

- Diesel fuel $CO_2$ content per litre: 2,68 kg/lit.

- Bio-gas $CO_2$ reduction content per $m^3$: 1,62 kg/$m^3$.
- Generated $CO_2$ from diesel fuel per month: 10500 lit = 28140 kg/month $CO_2$.
- Generated $CO_2$ from diesel fuel per year: 12 × 28140 = 337680 kg/year $CO_2$
- **Reduced $CO_2$ from bio-gas per year: 12500 × 12×1.6 = 240000 kg/year $CO_2$.**

- The **third measure** is implementation of heating collectors on roof top for generating hot sanitary water that will save around 2% of yearly energy consumption in production facility. Existing boilers (3×3 kW) can be replaced with one simple rooftop vacuum (36 vacuum tubes, around 7.5 $m^2$) 4.5 kW heating collector and it will be used for sanitary water for offices. Installing of this system will cost around 600 € providing 300 liters per day of hot water during whole year, due to relative higher ambient temperatures and mild climate.
- The **fourth measure** is integration of heat recovery system for cooling units. This solution will manage to use excess of heat generated during running period of cooling units. It will result in cheap preparing of hot water and savings for fuel for steam boilers. Used equipment is older type so there is lack of data for other calculations. Further deeper analysis is needed in order to give proper calculations and suggested heat recovery system for using waste heat from cooling units
- The **fifth measure** is possible use of PV System in main grid that will give company 162583 €/year savings for electricity and also lowered carbon emissions in the air.

All of these alternatives give company valuable financial and energy savings per year. This provides company with competitive advantage on the domestic and international markets [10].

## CONCLUSION

The conducted research shows that the regular miner's helmet is simply not enough for maximum protection of the user. Aa result of that the miner is forced to use additional equipment such as light, radio transmitter, batteries, air filter, protective mask for eyes and other body parts that only make the operation more difficult.

The RECP project was mainly focused on minimizing the consumption of water, fuel (diesel), raw materials, and waste production, with the aim of determining RECP options. The main focus of RECP options is related to reduction of fuel consumption and monitoring process of exhaust flue gases from boiler (Table 3) [6]. The effect of the options, if implemented, are presented in Table 5.

Table 4

*Benefits from options.*

| Absolute indicator | Change (%) Year 1 | Relative indicator | Change (%) Year 1 |
|---|---|---|---|
| Resource use | | Resource productivity | |
| Energy use | –75 | Energy productivity | 334 |
| Materials use | 0 | Materials productivity | 10 |
| Water use | –10 | Water productivity | 23 |
| Pollution generated | | Pollution intensity | |
| Air emissions (global warming, $CO_2$ equivalent) | –29 | Carbon intensity | –35 |
| Waste water | –26 | Waste water intensity | –33 |
| Waste | –100 | Waste intensity | –100 |
| Production output | 10 | | |

Table 5

*Success areas from the assessment.*

| Principal Options Implemented | Benefits | | | |
|---|---|---|---|---|
| | Economic | | Resource Use | Pollution generated |
| | Investment (€) | Cost Saving (€/year) | Reductions in energy use, water use and/or materials use (per annum) | Reductions in waste water, air emissions and/or waste generation (per annum) |
| Use monthly waste produced from milk cattle (cow manure) for production of bio-gas and fuel supply for steam boilers | 750,000.00 | 124,389.00 | Reduction of fuel (diesel) consumption) by 85% | 240,000 kg/year $CO_2$ |
| Implementation of vacuum tube heating collectors on roof top for generating hot water | 600,00 | 1,200.00 | Reduction in electricity for providing hot water for sanitary usage by 5–10% | |
| Installing of PV | 2,240,648.00 | 162,583.00 | | 133,892.50 kg/year $CO_2$ |

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