SAP-Based Solution for Planning of the End-to-End Production and Supply Chain of a Mining and Metallurgical Holding
1. METINVEST Group

2. Supply planning powered by SAP

3. Planning mechanisms provided by SAP: limitations and course of development

4. End-to-end "coal-coke-cast iron" planning model powered by SAP

5. Course of development for the Company's integrated planning system
METINVEST Group, a vertically integrated group of steel and mining companies

### PRODUCTION ASSETS OF METINVEST

<table>
<thead>
<tr>
<th>Ukrainian assets of Metinvest (below)</th>
<th>Global assets of Metinvest (above)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azovstal</td>
<td>EMZ</td>
</tr>
<tr>
<td>Ilyich Iron and Steel Works of Mariupol</td>
<td>Marius (United Kingdom)</td>
</tr>
<tr>
<td>DMZ</td>
<td>Ferriera (Italy)</td>
</tr>
<tr>
<td>DKHZ</td>
<td>Valsider (Italy)</td>
</tr>
<tr>
<td>ZKHZ</td>
<td>Metinvest</td>
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<tr>
<td>SevGOK</td>
<td>Trametal</td>
</tr>
<tr>
<td>CGOK</td>
<td>Spartan (United Kingdom)</td>
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<tr>
<td>InGOK</td>
<td>Promet Steel (Bulgaria)</td>
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<tr>
<td>HTZ</td>
<td>United Coat (USA)</td>
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<tr>
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<td>USOK</td>
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<tr>
<td>Zaporozhstal</td>
<td></td>
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<tr>
<td>UGOK</td>
<td></td>
</tr>
</tbody>
</table>

### PRODUCTION ASSETS OF METINVEST

**Legend**
- Assets
- Joint Ventures
- Independent Enterprises
- Logistic routes

- **COKING COAL**
  - 3,051 million tons

- **IRON ORE CONCENTRATE**
  - 29,640 million tons

- **CAST IRON**
  - 8,821 million tons

- **STEEL**
  - 8,393 million tons

- **SEMI-FINISHED PRODUCTS**
  - 2,229 million tons

- **FLAT PRODUCTS**
  - 4,385 million tons

- **LONG PRODUCTS**
  - 1,991 million tons

- **PIPES**
  - 109 thousand tons

*These data refer to 2016.*
Operational Planning Business Model at METINVEST

Incoming Information
- Sales forecast
- Contracted volumes
- Orders from the distribution network
- Logistic costs
- Logistic limitations
- Materials
- Commercial priorities and limitations
- Available workforce fund of the primary equipment
- Specifications and technological flow charts
- Production versions

Strategic Planning
- Strategic Goals and Objectives

Long-term Planning (LTP)

Sales & Operations Planning (S&OP)

Short-term Operational Planning (OFP)

Calendaring (MS)

Management Company

Enterprises

Processes provided by SAP

Directions for further development

Planning results

Operational plan:
- Sales plan
- Transportation plan
- Procurement plan
- Production plan

Company Enterprises

Strategic Goals and Objectives

Processes provided by SAP

Direction for further development

Operational plan:
- Sales plan
- Transportation plan
- Procurement plan
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Company Enterprises
Architecture of the Solution for Implementing Planning Processes in SAP

SAP MDG
- Materials

SAP ERP
- Specifications and technological flow charts
- Workplaces
- Materials
- Schedule of repairs
- Forecasted commodity prices

SAP APO/DP
- Forecasted sales for product groups
- Price forecast based on the terms of sale

SAP APO/SNP
- Supply chain planning

SAP BW
- Sales plan
- Production plan
- Transportation plan
- Demand for primary raw materials

SAP ERP
- Planned Order Form
- Planned orders
- Purchase requests
- Quoting table
Supply Chain Planning Model at METINVEST

Scope of the supply chain planning model at METINVEST:

• 12 manufacturing enterprises
• > 700 locations of demand
• > 3,000 transportation relations

Fragment of the logistical model of the intragroup cooperation at METINVEST

Structure of the supply chain planning model at METINVEST:

• Logistic model
• Production planning models

Fragment of the logistic model of commodity delivery from metallurgical enterprises to the locations of demand
Logistic model in SAP APO SNP

**Logistic model:**

**Graph vertices:**
- locations of demand
- suppliers
- load transfer point
- manufacturers

**Graph edges:**
- transportation relations
Production planning models powered by SAP ERP

The capacity of the production vertices on the graph is determined by production planning models.

Production model:

- workplaces
  - production machines

- Materials Master Record
  - manufactured products

- master data
  - specifications
  - technological flow charts
  - production versions
Implementation of SOP on the Basis of SAP

Planning of production

Planning of logistic flows of commodity output

Planning of supply chain at METINVEST:

1. Planning and optimization of utilization of capacities of metallurgical complexes
   - Logistics cost planning
   - Planning and optimization of logistic flows of commodity output

2. Planning and optimization of GOK capacity utilization
   - Planning and optimization of requirements for primary raw materials and materials

3. Planning and optimization of utilization of capacities of KHP
   - Planning and optimization of requirements of KHP for METINVEST in relation to coal raw materials

Evolution of the SOP project

2014
2015
2016
Planning Mechanisms in SAP APO SNP

Production planning mechanism in SAP SNP

Determination (selection) of the most expedient (optimal) version of the manufacturer from the many versions loaded into the system

Applicability

- concentrating and burning capacities of GOKs
- steelmaking capacities of metallurgical enterprises
- rolling capacities of metallurgical enterprises
- coke and chemical plants
- agglomeration and blast-furnace processing at metallurgical enterprises
User Limitations

SAP MDG
- Materials

SAP ERP
- Specifications and technological flow charts
- Workplaces
- Materials
- Schedule of repairs
- Forecasted commodity prices

SAP APO/SNP
- Pre-configured logistics model powered by SAP

SAP APO/DP
- Logistic component
- Logistic limitations
- Forecasted sales for product groups
- Price forecast based on the terms of sale

SAP BW
- Sales plan
- Production plan
- Transportation plan
- Demand for primary raw materials

SAP ERP
- Planned orders
- Purchase requests
Architecture of the Solution for the End-to-End Planning of the "Coal-Coke-Cast Iron" Technological Chain

The end-to-end planning model consists of three modules:

1. **KHL**
   - **Mix material production**
   - **Production of coke**
   - **Coke sorting**

2. **DC**
   - **Sinter production**
   - **Liquid cast iron production**
   - **Cast iron pouring**

**Model of interrelations between qualitative indicators**

\[
\begin{align*}
\text{Coal}^{\text{mix}} &= \text{Coal}^{\text{mix}} - \sum \left( \frac{\text{mix}}{100} \right) \text{K} \text{K}_{\text{mix}} \\
\text{Coke}^{\text{mix}} &= \text{Coke}^{\text{mix}} + \sum \left( \frac{\text{mix}}{100} \right) \text{K} \text{K}_{\text{mix}} \\
\text{Iron}^{\text{mix}} &= \text{Iron}^{\text{mix}} - \sum \left( \frac{\text{mix}}{100} \right) \text{K} \text{K}_{\text{mix}}
\end{align*}
\]

- **Productivity of DP**
- **Coke consumption**
Results of Testing the Prototype of the Solution for the End-to-End Planning of the "Coal-Coke-Cast Iron" Technological Chain

Solution scope

- 4 coke and chemical plants
- 3 metallurgical enterprises
- > 60 suppliers of coal and coke

Results of testing

- Cost of coal mix material: +0.2%
- Specific coke consumption: -2.6%
- Production volume of cast iron: +1.5%

Structure of the economic effect, $

<table>
<thead>
<tr>
<th></th>
<th>Coke consumption</th>
<th>Coal mix material</th>
<th>Production volume of cast iron</th>
<th>Economic effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+1 239 611,3</td>
<td>-276 105,7</td>
<td>+ 556 640,4</td>
<td>1520 145,9</td>
</tr>
</tbody>
</table>
Computational performance

Direct calculation process

Basic SOP solution (without the Interrelations model)

Data uploading – **1.5 minutes**
Calculations – **15 seconds**

Two-stage calculation process

Integrated Solution (Database + Interrelations model)

Model loading **15 minutes**

SAP APO SNP

Calculations > 72 hours

SAP APO SNP

Calculation ~ **2 hours**
Directions for the Further Development of the Integrated Supply Chain Planning System at METINVEST

**SALES**
- Sales forecast
- Contracted volumes
- Orders from the distribution network

**LOGISTICS**
- Logistic costs
- Logistic limitations
- Materials
- Commercial priorities and limitations

**PROCUREMENT**
- Available worktime fund of the primary equipment
- Specifications and technological flow charts
- Production versions

**PRODUCTION**
- Available worktime fund of the primary equipment
- Specifications and technological flow charts
- Production versions

**SAP IBP**
- Long-term Planning (LTP)
- Sales & Operations Planning (S&OP)
- Short-term Operational Planning (OFP)
- Calendaring (MS)

**BUDGETING**
- Long-term Planning (LTP)
- Sales & Operations Planning (S&OP)
- Short-term Operational Planning (OFP)
- Calendaring (MS)

**Planning results**
- Operational plan:
  - Sales plan
  - Transportation plan
  - Procurement plan
  - Production plan

**APO PP/DS & APS**
- Management Company
- Enterprises
Thank you.