COMPANY PROFILE

Background & Capabilities

Magnesium Capabilities

 novopro
Project Development & Management

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NOVOPRO is a project-based company specializing in developing, engineering, and managing projects and related technologies as applied to the metallurgical, mining, mineral processing, and chemical industries. NOVOPRO provides complete support and services needed to design and build projects fitting within well-defined quality-budget-schedule constraints. NOVOPRO has assisted international and North American clients to develop their projects from inception through feasibility and into financing, implementation, and start-up.

**Mission Statement**

Early phase project development has been identified by NOVOPRO as an area where a gap is existing in capabilities offered in the consulting space, and therefore our goal has been to fill this gap with as much pertinent expertise in this area as possible. NOVOPRO has been involved in assisting clients develop a number of projects from inception and feasibility, to financing, implementation, and start-up. Our experience has been gained through the development of projects up to $3 billion.

A list of relevant expertise is listed below:

- Conceptual Design
- Feasibility Studies
- Project Engineering
- Program Development
- Due diligence reviews
- Project Financing assistance
- Capital and Operating Cost Estimation
- Preparation of Cash Flow Projections and Financial Models
- Project Risk Reviews, Mitigation and Monte Carlo simulations
- Preparation of 43-101 compliant reports
- Operational inspections and support

In many cases, during project development, many of the activities listed above take place in an integrated client-consultant team.
Project Engineering

NOVOPRO provides engineering services, where applicable, to develop and implement various phases of potash projects, from preliminary studies to detailed engineering and EPCM.

The participation of the NOVOPRO team in numerous projects, both in international and domestic markets, has provided the company with a unique and focused project philosophy, enabling the examination and evaluation of new technological applications, translating into more efficient processing alternatives.

The available multidisciplinary capabilities tailored to projects provide clients with highly applicable services to fulfil all managerial and technical needs of the project. These include the following areas:

- Process design, PFD’s, P&IDs, modeling, and simulation capabilities (METSIM and PHREEQc)
- In-house testing capabilities
- Knowledge of potash specific process providers and vendor information
- Mechanical design, including 3D modeling and detailed design
- Piping design
- Plant layouts, including rendered 3D plant models
- Electrical and controls engineering
- Civil and structural design
- Environmental engineering, including ESIA and mitigation measures.

Project Management

Project management is considered a core competence at NOVOPRO, considering its impact on project implementation efficiency and the potential to determine the outcome in terms of successful implementation. The lessons learned over the years have provided the managers at NOVOPRO with expertise to use sound methodology and diligence when making recommendations for decisions to be made by the client. Providing the correct information in a timely manner is essential for a sound decision to be made, and proper project management ensures this, and therefore drives all other disciplines to produce the tools necessary for the project to run safely, within the agreed schedule and budget.
Considering project management as the key ingredient in developing and implementing projects, NOVOPRO has emphasized this aspect of its capabilities by ensuring that managers and key personnel all have the skills and tools required to enable services to be provided efficiently. By developing, managing, and implementing projects NOVOPRO understands the needs of projects and adapts its services and approach to suit the size of the projects, as well as the expectations of the client.

**Client/Owner’s Representative**

Acting on behalf of the client/owner’s is a part of the services offered by NOVOPRO which would assist the client’s team in dealing with large increases in workloads that inevitably result during project development and implementation stages. In fulfilling this role, NOVOPRO understands the reporting requirements for a sound decision-making process at various stages of the project.

**Integrated Team Approach**

NOVOPRO works closely with the client and other consultants as one close-knit team, the client’s interests always being regarded as our primary objective. This has been achieved through participation in the owner’s team as a technical and commercial specialist in the field of potash. Having worked closely with and as consultants, we are well aware of all operational aspects of projects such as project control, cash flow forecasting, scheduling, manpower projection, managerial procedures, and other requirements that drive a project as it unfolds. This grants us the required skills when interfacing with clients and assisting them in the decision-making processes.
Project Planning and Control

As part of the project management requirement, project planning tools are well understood and utilized to produce detailed project schedules and manpower forecasts, enabling the planning of resources and budget.

Project cost reporting and control is essential to successful project implementation by tracking past expenditures and forecasting future capital needs to ensure budget and cash flow availability meets requirements of the project and the client.

NOVOPRO can offer complete commercial services, including invoice verification and approval, and the reviewing of technical and commercial contract documents. Weekly and/or monthly financial reports are prepared to provide details concerning commercial project activities taking place and provide the reader with details of activities anticipated in the future.

Procurement and Contract Administration

To support engineering and construction management, NOVOPRO provides procurement and contract administration services to enable complete EPCM services to the clients on a variety of project sizes. This includes the preparation of contracts and RFQ’s, technical and commercial evaluations, bids, contract award, administration, as well as expediting.

Other relevant services are inspection, logistical support, progress monitoring and tracking, vendor and contractor evaluations, quality control, and management.
Magnesium Experience

The nature of the magnesium industry requires that new processes be developed and that existing technologies be adapted, based on local raw materials and conditions. A good knowledge of the major players with regards to available technologies and related equipment is also essential.

Through years of experience, the engineers at NOVOPRO have acquired the knowledge and expertise necessary to carry out effectively magnesium metal related projects in all of their phases.

Experience has provided us with detailed design capabilities for specialized equipment, such as chlorination units, fluid bed dryers, casting furnaces, molten metal pumps, and high current bus bars. This expertise is usually not available within engineering firms and frequently has to be acquired through specialized consultants or vendors.

NOVOPRO’s team has identified the majority of relevant equipment suppliers in the magnesium sector and is well aware of their performances. This is essential in all stages of a project with regards to qualification of contractors and vendors.

*Norsk Hydro’s magnesium plant in Bécancour, Québec, Canada*
Furthermore, given its involvement in development activities that have led to licensing of technology, NOVOPRO understands and appreciates not only the technical requirements, but also the business aspects of technology development and transfer. Such activities are key in almost all phases of any magnesium project.

NOVOPRO’S technical capabilities include:

- Raw materials test work;
- Raw materials purification and impurities bleed mechanisms;
- Technology transfer package preparation and negotiations;
- Development of cost models for capital and operating expenditures;
- Bench marking of cost models as compared to other existing projects;
- Process design including mass and energy balance model;
- Design of specialized process equipment;
- Specialized know-how with regards to refractory selection;
- High amperage bus-bar design;
- Magnesium transformation and recycling know-how;
- Cell house and foundry overall design and layout;
- Safety requirements in cell-house and foundry as well as HAZOP;
- Dross treatment plant design;
- Chlorine treatment and transformation into value added products.
Magnesium Primary Metal Production

Magnesium metal primary production requires a highly complex extraction process, demanding intimate knowledge of the various forms of magnesium compounds, as well as the behaviour of the metal and its alloying elements. NOVOPRO can claim to be one of the leading technological and engineering-based companies in this challenging field, encapsulating all aspects of the process, from raw materials preparation to dehydration, electrolysis/reduction and refining-casting.

10,000 TPY recycling plant built in less than one year in The Netherlands

Magnesium Chloride Purification for Metal Processes

NOVOPRO has been actively involved in the development of several magnesium metal operations. Each of these process developments required the preparation and purification of MgCl₂ solutions for feeding into the crystallization, dehydration, and electrolysis sections of the plant. Systems including leaching of Mg (OH)₂ and MgCO₃ in HCl; iron, nickel and manganese removal; boron removal; sulphate removal as well as MgCl₂.6H₂O and carnallite crystallization have been developed and designed.
Evaporation Pond Development

NOVOPRO has considerable experience with the investigation and design of solar evaporation ponds related to the Potash industry in regions such as North America, Africa and Asia, utilizing a range of ore recovery methods including solution mining, recovery wells and playa extraction canals for both carnallitic and sulfate brines.

NOVOPRO has a methodical approach to pond design, which commences with compiling all available environmental and weather data, and reviewing the projected brine composition to be delivered to the evaporation Pond system. Based on these inputs, an initial pond model is developed using PHREEQC and METSIM modeling software, with subsequent iterations made to the initial pond model in order to optimize the pond design.

The optimization is performed by introducing recycle streams from the processing plant itself, and or the pond end brine, in order to adjust the pond chemistry to precipitate out undesirable components in the pre-concentration ponds, and more favorable minerals in the harvesting ponds. The configuration of the ponds is also investigated/optimized by analyzing the impact of the end brine composition of each pond verses the pond area required, resulting in a design featuring the minimum pond area required for the project.

Pond Modelling

NOVOPRO’s method of process development weighs heavily on designs that have been validated by past Testwork programs, both bench top and in the field. The in-house experts are supported by NOVOPRO’s data base of the key operating parameters of solar based evaporation ponds worldwide, and integrated/iterative modelling capabilities.

It is NOVOPRO’s modelling capacity that allows for mineral reactions to be extrapolated based on Testwork validated thermodynamic coefficients integrated into the process model, which is used to iterate and balance internal recycle streams within the process, and identify sensitivities as well as weak points within the design. Such analysis allows for a continuous feedback loop between modelling and Testwork until the true picture is resolved.
In addition, the process modelling capacity allows for an adaptable process design, which can input new data as it is modified. This modelling allows for the development of transient start-up scenarios, ramp-up, and steady-state operations, providing process data outputs through the various scenarios, allowing for value engineering and cost-benefit decisions to be made.

The integrated model as described consists above all of three main components:

- **METSIM** – Steady State & Transient Process Modeling Software
- **PHREEQc** – Thermodynamic Data Base Software
- **Pond Model** – Pond Chemistry, Evaporation Rate and Area Determination

The METSIM models developed by NOVOPRO are built from a wealth of data from industry experts, testwork and piloting of both processes and evaporation ponds. The reliability and accuracy of the results produced from the METSIM models is supported by the fact that the chemistry has been compared and validated with pilot plant data and operational data from full-scale operations.

Subsequent to the modelling, NOVOPRO will recommend only the testwork necessary to de-risk and validate the model with respect to the unique properties of each deposit.

The pond modelling methods stem from the methods of international industry expert David Butts, with +40 years of pond design and operations experience. NOVOPRO has tested and validated the pond models with several pilot ponds across the globe and with full-scale operations. The pond model is a key tool in developing a cost-effective pond design and understanding the cost and operational impact in pond design trade-off studies.
Pond Design

For the design of the solar evaporation ponds, measured or documented evaporation rates, brine chemistry, and solids mineralogy are combined to determine the necessary pond area to produce the desired output of product. The Ponds process design development is completed in conjunction with the process Testwork programs, modelling data, and results from Class A pans installed at or in proximity to the site. Novopro will also work with any Third-Party Contractors engaged by the Client to optimize the Pond Design.

The following are the main design considerations for the pond design;

- Optimization of Pond Cut-Off Concentrations
- Pond Area Contingency
- Shutdown Area for harvesting
- Rainfall events
- Deposition Rate
- Species of minerals deposited
- Brine entrainment with the precipitated salts
- Soil permeability and brine lost from un-lined ponds
- Area topography
- Operating Philosophy
- Harvest Cycle
- Storage / Buffer Capacity
- Seasonality
- De-Brining Methodology
- Mobile and Installed Pumps
- Harvesting Methodology
- Harvesting Schedule/Time
- Crushing and Size Classification Circuit Design
- Maintenance Equipment
- Instrumentation & Control
NOVOPRO’s comprehensive and detailed analysis of the site climatic data provides a clear understanding of the pond operating conditions over the span of an average climatic year, as well as the expect variability of the pond operating condition. Penmen based evaporation models are used to evaluate large pond evaporation rates and effectively correlate pilot pond and pan data to full scale operation.

NOVOPRO analyzes the pilot pond data and pan evaporation data as well as existing the full-scale pond operations data to extract key evaporation, speciation, equilibrium, and kinetic information to be used within a pond model to determine optimal cut-off brine compositions, salt compositions precipitated and their quantities, as well as the evaporation pond area required.

Details such as topography, ground conditions, soil permeability, and relevant climatic data along with the brine composition, phase chemistry and brine transfer design parameters are incorporated to develop the different pond sizes, configuration, and brine transfer philosophy. NOVOPRO will work in conjunction with the client’s geotechnical and civil engineer to develop an efficient and cost-effective construction and operations strategy, taking into consideration all challenges in this respect.

Harvesting studies are also generated to establish the schedule, philosophy and mobile equipment requirements to ensure a timely and cost-effective process for harvesting the precipitated salts to be delivered to the plant, selection of the appropriate mobile equipment required, and optimal utilization of the pond area.
Environmental Engineering

Sustainable and sound industrial design must always consider the long-term environmental effect of a facility on its surroundings. The goal of our specialists is to achieve this harmony with elegant solutions that will also yield a competitive commercial operation.

To complement our process expertise, clients can benefit from our know-how in environmental engineering as applied to metallurgical and inorganic chemical plants. Process simulation in combination with laboratory test work is used to optimize processes and reduce solid waste as well as liquid effluents. Process heat recovery is used as an internal means of energy optimization, including integrated cogeneration schemes for maximisation of energy efficiency. Other areas of expertise are capabilities in waste characterization, minimization and management, leading to overall sound waste management strategies.

Environmental audits and risk analyses studies may also be performed. Environmental and social impact assessments and statements (ESIA’s) will be essential to the client in identifying risks and potential impacts of a project. ESIA’s can be further instrumental in:

- Understanding corporate responsibilities regarding project-related environmental concerns
- Evaluating regulatory compliance of projected process operations
- Assessing the overall environmental viability and sustainability of a project
- Planning mitigation measures and technological alternatives to improve plant performance and acceptability within well-defined environmental parameters
- Anticipating the impact of stated environmental government policies
Our combined expertise in the fields of metal extraction and environmental processes has given rise to innovative engineering initiatives. These have brought significant improvements to plant operations and to current waste management practices through more economical production and improved environmental controls, which translate into direct benefits to the industry.

Research and development has been a key asset in assisting NOVOPRO address technical challenges posed by clients and projects, as well as develop in-house processes that complement our engineering expertise. Our personnel, together with links to specialized research organizations, provides for an efficient means of developing new technologies and processes as required by our involvement in projects with high technical content.
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<thead>
<tr>
<th>Project</th>
<th>Phase of Involvement</th>
<th>Capital Cost (USD)</th>
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<tbody>
<tr>
<td>Sevier Playa Potash Project – Associated Minerals MgCl₂ as by-product</td>
<td>Preliminary Economic Assessment:</td>
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<td>from the SOP process</td>
<td>Investigation</td>
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<td>Final Report</td>
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<td>Crystal Peak Minerals Inc</td>
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<tr>
<td>Magnesium Metal, Silica and Sodium Sulphate Production Plant based on</td>
<td>Process Design</td>
<td>$ 400,000,000</td>
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<td>serpentine ore</td>
<td>Value Engineering</td>
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<td>Minmet Financing (Rusmag)</td>
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<tr>
<td>Magnesium Metal and Potash and Production Plant, based on Carnallite</td>
<td>Pre-Feasibility Study</td>
<td>$ 850,000,000</td>
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<tr>
<td>• MagMinerals, wholly owned subsidiary of MagIndustries Toronto, Canada</td>
<td>Bankable Feasibility Study</td>
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<td></td>
<td>Detailed Engineering</td>
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<td>Construction</td>
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<td>Minmet Financing (Rusmag)</td>
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<tr>
<td>Magnesium Metal Primary Production Plant, based on Magnesite</td>
<td>Feasibility Study</td>
<td>$ 700,000,000</td>
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<td>• Norsk Hydro</td>
<td>Basic Engineering</td>
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<tr>
<td>• Magnola Metallurgy (Noranda)</td>
<td>Detailed Engineering</td>
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<tr>
<td>• Antheus Magnesium</td>
<td>Start-up and Commissioning</td>
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<td>• MagIndustries</td>
<td>Expansion Projects</td>
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<td>• Rusmag</td>
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<td>• Australia Magnesium Corporation</td>
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<tr>
<td>Magnesium Metal Primary Production Plant, based on Asbestos tailings.</td>
<td>Pilot Plant Design, Operation</td>
<td>$ 900,000,000</td>
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<tr>
<td>• Noranda, (Magnola)</td>
<td>Feasibility Study</td>
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<tr>
<td>Antheus Magnesium, The Netherlands</td>
<td>Technology Selection</td>
<td>$ 300,000,000</td>
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<tr>
<td>• Magnesium Primary Metal Production based on MgCl₂</td>
<td>Feasibility Study</td>
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</tbody>
</table>
| Magnesium Metal Recycling  
  - Remag B.V. The Netherlands | • Bankable Feasibility Study  
  • Detailed Engineering  
  • Construction  
  • Commissioning and Start-up  
  • Operational Assistance  
  • ISO Certification | $ 15,000,000 |
| Metal Chloride Pyrohydrolysis  
  - Magnola Metallurgy  
  - Quebec Iron and Titanium  
  - Nedmag Industries  
  - Falconbridge  
  - Ollimag Sands | • Feasibility Study  
  • Basic Engineering  
  • Detailed Engineering  
  • Start-up and Operation | $ 15,000,000 |
| HCl Recovery by Pyrohydrolysis of Alkali Metal Chlorides  
  - Australian Magnesium Corporation | • Feasibility Study | $ 5,000,000 |
| Dead Burnt Magnesia Production from MgCl2 Brine  
  - Russia Mining and Chemical Company | • Pre-Feasibility Study | $ 150,000,000 |
| Upgrade of a Magnesium Chloride Evaporator System  
  - Nedmag Industries | • Process Evaluation | $ 5,000,000 |
| Expansion of a calcium chloride production plant  
  - Nedmag Industries | • Feasibility Study | $ 25,000,000 |
## Company Profile – Magnesium Capabilities

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<tr>
<th>Project</th>
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<th>Capital Cost (USD)</th>
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<tbody>
<tr>
<td>Calcium Chloride Prills Production by Calcium Carbonate Leaching</td>
<td>• Feasibility Study&lt;br&gt;• Laboratory Testing</td>
<td>$20,000,000</td>
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<tr>
<td>• Antheus Magnesium BV</td>
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<tr>
<td>• Nedmag Industries</td>
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<tr>
<td>Sulphate Removal from MgCl2 Brine</td>
<td>• Feasibility Study&lt;br&gt;• Laboratory Testing</td>
<td>$10,000,000</td>
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<tr>
<td>• Antheus Magnesium BV</td>
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<tr>
<td>New Potassium Sulphate Production Process</td>
<td>• Laboratory Testing&lt;br&gt;• Pre-Feasibility Study</td>
<td>$65,000,000</td>
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<tr>
<td>• In-house development</td>
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