doi:10.36487/ACG_repo/2063_0.01

Codelco: present, future and excellence in projects

O Araneda CODELCO, Chile

Abstract

Codelco since its inception has been the world's biggest copper producer. During 2019, production totalled 1,706 thousand tonnes of copper, a figure that represents 8% of world production and 29% of national production. Through almost 50 years of history, Codelco's contribution has been relevant to the development of Chile, generating, for example, pre-tax profits equivalent to 8.5% of fiscal revenues and 20% of Chilean exports. To ensure its contribution for the following 50 years, Codelco must overcome many challenges, some of them common to the mining industry, others related to its own assets and perspectives. In the first group of challenges: declining ore grades, deeper deposits, climate change, increasing regulations, higher sustainability standards, and intense social scrutiny can be listed. On the second group, Codelco is facing the closing of many of its productive sectors. Toward year 2030, 76% of our copper production will be generated by projects currently under study or under construction. Considering this complex outlook, in 2019, Codelco commenced a profound business transformation to reposition itself among the most competitive, sustainable and profitable copper producers in the world. In this frame, Codelco aims to deliver additional pre-tax profits of US$ 1,000 million, starting in 2021, taking 2018 as the base. In addition, Codelco has committed to reduce its investment portfolio by US$8,000 million in 2019-2028, without neglecting the most relevant projects. Excellence in projects is one of our strategic priorities and lean philosophy is in its core, by considering it from design through execution. Our projects portfolio is taking full advantage of digital transformation and technological innovations, aligned with our CAPEX reduction goals and our sustainability policy. To be successful in this endeavour, Codelco requires an unprecedented cultural and construction capacity transformation, developed internally and with our stakeholders, promoting new ways of learning and working in a collaborative environment. The Chuquicamata Underground project and El Teniente portfolio demonstrate how this strategic vision is becoming a reality.

1 Introduction

Codelco is the biggest copper producer in the world and, throughout its history, has contributed significantly to the development of Chile. To maintain this contribution, Codelco has defined a transformation program that will allow it to overcome its challenges and position itself among the most competitive copper producers. Within this framework, excellence in projects is a priority, which materializes in large structural projects such as Chuquicamata Underground and El Teniente portfolio.

2 Codelco: a brief description

Corporación Nacional del Cobre de Chile, Codelco, from its origins has been and is today the world's biggest copper producer. Its main commercial products are grade A copper cathodes, copper concentrates and blister copper, among other products and by-products.

During 2019, production totalled 1,706 thousand tonnes of copper (including its interests of 49% in El Abra and 20% in Anglo American Sur), a figure that represents 8% of world production and 29% of national production. In addition, Codelco concentrates 6% of the global copper reserves, contained in world-class deposits, and, with a market share of 8%, is one of the largest producers of molybdenum as well.

Codelco is comprised of eight divisions, with facilities as listed in the following table:

Table 1 Codelco´s Divisions and their main facilities

Division	UG Mine	OP Mine	Concentrator	SX-EW	Smelter	Refinery
Radomiro Tomic		✓		✓		
Chuquicamata	✓	✓	✓	✓	✓	✓
Ministro Hales		✓	✓		(Roaster)	
Gabriela Mistral		✓		✓		
Salvador	✓	✓	✓	✓	✓	✓
Andina	✓	✓	✓			
El Teniente	✓	✓	✓	✓	✓	
Ventanas					✓	✓

Codelco also holds interests in several companies focused on exploration, technological research and development, both in Chile and abroad. As for international exploration, during 2019, Codelco performed exploration activities in Ecuador and Brazil.

As of December 2019, Codelco had consolidated assets of US$ 40.3 billion and consolidated equity of US$ 11.6 billion, both figures at carrying amount.

As a state owned company, through almost 50 years of history Codelco's contribution has been relevant to the development of Chile, (figures in 2019 currency):

- US $ 116 billion in pre-tax profits equivalent to 8.5% of fiscal revenues.
- US$ 309 billion in exports, representing almost 20% of total Chilean exports.
- US$ 131 billion in remunerations, materials, third party services, fuel and energy, with a very relevant share of local production chains.
- US$ 68 billion of cumulated investments, equivalent to 5% of total capex in Chile during this period.

Nevertheless, to maintain and increase its relevance and contribution to the country for the next 50 more years, Codelco must overcome many challenges.

3 Conditions for mining are increasingly complex

Copper producers have suffered with the decreasing trend of ore grades since 2001, with a cumulative decrease of 36% until 2019.

Deposits are getting deeper, with cost and geotechnical issues growing increasingly relevant. In addition to that, we are seeing an increased role of underground mining. In fact, block caving projects hold a significant share of the projected growth of supply, and these projects will be larger scale and will face harder rock types than previous underground projects.

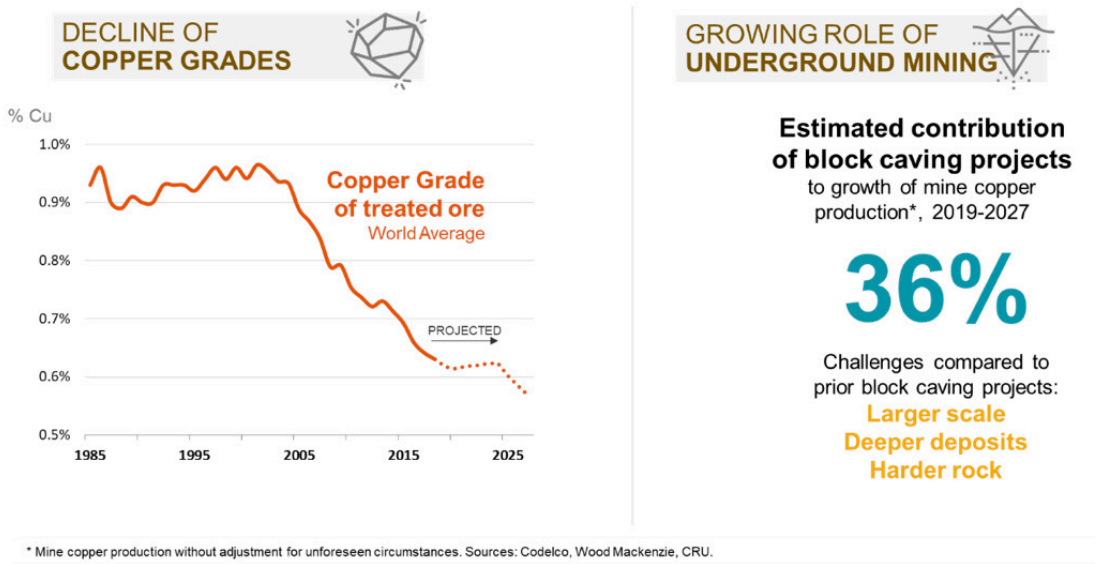

Figure 1 Conditions for Mining are Increasingly Challenging

Climate change is also an undeniable reality, and in Chile this is reflected in severe drought conditions that are limiting water availability for mining projects. The company is subject to increasing regulations, with an intense level of social scrutiny, in which expectations and demands evolve quicker than regulators can catch up.

Finally, this year, COVID-19 irruption has prompted us to rapidly redesign our work and hiring practices, aiming -and quite successfully achieving- to protect people's health while maintaining or attaining greater productivity.

4 Codelco's own challenges

Since 2010, ore grades treated by Codelco's facilities have fallen around 20%, requiring a comparable increase in treated minerals to keep production relatively stable, around 1.7 million tonnes of copper. This has meant a significant upward pressure on throughput capacities and especially on costs, demanding greater management efforts to contain them.

Figure 2 Counteracting falling ore grades with higher treatment capacity

However, the challenge of lower ore grades is not the only one imposed by its mining base. Codelco must face depletion of mining reserves in certain current productive sectors. Therefore, Codelco is developing an optimized investment program, where the Structural Projects stand out. Toward year 2030, 76% of our copper production will be generated by projects currently under study or under construction.

This portfolio execution implies many engineering challenges, demanding our technical and adaptive capabilities, our creativity, and requiring significant investments of tens of millions of dollars.

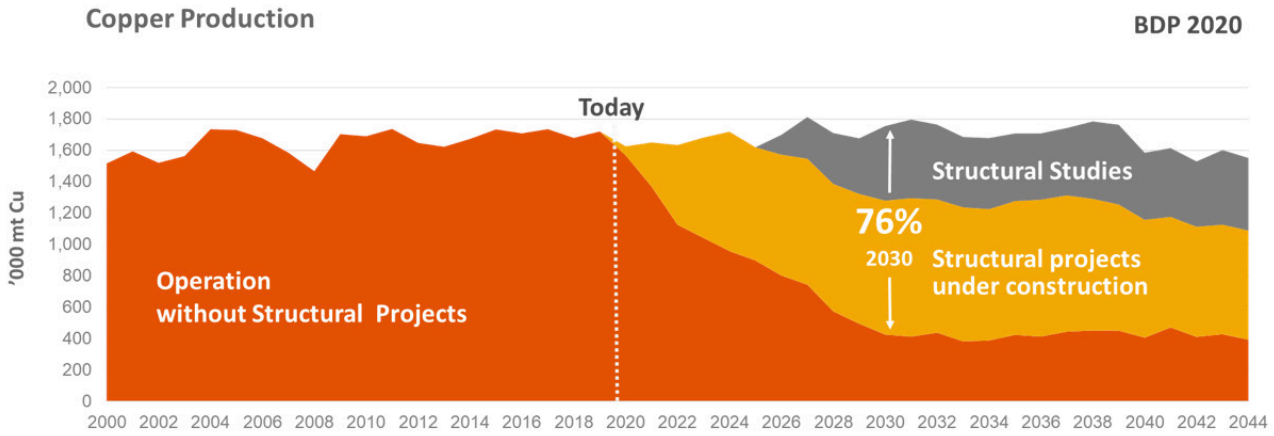

Figure 3 Share of Codelco´s structural projects & studies

5 Codelco's transformation

Considering both industry challenges and its own challenges, in 2019, Codelco commenced a profound business transformation. This inescapable task aims to reposition us among the most competitive, sustainable and profitable copper producers in the world, while continuing to contribute to the nation's development and, in turn, a better quality of life for its citizens.

Codelco's mission is to maximize, in a competitive and sustainable way, its economic value and its contribution to the Government in the long term, through copper mining operations.

The focus of this strategy is on the mine, concentrator and hydro processes for copper production in Chile.

Ten strategic priorities emerge from the new strategy:

- Excellence in operations.
- Excellence in projects.
- Resources and reserves.
- Strengthening sustainability.
- Develop people and strengthen organization.
- Digital transformation.
- Develop innovation.
- Integrity and Transparency.
- Reform smelters and refineries to make them competitive and independent.
- Manage non-mining assets to maximize their contribution

The ten strategic priorities generate numerous initiatives which, in turn, are translated into action plans.

In concrete terms, Codelco aims to deliver additional surpluses of US$ 1,000 million, starting in 2021, taking 2018 as reference base. In addition, Codelco has committed to reduce its investment portfolio by US$8,000 million in 2019-2028, without neglecting most relevant projects.

Achieving these goals will enable Codelco to position itself in the second quartile of costs of the industry and significantly reduce its financing needs.

6 Excellence in projects

In relation to the strategic priority of excellence in projects, to reach our goals:

- We will prioritize the best projects to be executed.
- The designs of our projects will be simpler and adjusted to meet real requirements of our business; incorporating creative solutions and best practices.
- Hiring and construction will be executed on time, according to the agreed scope, increasing disciplined work in productivity and following up on our efficiency and continuous improvement goals.

Lean philosophy gear the strategy of excellence in projects in both design and execution. In design, to meet our goals we incorporated the best practices of the industry: Value Engineering, Classes of Facility Quality, Constructability, Maintainability, Selection of Technologies, among others. In construction, practices of productivity improvements (full potential and should cost) have been implemented, and progress is currently being made in the use of Advanced Work Packaging (AWP). Taking advantage of digital technological advances, strategy also includes initiatives such as the implementation of Building Information Modelling (BIM), with the ambition to foster digital transformation in construction management.

In terms of innovation, to satisfy needs of our project portfolio, we defined technological roadmaps aligned with cost reduction goals (CAPEX) sustainability policy of the company.

The above-mentioned challenges demand for Codelco an unprecedented cultural and construction capacity transformation. We are working internally and with our stakeholders promoting the “agile” methodology, new ways of learning and working in a collaborative environment.

The following cases show how this is making real: Chuquicamata Underground and El Teniente portfolio.

6.1 Chuquicamata Underground

Structural project to transform Chuquicamata from an open pit operation to an underground mine is now a reality. Chuquicamata Underground will extend life of mine of Chuquicamata Division for at least 39 years.

Some key data of Chuquicamata Underground:

- Initial CAPEX: US$ 5.5 billion
- Life of mine: 39 years, from three sequential levels
- Capacity: 140 ktpd.
- Expected production: 360,000 tonnes copper per year.
- Reserves: 1,738 million tonnes. Copper ore grade: 0.69%.
- Footprint: 225 hectares.
- Total developments: 750 km (LOM).

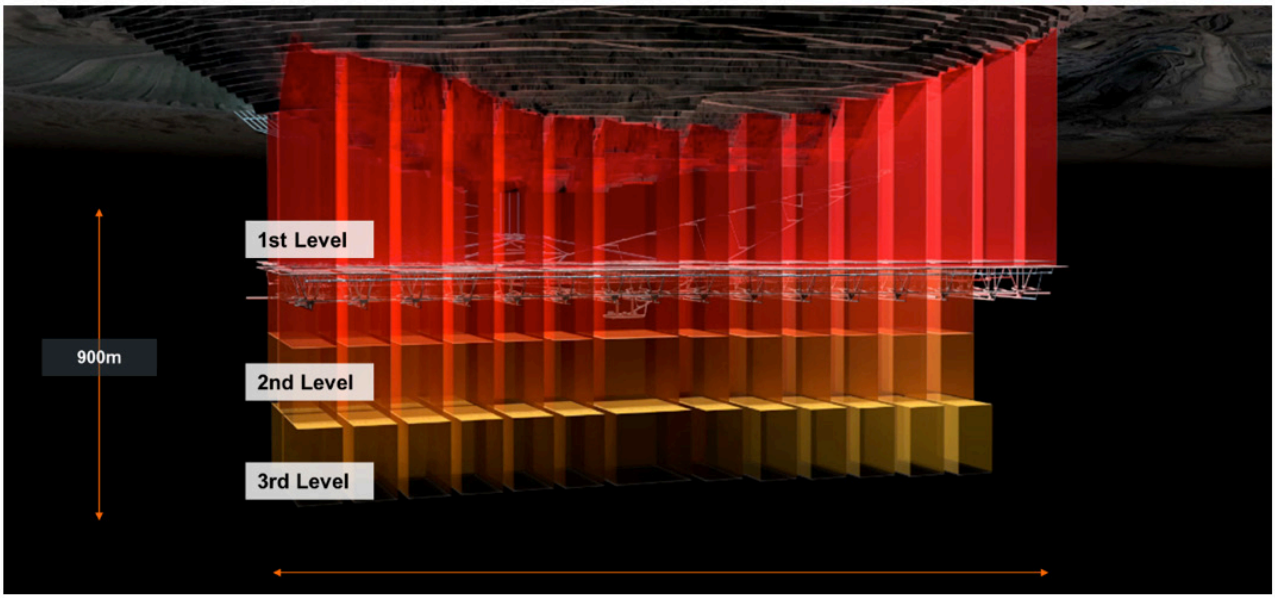

Figure 4 Chuquicamata's 3-level projected underground configuration

An innovative productivity management model allowed us to implement this project, with all key productivity milestones achieved ahead of schedule. Production began in May 2019 and the material management system went online in September, meeting the key milestones for 2019 and launching operations at the project.

Other key achievements included the use of lean design, generating a higher utilization of material handling system. Productivity gains and better designs have allowed a number of significant optimizations and savings. Estimated savings in relation to the project's authorized budget amounted to around US$ 700 million.

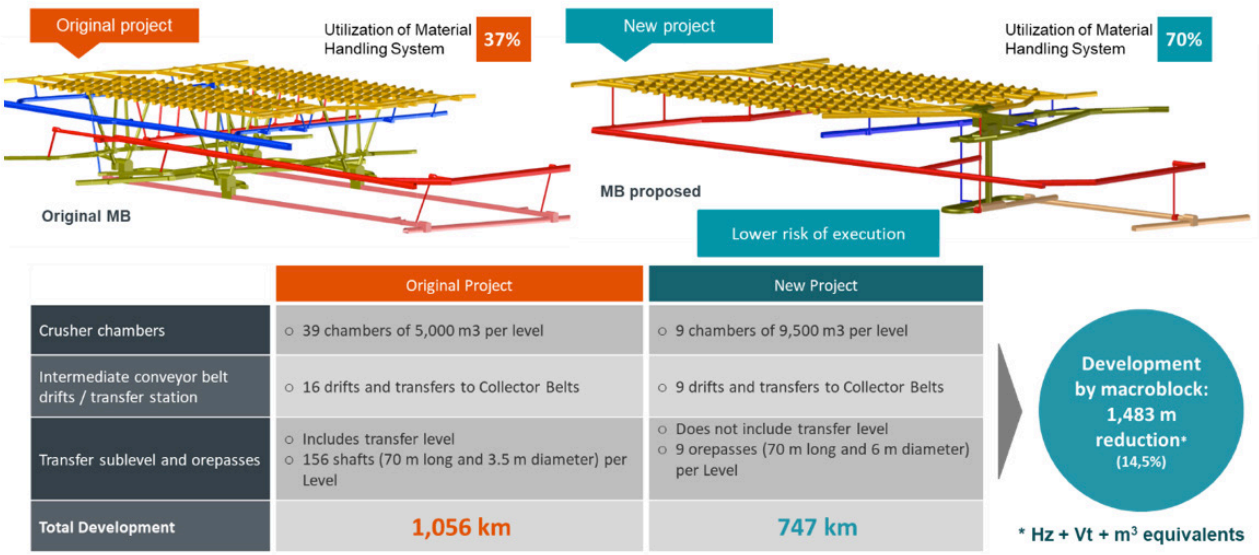

Figure 5 Use of Lean Design in Chuquicamata project

Mine configuration allows operation and construction of macroblocks simultaneously, given that we have independent accesses, controlled interferences, a modular design and having productivity as a lever of value.

Despite the effects linked to the pandemic that forced the temporary demobilization of workers, Chuquicamata Underground is moving forward to complete the goal of producing 8 million tons of mineral in 2020.

Progress, faster than expected, could mean shortening the overall ramp up to design capacity at 140,000 tpd from 7 to 5 years in two simultaneous production fronts. Accelerate the ramp-up would allow capturing in advance the value committed by the project, accessing before the best grades of the underground mine.

In terms of innovation, new technologies and designs were implemented, such as the use of gyratory crushers on the periphery of the Macroblock production area, as well as the application of semi-autonomous loaders (LHD) improving the safety of our workers.

Mine construction was very successful, development of tunnels achieved rates higher than 3,500 meters per month. Likewise, success stories are found in the assembly of the surface-operated conveyor belt system, with the highest electromechanical capacity in the world, as well as in the Main Ventilation System with high-power fans and a distributed system within the mine which, allowing to control ventilation according to the demands of each shift, safety, access and control of people and equipment inside the mine.

In addition, massive use of intensive preconditioning process of the rock mass was applied, combining confined blasting and hydraulic fracturing techniques.

The following production lift will be required early in the 2030's. The pre-feasibility study for the exploitation of the second level of the mine has a progress of 21% up to August, baseline studies are under development and the main engineering contract started in July.

6.2 El Teniente portfolio

El Teniente portafolio is comprised of Diamante, Andesita y Andes Norte projects.

Diamante and Andesita maximize the use of current mine infrastructure: accesses, ventilation and transport through Teniente 8 haulage level.

Some key data of Diamante:

- Initial CAPEX: US$ 730 million
- First year of production: 2022.
- Life of mine: 17 years.
- Capacity: 35 ktpd.
- Reserves: 235,5 million tonnes. Copper ore grade: 0,88%.
- Total developments: 42 km (horizontal and vertical)
- Progress in early works: 48% (September 2020).

Some key data of Andesita:

- Initial CAPEX: US$ 510 million
- First year of production: 2023.
- Life of mine: 17 years.
- Capacity: 25 ktpd.
- Reserves: 121 million tonnes. Copper ore grade: 0.87%.

- Total developments: 19 km (horizontal and vertical)
- Progress in early works: 51% (September 2020).

Andes Norte will extend operations at the division nearly 40 years, accessing Teniente 9, 250 m below Teniente 8. Andes Norte include a new material handling system (conveyor belt), replacing Teniente 8 railway. Andes Norte' greater depth implies a greater geomechanical complexity (high-stress environment) which has been confronted with pioneering work using hydraulic-fracturing prior to digging tunnels as de-stressing technique especially the mine access and conveyor tunnels.

Some key data of Andes Norte:

- Initial CAPEX: US$ 2 billion
- First year of production: 2023.
- Life of mine: 37 years.
- Capacity: 35 ktpd.
- Reserves: 375 million tonnes. Copper ore grade: 1.02%.
- Horizontal developments: 28 km
- Progress in construction: 23% (September 2020).

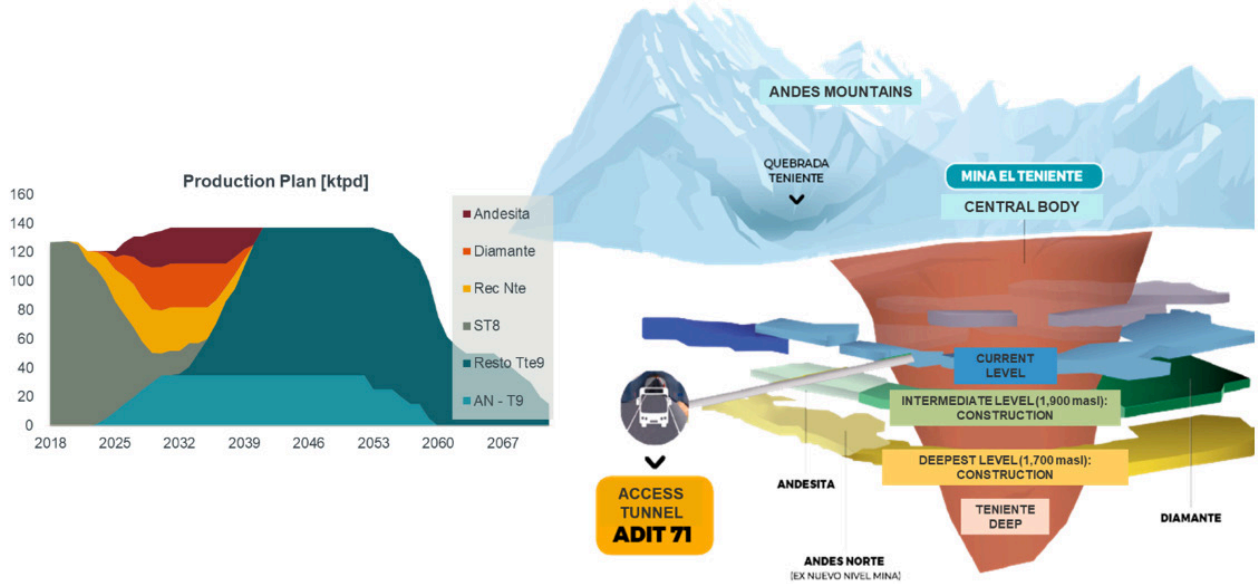

Figure 6 El Teniente project portfolio

El Teniente portfolio has pioneered the application of disruptive technologies in tunnels development, with implementation of mechanized activities for mucking and rock support installation followed by remote control solutions of the mining cycle activities. Additionally El Teniente has implemented innovative use of preconditioning techniques at tunnel scale, hydraulic fracturing and destress blasting, and improvements on the rock support systems in order to increase energy dissipation and definitions of maximum development rates. As a consequence, we minimize workers exposure on work fronts and to manage seismic risk in deep mining.

The transformation of traditional operations into remote operated ones represented the biggest challenge from an engineering, technological but also cultural point of view, and pushed forward current practices to a complete new state of the art for El Teniente Mine Projects. The main goals have been successfully achieved, from considerations of remote operation designs to implementation of an integrated center of operation located kilometers away from the critical areas underground, resulting in safer, more efficient and productive mines.

Andes Norte's Materials Handling System considers ore reduction and its conveying from mine to Colón Plant for all future mines below current Teniente 8 rail haulage level. It considers a crusher chamber among the largest in the world underground, hosting a 4,000 tph rotary crusher in a 100,000 m^3 excavation. In addition to that, it considers the development of the 9 km "geotechnically very complex" conveyor tunnel and the Conveyor Belt System for a future capacity of 140,000 tpd that extends for 12 km.

El Teniente portfolio has a Productivity Management System that incorporates concepts of Full Potential and Should Cost into project management. Early implementation of this system from the processes of contract formation, bidding and awarding, have generated reductions in time and CAPEX in Andes Norte. In addition, productivity management in project execution allows safeguarding the value promise of the projects and continuous processes optimization.

In line with Codelco's transformation, this portfolio is being developed under Building Information Modelling (BIM) concept. Infrastructure for belts, crusher, electrical system, civic neighborhood and workshops were designed in 3D, and implementation of 4D tools is currently being prepared, making use of Advanced Work Packaging (AWP), methodology that ensures a link between scope bundling with planning of its execution from the last planner point of view.

To protect people's safety, the projects of the El Teniente Portfolio have incorporated concepts of autonomy in the main equipment from early engineering phases, resulting in future operations with LHD and autonomous trucks and loadout bins monitored from CIO Room ("Centro Integrado de Operaciones", or Integrated Operation Center) located in Rancagua 60 km from underground mine.

7 Concluding remarks

Codelco since its inception has been the world's biggest copper producer and an important lever for the development of Chile.

To ensure its contribution for the following 50 years, Codelco must overcome many challenges, both technical and adaptive. Considering this complex outlook, in 2019, Codelco commenced a profound business transformation to reposition itself among the most competitive, sustainable and profitable copper producers in the world. Excellence in projects is one of our strategic priorities and lean philosophy is in its core, considering design and execution. Our projects portfolio also is taking advantage of digital transformation and technological innovations aligned with our CAPEX reduction goals and our sustainability policy.

To be successful in this Codelco requires an unprecedented cultural and capacities-building transformation, whence we are working internally and with our stakeholders promoting new ways of learning and working in a collaborative environment.

Chuquicamata Underground and El Teniente portfolio, our two main structural projects, are part of the future of Codelco which is making real today.