PT Semen Tonasa

*The largest cement industry in Eastern Indonesia was the **first receiving ISO 50001 certification**, we achieved an **energy efficiency of 18.52%**, agricultural waste as **renewable energy by 435,864.37 tons** with a circular economy value of **2,812,224 USD** and support one of the sites of environmental conservation Semen Tonasa selected as a **UNESCO Global Geopark (Flora & Fauna Bulu Sipong)** by reducing **Pollutans CO_2 emissions by 435,864.37 tons**.*

Figure 1. Tonasa Cement Plant

Case Study Snapshot	
Industry	Manufacturing
Products/Services	Ordinary Portland Cement (OPC) and Portland Composite Cements (PCC)
Location	Pangkajene, South Sulawesi
Energy performance improvement percentage	18.52% improvement over 4 years
Total energy cost savings (over the improvement period)	USD 16,164,305
Cost to implement Energy Management System (EnMS)	USD 308,391 (over 4 years)
Total energy savings (over the improvement period)	1,214,159 MWh
Total CO_2-e emission reduction	435,864.37 Metric Tons

Organization Profile / Business Case

Semen Tonasa is the first cement company in Eastern Indonesia, a part of SIG (Semen Indonesia Group SMGR), also as state-owned enterprise and the largest cement producer in Indonesia with installed capacity 7.4 million tons of cement per year and market areas are not only in domestic but also exported in Asia, Pacific, and Australia. Electrical energy consumption for the cement plant is supported by a Steam Power Plant (PLTU) with a capacity of 120MW.

Our Motivation for Managing Energy – The cement industry consumes plenty of thermal energy and electricity, with a total energy consumption of 5.6 million MWh. The cost of good manufacturing (COGM) is approximately 50% which has a significant impact on the company's financial performance. With uncertain global economic conditions today, businesses should survive by exporting semi-finished products clinker (which consume roughly 80% of total energy). Another risk identified is that the availability of energy for operations may be disrupted due to global external factors. As a result, businesses must ensure energy supply and engage in energy efficiency activities and in another side companies must comply with government regulations energy efficiency and commitments to reduce greenhouse gas emissions and implement a carbon tax plan by 2025.

Energy efficiency efforts have been ongoing for years, but they have been well unorganized and have resulted in significant impact on the company. By adopting the ISO 50001 energy management system (EnMS) not only provides an opportunity to reduce energy costs, but also adds value to product quality, the environment, and society (circular economy) and **the most important thing is the key to supporting the vision of Semen Tonasa to become a leading cement company that is efficient and environmentally responsible by EnMS**.

Climate and Sustainability Strategy – We ensure the excellent implementation of EnMS in many programs and including the massive of renewable energy use. This effort began in 2015 when UNIDO conducted an assessment in Tonasa and recommended for implementation ISO 50001. At the preparation stage (2016-2018) Management formed

the energy teams from various work units. In this early phase, we get support from an external consultant. The ISO 50001:2011 certification was obtained in 2019 and then migrated to ISO 5000:2018 in 2020. Further improvement made by integrating ISO 50001 with other management systems by 2021 (Figure 2).

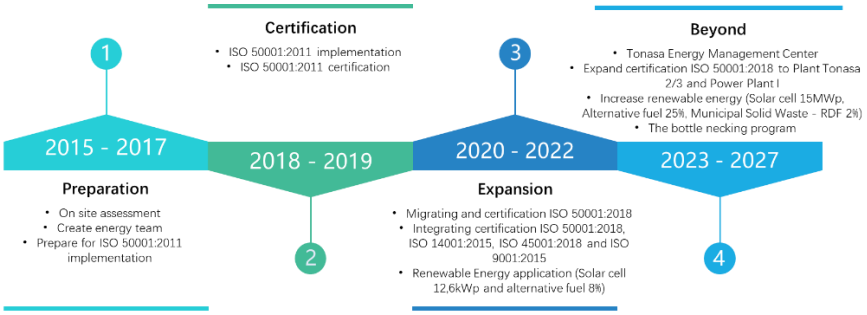

Figure 2. The Process of Implementing an ISO 50001 & Roadmap Semen Tonasa

Semen Tonasa's use of EnMS aligns with SIG's Sustainable Road Map, which represents the company's commitment to environmental, social, and governance issues (ESG). This road map includes the measures to reduce greenhouse gas (GHG) emissions such as specific thermal energy consumption (STEC), specific electrical energy consumption (STEC), solar cell energy generation, and thermal substitution rate (TSR). These measures are integrated on EnMS in the form of action plans which are monitored and reviewed strictly by management. The use of digital technology in the form of vibration and temperature monitoring as well as diagnostics on the main drive motor of the cement mill of Tonasa plant IV has been implemented since 2021 in order to support the digitization of Critical Maintenance Parameters. The application of artificial intelligence in the form of an expert process that operates equipment on auto-pilot has been implemented since 2022 at the Tonasa plant V in the Cement Mill and Kiln area which has contributed to reducing energy consumption. Our efforts in digitalization were recognized by the Indonesian government through the INDI 4.0 award on the Aggressive Digitalization category. This award granted to companies that significantly and aggressively develop digital technology in their business processes to increase competitiveness and productivity as well as efficiency in the production process. Tonasa was selected as one of the exhibitor in Indonesian pavilion at International Industrial Exhibition Hannover Messe 2023.

Tonasa plant located in the protected national park area and there has a few pre-historic sites, one of them is the Bulu Sipong which had one of the oldest paintings in the world (45,500 years) and a part of UNESCO Global Geopark. Reducing pollutans & emissions through energy efficiency is one of the company's contributions to protect flora and fauna existence in Geopark.

Fig 3. Prehistoric paintings at Bulu Sipong site

"Implementation of energy Management based on ISO 50001 is the foundation for the company to go Beyond Performance and achieve sustainability"

—Mufti Arimurti, President Director

Business Benefits

The implementation of EnMS at Semen Tonasa includes capacity building activities such as developing EnMS implementation for staff and employees, ceminars/ workshops, certification, knowledge sharing, third party audits and technical assistance. Semen Tonasa has spent $308,391 for those activity with benefits during the implementation of EnMS as follows.

Energy Cost Savings - Since implementing EnMS at Semen Tonasa, we achieved the total energy savings as a whole and measured by 1,214,159 MWh. In first year implementation, US$ 5,461,358 energy cost saving achieved and continued to a total of US$ 16,164,305 in four years of cumulative saving. To determine the energy cost saving, we were measuring the energy performance by calculating the differences between actual energy consumption and the predicted energy consumption as given from the predetermined baseline. The differences were displayed in the cumulative of sum (CUSUM) and clearly described our energy performance along with energy cost saving (figure 4).

Figure 4. Cumulative Summary Energy and saving cost period 2019-2022 (Gj)

Conserving the Energy - We achieved saving of 1,214,159 MWh of energy within 2019 – 2022. This sum was made up of 1,170,463 MWh thermal energy and 43,696 MWh electrical energy. These savings equivalent to 281,893 tons of raw coal based on the specifications used.

Agricultural Waste Reduction (Renewable Energy) - Agricultural waste (biomass) is used as an alternative fuel to replace coal consumption. The thermal substitution rate (TSR) of biomass increased significantly from 1.17% to 8.13% between year 2019 and year 2022 (Figure 5), with a total amount of agricultural waste utilized of 157,297 tons. If this waste is unused, it will be burned by the community, causing environmental pollutants such as Particulate Matter (M. O. Andreae, P. Merlet, 2021). This increasing usage of biomass does not affect the quality of products due to adjustments are made to the raw mix design and COP (Critical Operating Parameters).

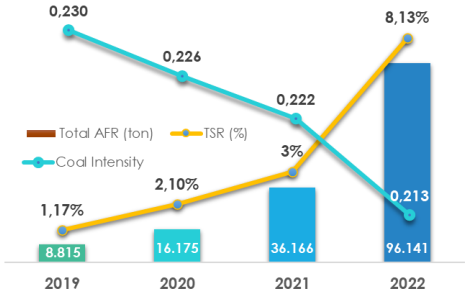

Figure 5. Thermal Subtitution from biomass and coal intensity

GHG Emission Reduction - Along with Indonesia's regulation to reduce the emission by 29% in 2030, Semen Tonasa supports the Government's effort to reduce CO_2 emissions as well as develops energy transition in Cement Industries. Semen Tonasa has contributed to the Nationally Determined Contribution (NDC) of 22.3% CO_2 emission reduction from 708 (2010 baseline) to 550 kg CO_2/ton cement eq with a total CO_2 reduction of 435,864.37 tons CO_2 during the implementation of EnMS (Figure 6) and this commitment will continue until 2030.

Corporate Social & Governance Benefits - The implementation of EnMS benefits are not only for the company but also the stakeholders such as the community on a socioeconomic level. This matter can be seen in Semen Tonasa's EnMS implementation's contribution to the Sustainable Development Goals (SDG) targets, namely goal 7 (Affordable and Clean Energy) in the form of substituting renewable energy for fossil fuels (coal), goal 13 (Climate Action) in the form of reducing greenhouse gas emissions, and goal 12 (Responsible Consumption and Production) in the form of reducing agricultural waste, maintaining supply chain sustainability with local suppliers, by collaborates with 6 vendors and involves 75,643 workers in the thermal substitute action plan, which has an economic impact on society of USD 2,812,224. Other benefits of improving the company's image provide:

- Achieving Green-Rating (Beyond Compliance) in the National Program for Assessment Performance Rating in Environmental Management (PROPER) from the Ministry of Environment and Forestry (2019, 2021 & 2022).
- Green Industry Certificate from Indonesian Ministry of Industry 2022.
- Winner of National Energy Efficiency Award (Subroto Award for Energy Efficiency) 2022.
- INDI 4.0 award in Aggressive Digitalization Category from Indonesian Ministry of Industry in 2021.

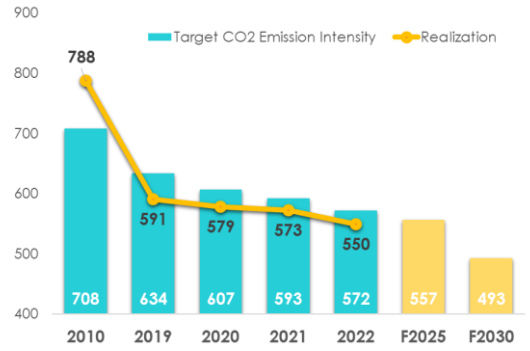

Figure 6. CO_2 Emission Intensity (kg CO_2/Ton cmn eq)

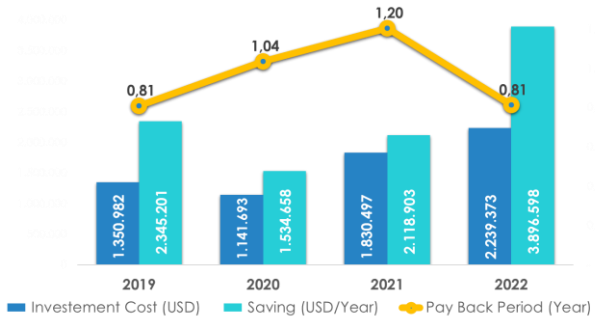

Figure 7. Investment Value and Savings (USD)

Multiple Sites Benefits - The beginning implementation of EnMS has been carried out at the Tonasa Boundaries in one site. The success of these EnMS can be replicated in the Tonasa 2,3, power plant unit I, and every SIG operating company ; we have shared EnMS with other SIG operating companies when they become ISO 50001 certified (by 2020 and 2021) and the SIG makes policies to implement energy management in each operational company (by 2022).

Plan

Leadership and Commitment – Our top management believe that the EnMS implementation will have a positive impact on a sustainable basis for the company and its stakeholders. This commitment is stated in the company policies that are consistently implemented and reviewed. The implementation of this commitment can also be seen in the official formation of the energy team, which comprises of various related work units and includes the establishment of a new organizational structure, namely the energy officer, to ensure that EnMS is carried out in a consistent and structured manner. Top management also provides financial support to carry out various action plans Capital Expenditure (CAPEX) of USD 6.5 million (Figure 7) and competency improvement in the form of certification, training, workshops, and audits of USD 308,391 million for Operational Expenditure (OPEX). The integration of energy performance measures in the company's Key Performance Indicators, such as STEC, SEEC, coal index, and TSR has shown the consistency of this commitment. Management is not only involved in reviewing monthly and annual energy performance achievements but also providing input for continuous improvement.

Data Quality and Energy Review - We measured coal and biomass consumption using a weighting scale calibrated annually by a third party and we used online power metering to measured electrical consumption in our plant. Thermal energy used in the combustion process is converted into electrical energy and used in Semen Tonasa operations. As a result of the identification, we create the Significant Energy Use table shown below. The criteria for determining equipment that dropped into the SEUs category are describe on the figure 8.

GHG Emission Reduction – Tonasa has identified pollutants using the Life Cycle Impact Assessment (LCIA) by Simapro Software to identify the hotspots that produce the most pollution, that is, kiln areas and power plants that consumed approximately 2 million tons of coal per year, and the results of the identification have become the focus of an energy efficiency planning program, We have created a sustainability roadmap for fuels and emissions, which includes an action plan to reduce fossil-based energy consumption, and increase the portion of renewable energy with the target of 493 kg CO_2/ton by 2030 (Figure 6).

Energy Baseline and Energy Performance Indicator (EnPI) - We used the single linear regression method to develop baseline SEUs in accordance with ISO 50006 standards. We have 13 baselines consisting of 3 baselines for equipment using thermal energy (level 3) and 10 for equipment using electrical energy (level 4). At the beginning of the implementation in 2019, we used a baseline with base year data of 2017-2018. Then using the Energy Performance Indicator to compare the amount of product produced to the total energy consumption of the equipment. The baseline data for 2022 that we use is as follows Table 1. To improve EnPI, Tonasa conduct the Normalitation process by adding new methode for regression linear, tonasa will use multiple variable to accommodate the change the fuel and production values.

Support on Strategy & Energy Target - We assessed the energy-saving potential of the equipment included in the SEU (Energy Conservation List). The potential is then entered into a quantitative priority scoring matrix. The quantitative assessment considers the potential for energy savings, the level of difficulty, Investment Rate Return and the impact on quality. The potential with highest assessment value is turned into a work program that will be implemented to meet the energy savings targets.

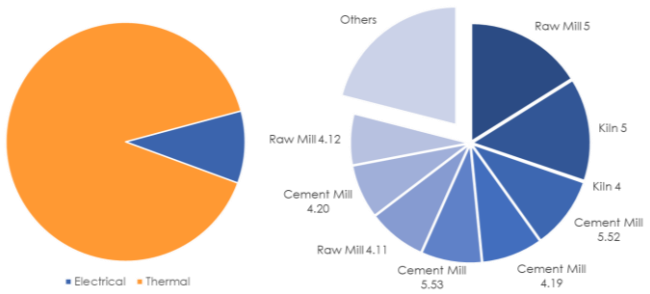

Figure 8. Significant Energy Use (Total & Electrical Energy)

Boundry	SEUs	Relevant Variable	Baseline Equation	R^2
Thermal		⚠		
Plant Tonasa IV	Kiln 4	Ton Clinker	y = 779,973x + 1,673,636,232.97	0.99
Plant Tonasa V	Kiln 5	Ton Clinker	y = 765,57x + 5,846,681,250.59	0.97
Power Plant	Power Plant CD	Output kWh	y = 3.272,91x + 756,174,708	0.98
Electrical		⚠		
Plant Tonasa IV	Raw Mill 4.11	Ton Raw Meal	y = 16.162x + 711,612	0.92
	Raw Mill 4.12	Ton Raw Meal	y = 15.809x + 289,667	0.97
	Kiln 4	Ton Clinker	y = 25.939x + 815,621	0.95
	Cement Mill 4.19	Ton Cement	y = 34.994x + 635,357	0.89
	Cement Mill 4.20	Ton Cement	y = 41.258x + 266,549	0.97
Plant Tonasa V	Raw Mill 5	Ton Raw Meal	y = 18.579x + 707,63	0.93
	Kiln 5	Ton Clinker	y = 23.155x + 708,087	0.99
	Cement Mill 5.52	Ton Cement	y = 29,595x + 556,040	0.95
	Cement Mill 5.53	Ton Cement	y = 30.829x + 282,628	0.93
Power Plant	Self Used CD	Output kWh	y = 0.12x + 667,569.72	0.97

Table 1. Baseline and boundary EnMS

Re-certification and Integration - We had a recertification process along with upgrading ISO 50001:2011 to version ISO 50001:2018, then integration with other management system such as ISO 9001:2015, ISO 14001:2015, 45001:2018 in 2021.

Do, Check, and Act

Operation and Implementation - The project charter action plan is created based on the determined priority action plan. The head of the related work unit, which may include personnel from other work units, is always in charge of the action plan. The action plan's progress is reviewed monthly and the outcomes of its implementation are verified by a certified energy auditor, the following is an example of a well-executed action plan (figure 9).

Year	Activity Program	Investement Cost (USD)	Plan Saving (Annual)		Actual Saving (Present)	
			USD	GJ	USD	GJ
2019	Reblading rotor blade turbin last stage unit C	302.257	385.130	147.466	1.199.538	536.664
2019	Heat Efficiency in Kiln & Cooler area	157.845	794.648	219.535	2.891.915	798.941
2020	Reducing ash fine coal 2% (13% to 11%)	50.376	228.281	84.693	654.249	242.728
2020	Reduce temperature top preheater from 440°C to 410°C	164.025	322.160	104.807	923.304	300.375
2021	Repair Bypass Main Steam Valve Unit C	167.920	148.440	63.080	179.449	120.607
2021	Cleaning GAH, SH3 and Economizer Power Plant unit II	16.792	175.047	74.386	211.614	142.224
2022	Process Optimizing Implementation (PXP)	302.593	179.222	45.942	41.519	10.643
2022	Increase Biomass (AFR) to 8 %	1,340,677	1,819,081	554.824	3.813.749	1.087.357

Figure 9. Examples of high efficiency program

We strictly control the operating and critical maintenance parameters related to energy consumption. We created a critical operation parameter index (COP-ID) to ensure the operational conditions which are still within the energy-saving control range. These COP-IDs are reviewed and corrective actions were taken on a daily, weekly, and monthly basis. Attempts to maintain our capabilities are carried out by developing and implementing a competency matrix, which includes energy manager certification (19 people), energy auditor certification (6 people), knowledge sharing (655 people), internal and external training (463 people).

Key high-level equations and explanation Individual energy savings were calculated for each SEU expected energy consumption (from their individual baseline) is *Actual Energy Consumption – Expected Energy Consumption.* Individual savings for Thermal and Electrical were accounted and a cumulative summary to total energy savings, Energy performance improvements as follow:

$$\frac{Total\ Energy\ Savings}{Baseline\ Period\ Energy\ Consumption} \ x\ 100$$

Assessing Energy Performance - To calculate monthly energy performance, comparing the actual energy consumption to expected energy consumption based on the established baseline. The CUSUM graph is used to display the results of energy efficiency performance. If the CUSUM graph is negative, it indicates that energy efficiency has been achieved in comparison to the baseline, and opposite. We will evaluate and plan follow-up improvements if we observe a

deviation of more than 50% from the previous month's energy performance according to ISO 50015 (Measurement and verification of energy performance of organizations).

GHGs implementation - The electrical and thermal energy usage data that has been verified as the basis for inventory for calculating CO_2 emissions reductions is analyzed using SimaPro software, and interpreted by third-party consultants. Another method is to incorporate the data into the calculation formula developed by the relevant ministries, and the results will be distributed nationally to the relevant government agencies for the benefit of PROPER, Green Energy, the Association of the Cement Industry, SIG and the relevant agencies.

Team Collaboration - The energy team is led by the General Manager of the Department and includes 98 people from different working units such as production, procurement, maintenance, human resources, finance, system management, supporting units and another working project team (Solar Panel Project team, Advance Control PXP Project Team, Biomass Project Team, Proper team, Green Industry team and cost efficiency team).

Figure 10. Management Review Meeting, ISO 50001 Audit, Biomass Storage and Trial Municipal Solid Waste (MSW)

Continuous Improvement - Semen Tonasa achieved cumulative savings of 161% from the target of 2,709,416 Tj during the EnMS implementation period. We also ensure that EnMS is properly implemented through internal and external audits (both technical and system management). The audit findings will be followed up on by the team and reported at the end of the year's management review meeting. At the 2019 management review meeting, top management stated that energy performance was very excellent (> 5% of the target). So, top management presented a challenge to use a new baseline for the next year. Using the new baseline, we still save 696,914 MWh, or the equivalent of 10,702,947 USD, in 2020-2022. If the fuel and production values change, we continues to perform normalization using EnPI and the multiple variable linear regression method.

"Reduce energy consumption by implementing ISO 50001 is our business strategy for efficiency and sustainability"

— Mochamad Alfin Zaini, Operations Director

Transparency

- Online Energy Management Reporting (POME) by the Indonesian Ministry of Energy and Mineral Resources (https://simebtke.esdm.go.id/sinergi/)
- ISO 50001 certification on our website (https://www.sementonasa.co.id/semen-tonasa-kantongi-sertifikat-iso-50001/)
- Corporate Performance Rating Program in Environmental Management (PROPER) and emission monitoring by the Indonesian Ministry of Environment and Forestry (KLHK) (https://proper.menlhk.go.id/) and (https://ditppu.menlhk.go.id/simpel/).
- Awarded Best Performance 2022 by Indonesian Ministry of Industry (https://bbt.kemenperin.go.id/)
- Mass Media Publication according ISO 50001 certification https://fajar.co.id/2019/05/31/tonasa-industri-semen-pertama-di-indonesia-kantongi-sertifikat-energi-berbasis-iso-50001/.
- Industry forums and communicate with fellow industry players through various associations such as the Indonesian Cement Association (ASI) and other associations (https://asi.or.id/).

What We Can Do Differently

Lessons Learned – within ± four years since the implementation of EnMS, there are several lessons that can be learned for our improvement on EnMS implementation as follows:

- The implementation of a single baseline regression must be changed to multiple variable regression and multiple regression based on the type of fuel consumption and continue evaluating baseline (base year).
- Manual data management using Microsoft Excel has contributed in lags of energy performance reviews. The information should be digitalized in real time and integrated with the factory operating system.
- Technical evaluation weight value for LCC implementation can be increased to 25%.

Looking Ahead

- The Tonasa Energy Management Center is built in the form of a dashboard and command center to improve integration energy performance and make the evaluation process easier.
- Install advance metering at level 5 to ensure more spesific the energy performance deviation evaluation process.
- Massively implemented action plans which contribute significantly to decarbonization programs in 2024, such as raising the amount of clean energy biomass from 8% to 25% for Thermal Subtitution, Municipal Solid Waste (MSW) from 0% to 2% for Thermal Subtitution and solar cells from 12.8 kWp to 15 MWp.
- Adding energy-saving criteria to the focus of improvement in the assessment of Total Productive Maintenance (TPM) conducted by small group activity and special awarding for innovation/continuous improvement based on energy conservation.