

## Brenmiller Energy LTD – Q3 Update Report

28.11.2021



Stock Exchange  
**TASE**



Symbol  
**BNRG**



Sector  
**Technology**



Sub-sector  
**CleanTech**



Stock price target  
**NIS 15.8**



Closing price  
**NIS 11.0**



Market cap  
**NIS 265 Mn**



No. of shares  
**24.07 Mn**



Average Daily Trading Volume  
**421 stocks**



Stock Performance  
(Since Jan. 2021)  
**-42%**

Completion of pilots with strategic partners and gradual transition to commercialization along with revenue growth; price target remains unchanged.

**Brenmiller Energy LTD (TASE: BNRG) is an Israeli publicly traded CleanTech company, founded in 2012. Brenmiller's core competence lies in materials engineering, high-temperature thermal effects and conductivity, product manufacturing, and renewable power production. The company pioneered a cost-effective and efficient thermal energy storage (TES) solution, which could predominantly assist the Commercial and Industrial sectors in fulfilling its decarbonization initiatives.**

### Q3 2021 highlights:

- Brenmiller continued to develop projects with Philip Morris International and expects it will soon sign a framework agreement with PMI corporate, enabling fast deployment of the bGen™ technology across PMI's global production plants.
- The company announced a pre-IPO towards an expected NASDAQ listing, and raised USD 15 million in capital through private placement with 4 investment firms.
- The company terminated negotiations with ENSO Global Solutions Ltd.
- The company announced that Gmool Energy 1 (1998) Ltd. failed to complete the financing for the Rotem 1.
- The EU Modernization Fund provided grants for 2 projects in Hungary amounting to approx. USD 7 million.

**The global market for TES is expected to triple by 2030. TES capacity is expected to increase to over 800 GWh, as TES is expected to play a major role in the penetration of renewables globally. It has been estimated that about 400 million tons of CO<sub>2</sub> emissions could be reduced using the right energy storage solution. Going forward, it is estimated that the European Union will invest an additional USD 370 billion in heavy industry sectors over the next thirty years on the decarbonization of the industrial sector.** The institution of a carbon tax by many countries, including Israel, and the continually increasing carbon price have significant positive implications for Brenmiller's potential. Since the beginning of 2021, EU carbon prices have risen from ~€30 per tonne to ~€50 in May, before passing €60 in August for the first time. Additionally, the U.S. recently passed a USD 1.3 trillion infrastructure bill to increase green energy.

On the next page, we further elaborate on the main events in 2021.



### Key events in the passing months and Q3 2021:

- In July, Brenmiller received an order for basic engineering and to enter into a **building permit process from Philip Morris International (PMI) for two projects** to replace gas-fired steam production with a storage-based biomass system.
  - Brenmiller will receive USD 76K for the project that is expected to begin in Q4/2021.
  - The two projects, in Europe and Asia, will amount to a total expected capacity of 40 MWh, in which Brenmiller will provide the biomass-based TES system.
  - On October 3, 2021, the company announced that the conceptual design phase for one of the projects has ended to the satisfaction of the customer and has approved the engineering of a project for the storage system of 15 MWh per hour for Philip Morris' production facility in Asia.
  - The company is expected to sign a global framework agreement with the company's headquarters very soon.
- On November 1, Brenmiller announced that it entered into a USD 15 million capital raising agreement through a private placement from four investors: Alpha Capital Anstalt, Moore Provident Funds Ltd., and 2 Wolf Clover hedge funds.
- On November 8, the company announced that Gmool Energy 1 (1998) Ltd. has not yet completed the financing required for the closing of the investment transaction for the Rotem 1 project and will therefore not be proceeding with negotiations to reach a binding agreement.
- On November 24, the company reported that it received grants from the EU Modernization Fund amounting to approx. USD 7 million for 2 projects in Hungary designed to upgrade the power plants of the company's customers, EB Csoport kft. and Reliable Energy Group Zrt. based on the company's bGen thermal storage technology.

For further details on the company and its markets, please read our initiation of coverage report [here](#).

## Investment Thesis

Climate change has been the greatest challenge of our times, and the numbers of countries that have pledged to reduce carbon emissions to zero by 2050 continue to grow. **It is estimated that the European Union will invest an additional USD 370 billion in heavy industry sectors over the next thirty years on decarbonisation of the industrial sector.** Meeting carbon emission reduction targets, requires a ban on fossil fuel boilers to give way for innovative replacements, installation of carbon capture, **storage systems, efficient recovery, and reuse of waste heat. Thermal energy storage (TES) becomes a default requirement for renewable energy to ensure reliability of supply.**

TES is a technology that stores energy by heating or cooling a storage medium that could be later used for heating or cooling applications and power generation. Brenmiller Energy (TASE: BNRG) pioneered a cost-effective and efficient thermal energy storage solution that could largely assist the C&I (Commercial and Industrial) sector in fulfilling its decarbonization initiatives. Brenmiller Energy's mission is to provide innovative, cost-effective TES solutions to reduce the environmental impact by enabling intermittent renewable sources utilization for main stream industrial heat demands and recovering medium to high temperature wasted heat streams at the industrial floors.

Brenmiller's patented product bGen™ is a high-temperature thermal energy storage unit. It utilizes crushed rock as the storage media to store heat in its modular sub-units and converts it into superheated steam for electricity generation, saturated steam or hot air for industrial use, or hot water when required, offering a minimum of 3+ hours of energy storage. The system is the only solution to include all the functionalities of waste heat recovery, hybrid charging from thermal and electrical sources, and inherent steam generation in the same storage unit while producing steam on demand in a modular unit. The system is less expensive, highly efficient, and has a longer life span than other competing technologies.

**The main applications** for the company products are Electricity to Heat, Biomass to Heat, Waste Heat Recovery, Combined Cycle Gas Turbine plants, Electricity to Electricity. Its products have the capacity for heat input of up to 750°C and output heat of up to 550°C, capturing wasted process heat and converting it back to electricity or high-value process heat in the segments of food processing, pulp and paper, plastic industry and more. Next generations with higher temperatures capabilities will potentially address other sectors like steel, refineries, and others.

The strength in Brenmiller’s strategy is its position at the center of the value chain of the energy storage field, with its customers being large plants. In our opinion, the system is cheaper, more efficient, and has a longer lifespan than other competing technologies. The main risk is in the widespread adoption of the technology and sales ramp up.

**Therefore, we view Brenmiller as an excellent opportunity for those seeking to invest in sustainable and positively impact the environment.**

## Company Overview

### General

Founded in 2012, Brenmiller Energy (TASE: BNRG) pioneered a thermal energy storage solution that is cost-effective and efficient, which could predominantly assist the C&I (Commercial and Industrial) sector in fulfilling its decarbonization initiatives. The innovation patent has been granted in all major continents. Brenmiller’s team of renewable energy experts is experienced in designing, building, and managing renewable solutions for power plants and industrial floors. It owns and operates a manufacturing and assembly line in Dimona, Israel. The company is headquartered in Rosh Ha’ayin, Israel, and consists of a team of 90 full-time employees in R&D, engineering, production, finance, and business. It has raised over US\$40 million since the IPO in 2017.

Brenmiller is working towards a sustainable future by supporting emissions reduction up to full carbon neutrality by providing innovative, cost-effective thermal energy storage solutions that enable intermittent renewable sources utilization for mainstream industrial heat demands and recovering medium to high temperature wasted heat streams at the industrial floors.

### Strategy



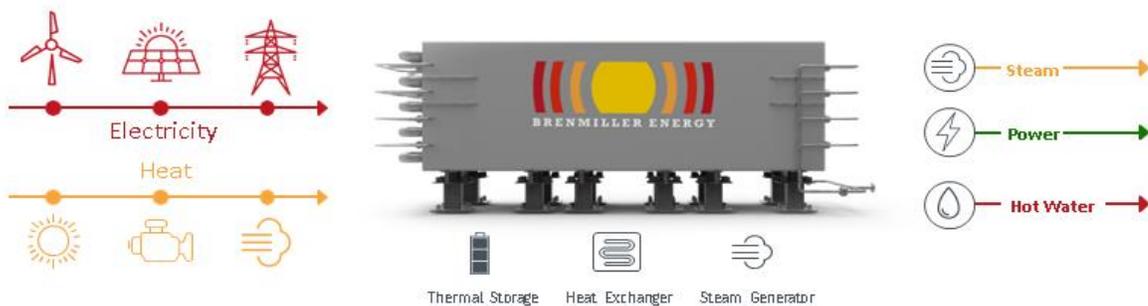
## Key Projects

Brenmiller's key projects include a 1 MWh Thermal Energy Storage (TES) plant with the Israel Defense Forces; a 2MWh TES plant in Fortlev, Brazil; a 400 KWh TES plant in the New York Port Authority; a 23 MWh TES plant for the ENEL project; and Brenmiller is the EPC contractor and TES supplier for the ROTEM1 project.

## 2. Products Overview

### Brenmiller’s bGen™ Thermal Energy Storage System

Brenmiller’s patented bGen™ is a high-temperature thermal energy storage unit. It utilizes crushed rock as the storage media to store heat in its modular sub-units and converts it into superheated steam for electricity generation, saturated steam or hot air for industrial use, or hot water when required. It inherently combines a heat exchanger, a thermal storage, and a steam generator. In addition, the system holds an embedded conversion capability of electricity to heat which enables a hybrid charging. The result is an effective solution offering a minimum of 3+ hours of energy storage. Brenmiller’s bGen™ requires minimal maintenance and offers the lowest Levelized Cost of Storage (LCOS) relative to other available technologies.



bGen™ requires minimal manpower in its operation. Its automatic control system regulates the power production process and the charge and discharge cycles of the thermal energy storage demand, tailored to the client’s electricity demand. Its negative impact on the environment is minimal since it is designed to use non-hazardous materials and uses no chemicals, oils, or salts that could potentially cause environmental damage. Its main applications are converting electricity and biomass to heat, waste heat recovery, increasing the degree of flexibility available for Combined Cycle Gas Turbine plants, and cost-effective energy storage.



#### Clean

- Environmentally friendly materials (crushed rocks)
- 60% reduced CO2 emissions



#### Modular

- From industrial to large scale power plants



#### Lifetime

- 30+ Years



#### Performance

- Unlimited cycles with minimal daily losses
- Energy on demand: Efficient managing of peak load and unload times



#### Hybrid

- Connects different energy sources



#### Economic

- Low investment at <math>\approx 50 / \text{MWh}</math>
- 50% reduced operational cost

### 3. Technology Overview

TES is a technology that stores energy by heating or cooling a storage medium that can be later used for heating or cooling applications and power generation. TES has been proven to increase the overall efficiency, reliability, reduce capital expenses, and operating expenses, and lessen CO<sub>2</sub> emissions.

***High energy storage density and high power capacity are the desirable characteristics in TES systems.***

#### Leading Technologies Performance Comparison<sup>1</sup>

Technology	Storage Capacity
SHS	10-50 KWh/t
PCMs	50-150 KWh/t
TCS	120-250 KWh/t

At present, TES based on Sensible Heat Storage (SHS) is commercially available, while TCS and Latent Heat storage (LHS) based on PCMs are under development. Brenmiller Energy's bGen™ system utilizes SHS technology and uses crushed rocks as the storage medium.

Brenmiller's systems have steam generator embedded in them, eliminating the need for external steam generators. Other key advantages are:

- They allow hybrid charging (can be charged both using waste heat and electricity from various sources).
- Their modular design allows the company to provide its clients with flexible installation dimensions.
- Since they can handle temperatures as high as 750<sup>0</sup>C, due to the use of special crushed rock, the volume of storage is low, and the storage density is relatively higher.
- Life span of 30+ years.
- Low cost per MWh installed and low maintenance costs.
- Fast startup time since the storage is always hot, and heating the heat exchanger to transition from cold to hot is unnecessary.
- Built to handle medium and high temperatures.

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<sup>1</sup> Sarbu, I; Sebarchievici, C; A Comprehensive Review of Thermal Energy Storage, *Sustainability*, 2018

***Brenmiller Energy's bGen™ system utilizes SHS technology and uses crushed rocks as the storage medium. The system is the only solution to include all the functionalities of waste heat recovery, hybrid charging from thermal and electrical into the same storage unit, and producing steam on demand in a modular unit. The system is less expensive compared to other competing technologies and has a 30-year lifespan.***

## 4. Markets Overview

### Electrification of heat-based industrial processes to Reduce CO2 Emissions

Globally, 40% of energy consumption in a nation is by the industrial sector, and approximately 21% or less is from electricity. 44% of the energy consumed by industries is fueled by coal, natural gas, or oil. Falling electricity prices driven by presents a major opportunity for decarbonization. Electrification of industries would require minimal changes either through retrofits or replacement of conventional equipment with electrical equipment. Some advantages of electrification are lower energy costs due to curtailment of renewables, subsidies from Governments, and the ability to charge customer with a premium for their sustainable practices. Hybrid setup with heat recovery and storage further lowers costs and improves process efficiencies.

The industrial Sector in the USA for instance, consumes 23% of the nation's primary energy use, and accounts for 28% of the CO<sub>2</sub> emissions. ***However, several industries reflect relatively low electrification ratio (electric to non-electric use) suggesting there is massive opportunity for electrification, which in turn might require a reliable thermal storage solution or waste heat recovery to optimize energy consumption or both.***

In addition to efficiency improvements, electrification provides several non-energy benefits like reduced waste, improved yield, quality, and safety. Other operational advantages include improved process speed, controllable heating, cleaner processing, and uniformity of the process environment.<sup>2</sup>

It is estimated that the European Union will invest an additional USD 370 billion in heavy industry sectors over the next thirty years on decarbonization of the industrial sector.

### Boilers

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<sup>2</sup> Beneficial electrification in industry, American Council for energy efficiency economy (ACEEE), 2020

Boilers are used to make steam in energy-intensive industries. Again industries are transitioning towards replacing natural gas-based boilers with electric boilers running on clean energy for emission reduction, and reliable storage becomes indispensable. Electric boilers can be readily integrated with other processes as they are easily programmable, and controllable, and maintain high efficiency regardless of the output range. They also cost 40% less than gas boilers.<sup>3</sup>

## Industry Specific Benefits of electrification

### PAPER & PULP

Electric boilers may be cost effective in cases where there is still moisture left in the wood. Green wood consumes just 10 Giga Joules while dried wood consumes nearly 20 Giga Joules inducing the need for energy efficient processing where wood has to be dried for further processing. Electric boilers may make the entire wood processing system relatively energy efficient.

### FOOD & BEVERAGE

Food industry is a large energy user mostly in the form of process heat. Preservation of moisture is required in some cases while in other cases, drying the food product completely off the moisture is required either for preservation or for low costs of shipment. Electric technologies such as ultra-sound assisted heating, electric magnetic heating become indispensable in these processes. Sugar production and lime kiln firing are high-temperature applications, and these processes are rapidly transitioning to electricity-based processes.

Reliable storage, and waste heat recovery from this industry are opportunities that Brenmiller can continue to capitalize on.

## Waste Heat Recovery and Thermal Energy Storage Market

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<sup>3</sup> ibid

Climate change has been the greatest challenge of our times, and the numbers of countries that have pledged to reduce carbon emissions to zero by 2050 continue to grow. As of April 2021, 44 countries, and the European Union, have pledged to meet the Net Zero target. These countries account for 70% of the global emissions of CO<sub>2</sub>. The Net Zero scenario would need all the least efficient coal plants to be shut down by 2030, the rest to be retrofitted by 2040, and the deployment of enough renewable energy plants to account for at least 90% of the total energy demand by 2050 and the rest from nuclear energy.

Further, industry emissions have to be cut down by 95% to achieve this goal. This would entail a ban on fossil fuel boilers to give way for innovative replacements, installation of carbon capture, utilization, and storage systems, and efficient recovery, and reuse of waste heat. Announced Net Zero pledges would cut emissions in 2050 by 60% in the electricity sector, 40% in buildings, 25% in industry, and just over 10% in transport.

The key pillars of decarbonization of the global energy system are energy efficiency, behavioral changes, electrification, renewables, hydrogen and hydrogen-based fuels, bioenergy, and CCUS. Among these carbon emission mitigation measures, while adopting renewable sources will result in the maximum contribution to the Net zero scenario, efficiency measures by industries and buildings are expected to contribute 3% and 7%, respectively. Electric vehicles are expected to contribute 18% of the reduction in CO<sub>2</sub> emissions.

***Frost & Sullivan believes that the mentioned areas could provide major opportunities for Brenmiller. In addition to its conventional solutions for TES in renewables and waste heat recovery for industrial processes requiring medium to high temperatures of up to 550°C in output, there is significant potential in participating in EV charging infrastructure where Li-ion batteries currently dominate.***

***Frost & Sullivan also believes there is a major opportunity to participate in the decarbonization of the booming Datacenters market in waste heat recovery and providing TES solutions as they shift to renewable sources, either in collaboration with Energy Services Companies (ESCOs) or through direct engagement.***

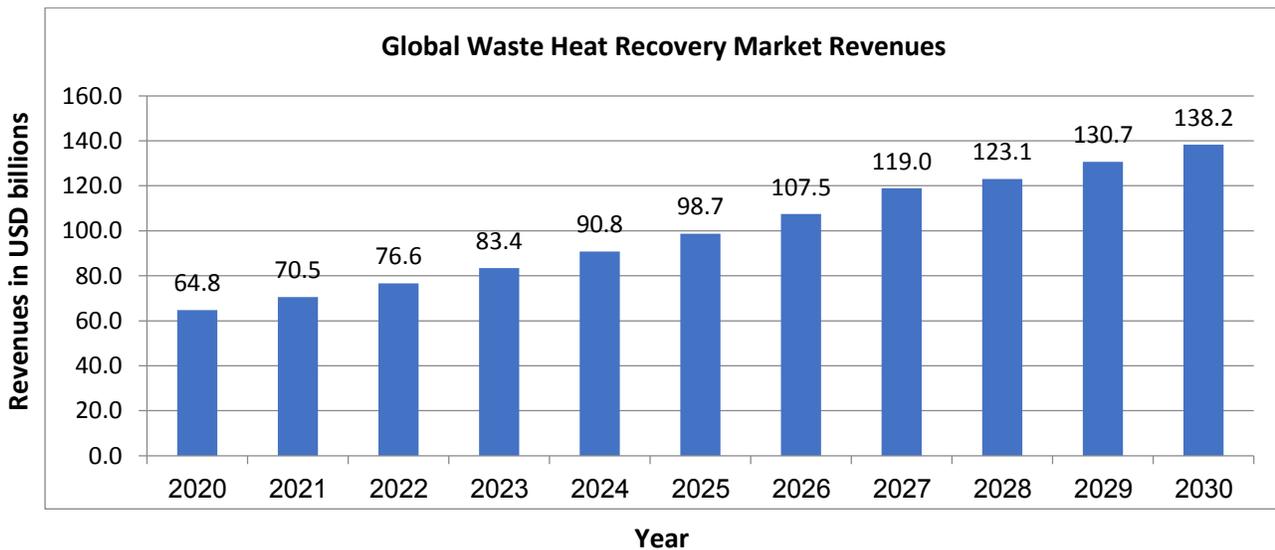
The Industry Sector is the largest global source of CO<sub>2</sub> emissions and has a vital role in achieving the Net Zero pledge. Industrial CO<sub>2</sub> emissions totaled to 8.4Gt in 2020, of which developing economies accounted for 80% and developed economies accounted for 20%. Heavy industries like Steel, Cement, chemicals accounted for almost 70% of the CO<sub>2</sub> emissions, and production of these is heavily concentrated in the emerging and developing markets, with China accounting for almost 60%. ***Brenmiller currently focuses on the food & beverage, pulp, and plastics industries and could potentially address other sectors, including steel, in the future.***

## WASTE HEAT

Waste heat recovery from industrial processes provides industrial clients tangible economic benefit in the form of reduced energy costs and improves their competitive position. Research studies estimate that 20 to 50 percent of energy consumption by the industrial sector is discharged as waste heat, and at least 18 to 20 percent could be recovered and reused.

***Brenmiller is in the medium temperature segment with the capacity for input heat of up to 700°C and output heat of up to 550°C to capture process steam and convert it to electricity in food processing, pulp and paper, and plastic industry.***

**Figure: Global Waste Heat Recovery Market Revenues**

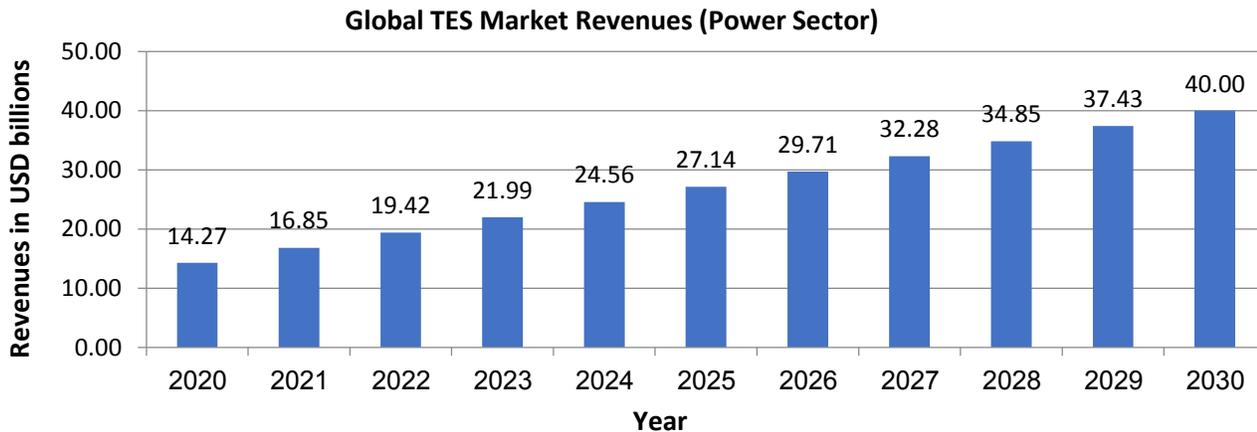


Source: Frost & Sullivan

## Thermal Energy Storage (TES)

The global TES market is expected to triple by 2030 and storage capacity is expected to increase to over 800 GWh from the current capacity of 234 GWh<sup>4</sup>. TES offers the benefits of demand shifting and seasonal storage. Some key barriers for the deployment of TES systems has been the relative immaturity of the technologies, uncertainty about their performance, lack of knowledge about their merits, the high costs of molten salts, the need for substantial backup of energy to minimize the risk of frozen salts, the corrosive nature of molten salts, and the limit of thermal stability of molten salts is at 565°C.

<sup>4</sup> Innovation Outlook : Thermal Energy Storage, IRENA, 2020

**Figure: Global Thermal Energy Storage Market Revenues from Power Sector**

Source: Frost &amp; Sullivan Analysis

## Growth Opportunities for Brenmiller by Geographies

### Europe

The binding target for countries in the European Union is to achieve an efficiency of 32.5%, translating to the primary energy consumption of no more than 1,273 million tons of oil equivalent (Mtoe) and final energy consumption of no more than 956 Mtoe in 2030.<sup>5</sup> There are at least 383 large industrial facilities located in this region that collectively consume more than 78,645 GWh of power. The waste heat recovery potential is much higher in Central Europe than in the rest of the continent.

### Israel

Israel envisages utilizing “natural gas or renewables only” for the production of energy by 2030 with 17% energy efficiency. This goal will entail shutting down coal-based plants with a capacity of 3.4 GWh, to be replaced with CCGT or dual-fuel plants. This transition is projected to produce a six-fold increase in renewables and a ten-fold increase in energy storage capacity. In 2030 Israel is positioned to be the world leader in solar energy dependency at a staggering 26% of the energy produced by the country. By 2030, 80% of the electricity generated in Israel will come from solar sources during the noon hours. In addition, several policy measures are expected to be imposed on electricity producers, like setting energy efficiency requirements as a part of their license conditions, promoting energy trading, and issuing energy efficiency certificates.

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<sup>5</sup> Eurostat

***It is estimated that NIS 7 billion will be invested in energy storage solutions. Brenmiller has provided storage solutions to the Israeli Defense Forces and is well poised to meet the demand for storage solutions with a targeted approach.***

## **Brazil**

Brazil has two major energy efficiency initiatives – the National Program for energy conservation (PROCEL) and the Program for Energy Efficiency (PEE). The PEE made it mandatory for businesses to invest at least 0.75% of their revenue in energy efficiency R&D and at least 0.25% into a program of energy efficiency. Brazil is a huge market for industrial thermal energy, and TES solutions may have huge opportunities in its cement sector. Brazil's share of renewable energy has remained over 40% over the last two decades. The need for storage solutions in Brazil is imminent. Brenmiller, with the right partnerships or JVs, has a major opportunity to capitalize.

## **The U.S.**

The industrial sector in the U.S. consumes the most energy than any other end-use sector, and it is projected to grow nearly twice as fast as any other end-use sector between 2020 and 2050. However, with several energy efficiency measures in place, the final consumption is set to reach 2019 levels by 2030. As the share of renewables increase, their intermittent nature is expected to be stabilized by investments in storage technologies, creating a huge potential for storage solutions providers like Brenmiller.

The Chemical, paper and refining industries require process steam and are the major end-user sectors of power and heat generated by Combined Heat and Power plants in the U.S. Clean energy storage solutions will further enhance the efficiency of such plants while also contributing to their energy efficiency targets.

## Additional Significant Growth Opportunities for Brenmiller

### Data Centers

Exponential growth is expected in data centers as global internet traffic is expected to double to 4.2 trillion gigabytes by 2025, mobile internet users to increase to 5 billion users in 2025 from 3.8 billion users in 2019, and IoT connections to double from 12 billion to 28 billion.<sup>6</sup> In 2019, data center energy represented nearly 1% of global energy demand at around 200 TWh.

The shift is towards hyperscale data centers, which are larger, high capacity, energy-efficient data centers compared to conventional data centers. Energy-efficient, self-contained data centers may require reliable storage systems that can recover, reuse, and store the waste heat from these large HVAC (heating, ventilation, and air conditioning) systems.

***Brenmiller is well equipped to leverage the growth opportunity present in the data centers market with its modularized solutions in the future, either purely for storage of renewable energy produced by these corporates in their facilities or for both heat recovery and storage.***

### Transition to Natural Gas-fired Power Plants from Coal-fired Plants

The transition from Coal to combined-cycle gas-fired plants is aiding the heat recovery and storage market. Coal power plants generate 40% of the world's electricity, with 80 countries heavily relying on coal for power generation – the top 10 of which account for 86% of the world's coal-fired plants' operating capacity – and 13 more planning to join them. 19 of these countries plan to completely retire coal plants in coming years in order to meet the goal of Net Zero, replacing them with natural gas-fired plants.

Combined Cycle Gas Turbine (CCGT) plants are energy efficient since waste heat is recovered, stored, and used to run the steam turbine to generate additional power, thereby maximizing the power output. Such plants in the U.S. have a combined installed capacity of over 67 GW, supplying 13% of the energy consumed in manufacturing and reducing CO<sub>2</sub> emissions by 200 million metric tons per year.

***Frost & Sullivan estimates that investments in new natural gas capacity will increase by nearly 377.5 GW between 2020 and 2030, with China and North America ramping up gas plant additions. Increased gas production, a better pipeline network in both countries, and lower gas prices favor gas power additions over***

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<sup>6</sup> Datacentres and Data Transmission Networks, IEA, June 2020

*coal, especially in CCGT plants, since it is a low-carbon power generation source with relatively high efficiency.*

## **Growth In Renewable Power Generation, Their Intermittency and The Need For Reliable Storage**

Electricity generated from renewable sources will increase from 26.1% in 2020 to 42.0% in 2030, rising at coal's expense, decreasing from 28.9% to 17.3%. One of the key outcomes of strong renewable investment has been high growth for energy storage solutions. Going forward, regulatory mandates and incentives for storage are likely to increase, further driving new investment. As the penetration of renewables increases rapidly, storage will play a pivotal role in ensuring grid stability and maximizing revenue opportunities from renewables – either through increased self-consumption to avoid high electricity costs and demand charges, or through selling electricity back to the grid at times of peak consumption. Given the cost advantages of SHS thermal storage as discussed elsewhere in this report relative to other comparable storage technologies, Brenmiller's addressable market is only growing larger.

## **Tapping into the growing ESCO/Energy as a Service (EaaS) Market**

Energy Service Companies (ESCO) were initially involved in improving energy efficiency for their customers coupled with equipment repair services. The Energy-as-a-service model encourages Distributed Energy Resources to meet customer's requirements without upfront costs or the skills required by the customers to install it themselves onsite otherwise. As Distributed generation grows, growth in storage requirement is expected to increase in tandem, which can be addressed by companies like Brenmiller with an innovative 'storage as a service' and their modularized solutions to new clients directly, or through partnerships with the EaaS service providers.

## 5. Competitive Landscape

Some of Brenmiller's closest competitors include Turboden (Italy), Ormat (U.S.), Alphabet Energy (U.S.), and Echogen (U.S.). The bGen system is the only solution in the industry to efficiently recover, store and reuse waste heat on demand. Brenmiller's patent gives it sufficient moat since few players in the market can promise the cost benefits and efficiency that Brenmiller promises. Most current players are either stand-alone WHR systems manufacturers or TES solution providers with other technologies whose advantages and superiority over Brenmiller are yet to be validated by the market.

***The bGen system is the only solution in the industry to efficiently recover, store and reuse waste heat on demand.***

## Appendix #1: About Frost & Sullivan

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