# Hot Spots for Renewable Heat

## Decarbonizing Low- to Medium-Temperature Industrial Heat Across the G-20

September 13, 2021

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# About this report

## About WBCSD

The World Business Council on Sustainable Development (WBCSD) is a global, CEO-led organization of over 200 leading businesses working together to accelerate the transition to a sustainable world. Our member companies come from all business sectors and all major economies, representing a combined revenue of more than $8.5 trillion and 19 million employees. Together, we are the leading voice of business for sustainability: united by our vision of a world where more than 9 billion people are all living well, within planetary boundaries, by 2050.

Our Climate & Energy program is designed to advance ambitious climate strategies and leverage the collective power of our members to accelerate climate recovery. We work to support and accelerate our members' plans to reduce and remove Greenhouse Gases (GHGs) and to develop resilient business models that can adapt to and maximize the opportunities from the low-carbon transition. We work across sectors and value chains, to integrate ambitious climate strategies, advance taxonomy and disclosure standards, advocate for policy intervention, and develop innovative solutions.

## About BloombergNEF

BloombergNEF (BNEF) is a strategic research provider covering global commodity markets and the disruptive technologies driving the transition to a low-carbon economy. Our expert coverage assesses pathways for the power, transport, industry, buildings and agriculture sectors to adapt to the energy transition.

BNEF's heating and cooling team focuses specifically on the challenges and opportunities faced by corporations, governments and households as they look to transition to low-carbon sources of heat. Our global coverage looks across all the different technologies, policies and costs. We put this research within the wider context of decarbonization to understand and identify impacts on other sectors.

## WBCSD and BloombergNEF Collaboration

This report is intended to provide guidance on the markets that are particularly attractive for renewable heat solutions. It also explores the applicability of specific technology solutions. This report is co-produced with BloombergNEF, a WBCSD member whose proprietary data, insights and guidance have been instrumental in producing this analysis.

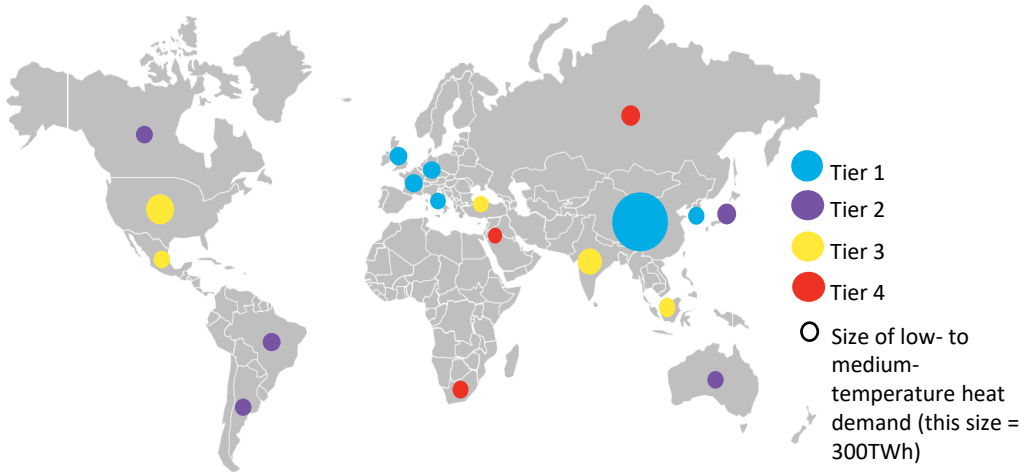
# Executive Summary

**The transition to low-carbon energy is well underway within the electricity sector, yet little progress has been made in decarbonizing industrial heat. This will be the next challenge for corporations on their path to net-zero. This report seeks to point industrial end-users towards markets with the best conditions to support the transition, as they begin to deploy renewable heat.**

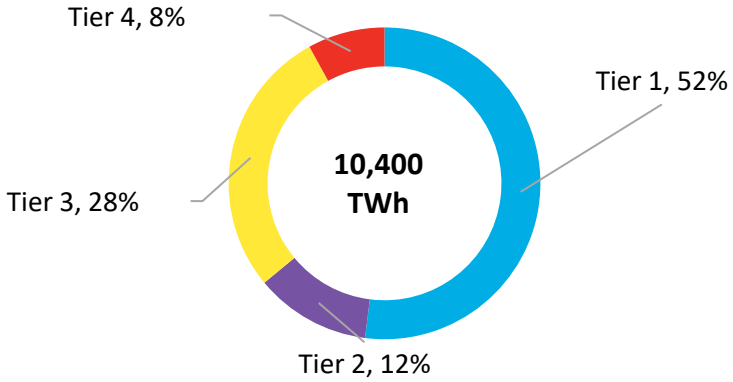
- Heat is essential to most industrial processes. It is the energy input that triggers the chemical reactions to make medicine and cleaning products. It is needed to transform metal ore into steel and, eventually, consumer goods like cars. It is used to pasteurize milk, brew beer and dry paper. Most of this heat is generated using fossil fuels like coal, gas and oil.
- Several renewable heat technologies are commercially available today to replace fossil fuels. These include industrial-scale heat pumps, electric boilers, solar thermal, geothermal and bioenergy. However, fossil fuel combustion is cost-competitive in most markets and has held back the uptake of renewable heat technologies.
- This report examines the ease of deploying renewable heat technologies in the Group of 20 (G-20) member countries, based on the presence of supportive policies, resource availability, and current economic conditions. It specifically focuses on low- to medium-temperature heat (<400°C), which is used in most light industry – especially food and beverage, pulp and paper, household chemicals, and pharmaceuticals.
- The most attractive markets to deploy renewable heat solutions today are China, France, Germany, Italy, South Korea and the U.K. These markets scored on average 19 out of the 30 points available. They rank highest because of their national-level policies, high existing renewable heat deployment and strong potential for future investment.
- More must be done to enable deployment of renewable heat across industrial sites. Supportive policies and enabling financing structures will be critical.

## Most favorable G-20 countries for low- to medium-temperature industrial heat decarbonization

G-20 ranking and size of low- to medium-temperature demand




Proportion of low- to medium-temperature heat demand




*Source: BloombergNEF, IEA. Note: TWh = terawatt-hours.*

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# Part 1

## Decarbonizing low- to medium-temperature industrial heat: the opportunity

# Industrial heat accounts for 29% of global energy demand

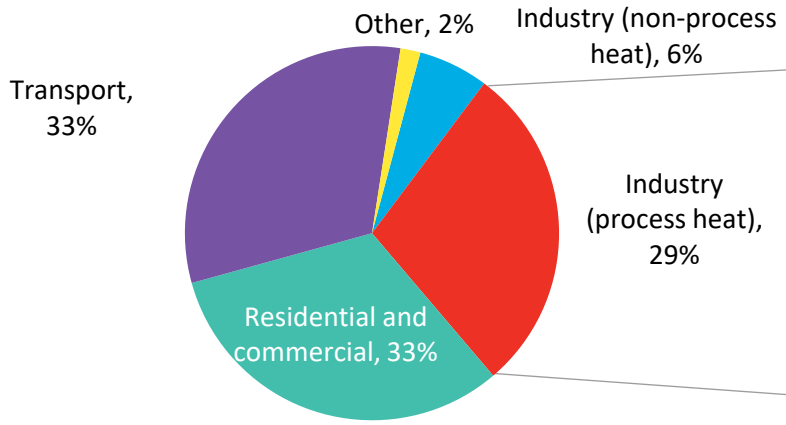
**Process heat in industry accounts for a third of global final energy demand today and demand is expected to keep growing to 2050.**

- Within total industrial energy use, process heat accounts for the vast majority in most industries (around 80%), while the remainder is used for electrical processes (such as cooling and powering motors) and non-process operations (including lighting).
- Process heat refers to energy input as part of thermal manufacturing processes, including material transformations and chemical processes. Process heat is used to manufacture many consumer products, such as paper, chemicals and food and beverages.

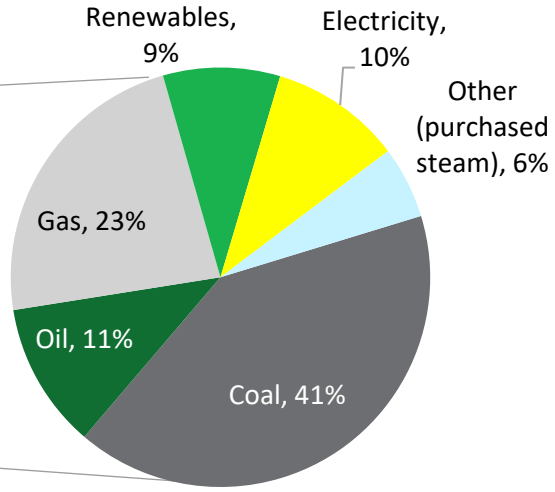
**Industrial sites rely overwhelmingly on fossil fuels to generate process heat.**

- Coal is the dominant fuel for industrial heat, making up over a third of all energy supplied for process heat in 2018. Coal, gas and oil account for 75% of total fuel supplied to process heat, but this share varies across different industrial sectors and countries.
- Less than 10% of global process heat is generated directly from renewable sources, primarily biomass and waste, which is concentrated in specific geographies and industries. This makes it difficult to scale production sustainably.

## Industrial heat use relative to global final energy consumption, 2018




## Global industrial heat production by fuel source, 2018




*Source: IEA, BloombergNEF. Note: IEA balances include combustible fuels consumed by industrial end-users, which are almost entirely used to generate process heat. Electricity use for non-process heat was assumed as 20% of total fuel use in low- to medium-temperature industries and was excluded. Coke ovens and blast furnaces are included in iron & steel, while fuels used as feedstock or in transformation industries (eg, petrochemical refineries) are excluded.*

# Decarbonizing industrial heat is key to achieving climate goals

**Industrial process heating emitted 7.5 metric gigatons of carbon dioxide in 2016.**

- This is equivalent to 15% of all greenhouse gas emissions, about the same as total emissions from the transportation sector.

**Decarbonizing industrial heat will play a key role in achieving net-zero targets.**

- Some 70% of the G-20 countries have either set net-zero targets or they are under discussion.
- More than 20% of the world's 2,000 largest public companies, representing sales of nearly $14 trillion, have set net-zero targets as of March 2021.[1]

**Introducing renewable solutions for industrial heat will be crucial.**

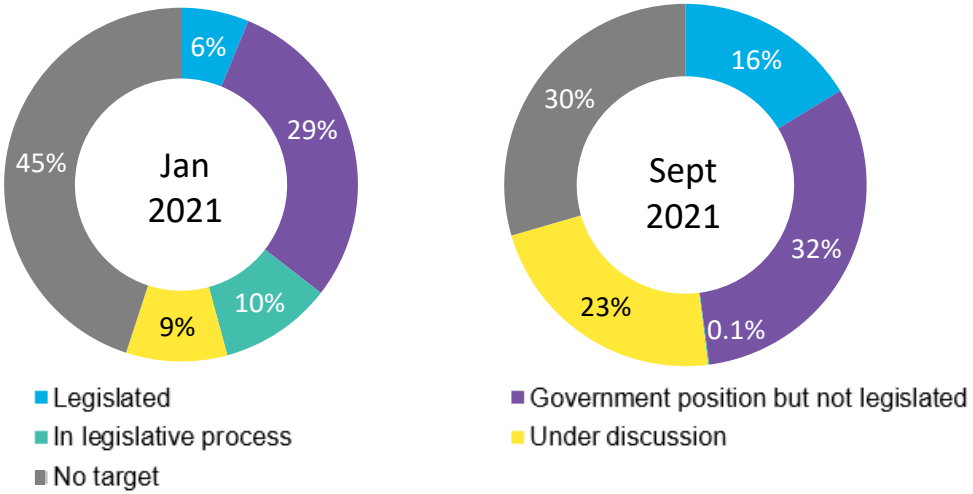
- In many industries, heat represents a larger portion of demand than power. While many companies have deployed renewable electricity at scale, most industrial heat is still provided by fossil fuels.
- Fuel switching from fossil fuels to renewable heat technologies is the focus of this report. But this is not the only pathway — energy efficiency and the circular economy will also play an important role in decarbonizing industrial heat.

**G-20 countries are responsible for almost 80% of fuel use in industry.**

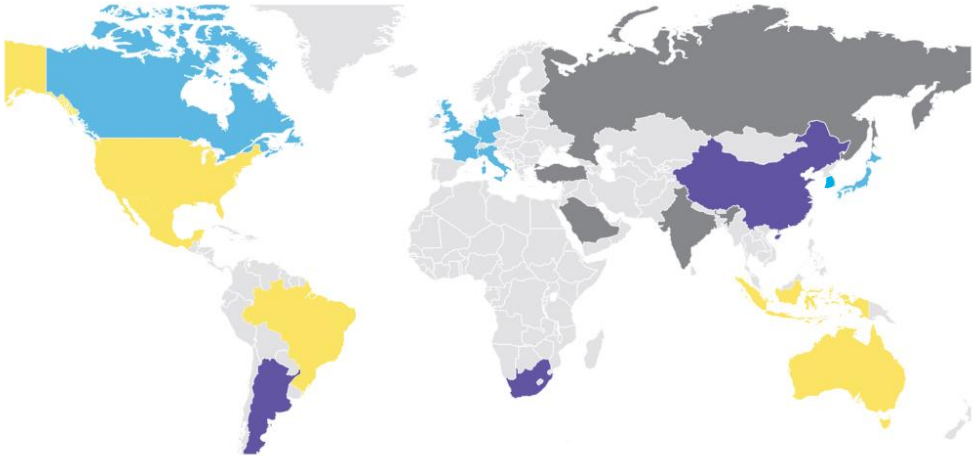
- This report identifies the most attractive markets to decarbonize renewable heat across the G-20. The 19 individual country members of the G-20 represent the largest economies and emitters and as such, a significant opportunity to decarbonize.

## Status of net-zero emission targets

Share of global emissions




G-20 countries net-zero emissions targets



*Source: Governments, WRI CAIT, BloombergNEF. Note: Greenhouse-gas emissions including land use and forestry covered by an EU national or state-level target.*

[1] *According to a report by The Energy & Climate Intelligence Unit and Oxford Net Zero.*

# Significant investment will be needed to transition industrial heat

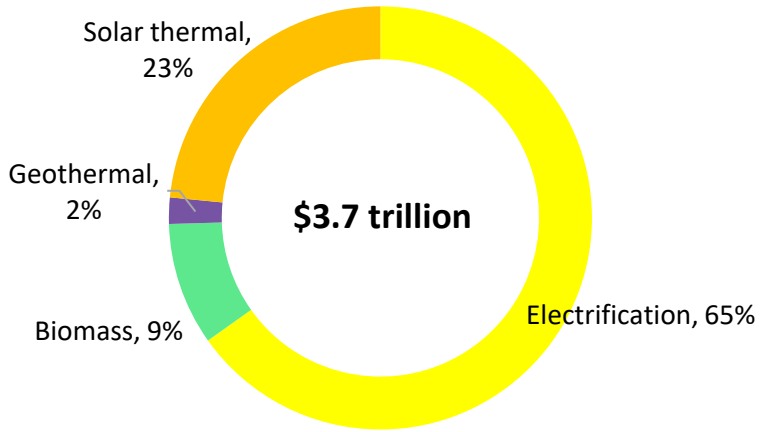
**Decarbonizing industry comes with a significant price tag.**

- Investment in low-carbon forms of industrial heat has lagged behind other sectors, such as the power sector. This leaves a large gap to fill. IRENA estimates around $3.7 trillion worth of investment will be needed to support the deployment of low-carbon fuel sources across all industrial processes by 2050. This would put industry on track to achieving their 1.5 degree scenario.
- Electrifying process heat has a significant role to play, with over half of all investment needed by 2050 focused on electrification.

**Supportive financial policies and regulation will be necessary.**

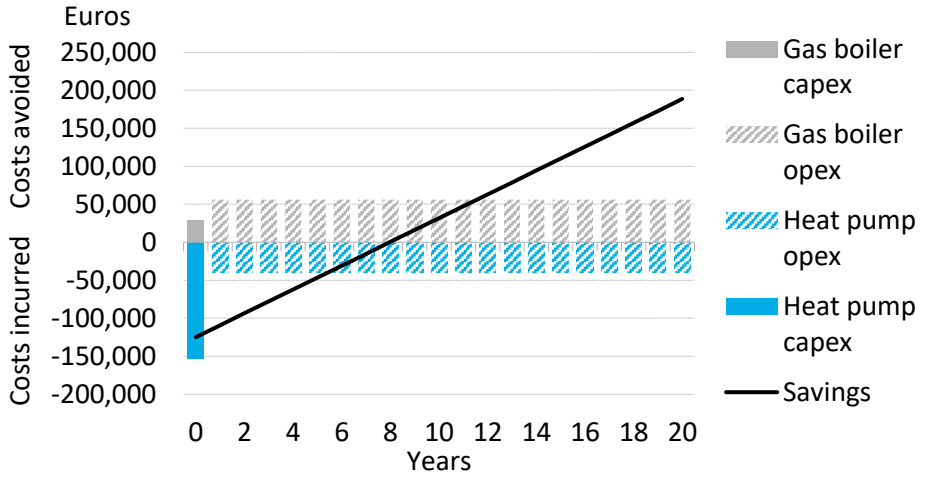
- Renewable heat options often come with higher upfront cost and long payback periods. This has been a persistent barrier to uptake. Supportive policies and regulatory environments that lower investment hurdles, such as off-balance sheet financing mechanisms, will be key.

## Estimated cumulative investment needed in renewable heat for industry by 2050




*Source: IRENA. Note: Estimated investment under IRENA's Energy Transformation Scenario. Includes all industry.*

## Example net present cash flow for an unsubsidized industrial heat pump in Germany



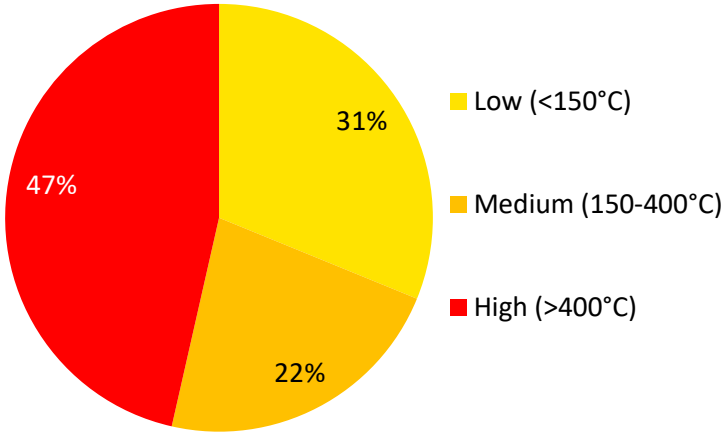

*Source: BloombergNEF, McKinsey&Company, Eurostat, IEA. Note: Illustrative only. Capacity of the heat pump 217kW with a COP of 3.63. Natural gas boiler is assumed to be 85% efficient. The heat pump and gas boiler are assumed to operate at 90% capacity annually. No discount rate has been applied. Excludes costs related to unit maintenance.*

# Not all heat is equal: temperature matters

**Industrial processes are diverse and temperature requirements vary significantly by industry and process.**

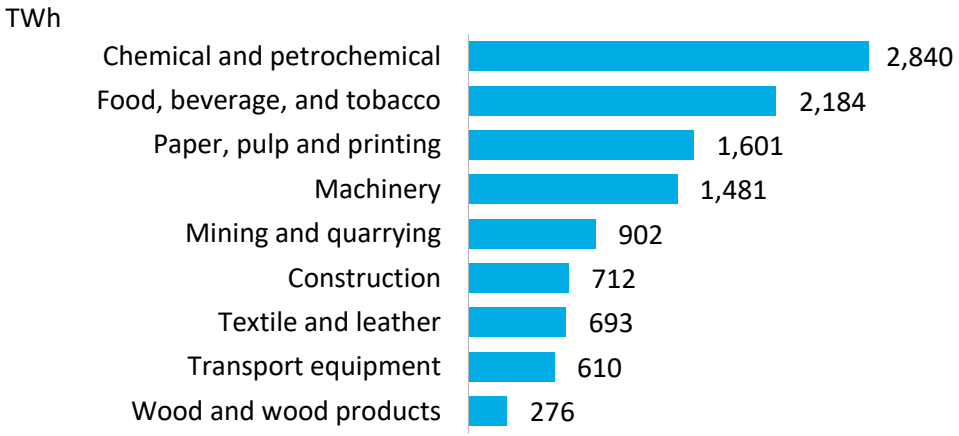
- Industrial process temperatures range between 50°C to 2,000°C (120-3,600°F) and can be grouped into three bands: low (<150°C); medium (150-400°C) and high (>400°C). About half of global industrial heat is high-temperature and half is below 400°C (752 °F).
- Industries like steel and cement rely heavily on high-temperature heat. The industries that dominate low- and medium-temperature industrial heat demand include chemicals (including detergents and pharmaceuticals), food and beverage, pulp and paper and machinery.
- Even within these industries, the processes that rely on low-temperature heat are diverse. They range from drying processes (present in everything from chemicals to wood to paper), to baking and pasteurizing, to distilling, bleaching, dyeing and boiling.
- Low- to medium-temperature processes are often separate from the source of heat generation, meaning the technologies used to produce heat can more readily be swapped as they are not involved in the process directly. There are many commercially available low-carbon technologies, especially for temperatures below 400°C; for more see slide 9.

## Global industrial heat demand by temperature, 2018




*Source: IRENA, IEA*

## Demand for low- to medium-temperature heat in selected industries globally, 2018



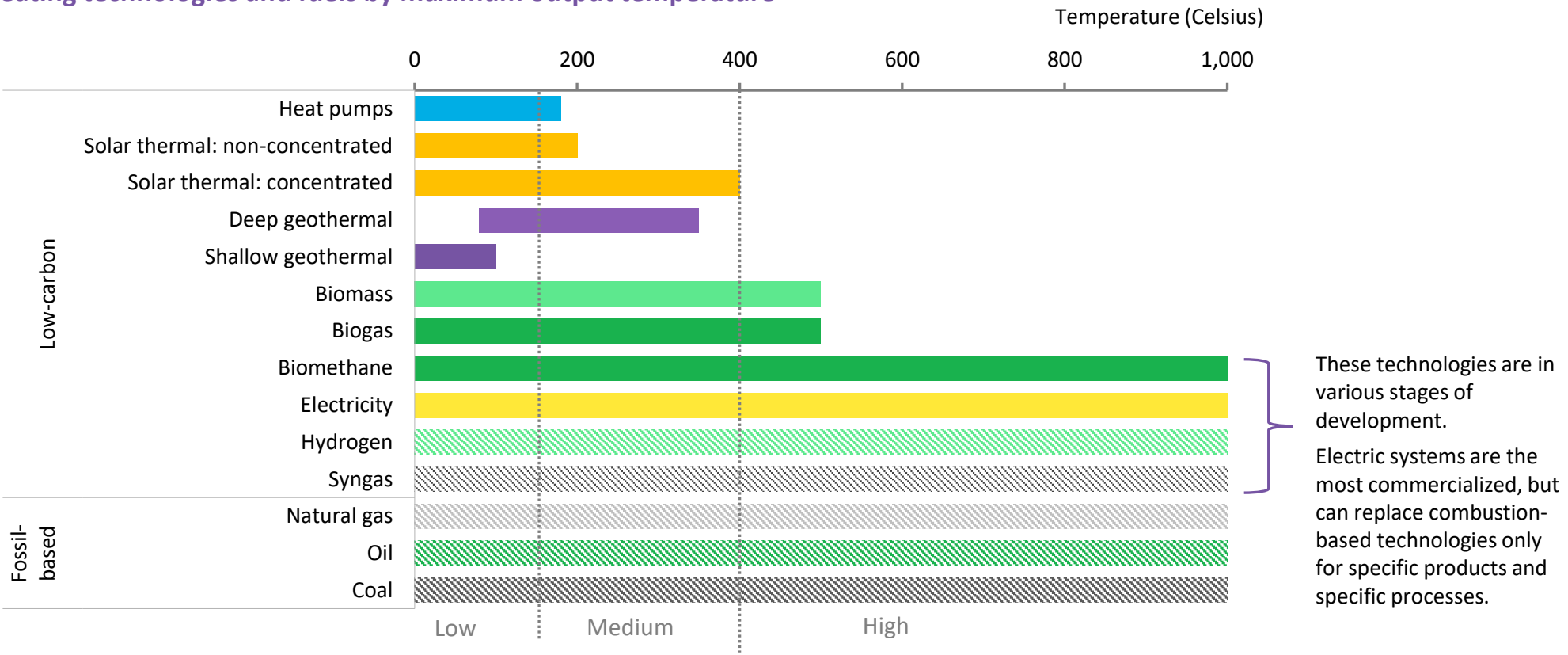

*Source: IEA. Note: Demand for low- to medium-temperature heat in energy-intensive industry is excluded since it represents a small portion of the total and is usually available as a by-product of high-temperature heat.*

# Low-carbon technology solutions do exist

**It is possible to decarbonize low- to medium-temperature heat with technologies that are commercially available today.**

- This report focuses on industrial-scale heat pumps, solar thermal, geothermal, various forms of bioenergy and direct electrification technologies. These technologies are commercially available to be deployed today but face specific barriers and opportunities. For more, see part three.
- There are fewer options available today to decarbonize high-temperature heat with renewable technologies. While green hydrogen and syngas could be used for low- to medium-temperature heat, we expect their initial deployment will primarily focus on high-temperature heat applications. They are therefore outside the scope of this report.

## Heating technologies and fuels by maximum output temperature




*Source: Oxford Energy Institute, BloombergNEF, EHPA, IEA-SHC. Note: Shaded technologies/fuels were not included in the scope of this analysis.*

# Low- to medium-temperature heat processes are concentrated in G-20

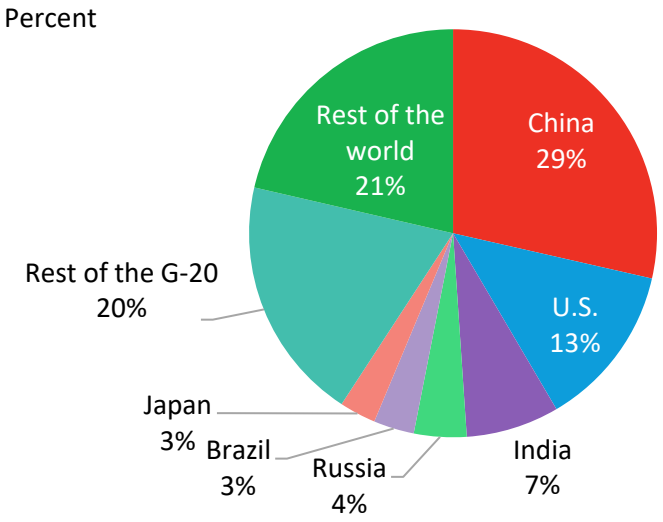
**Around 80% of global low- to medium- temperature industrial heat use is concentrated in the G-20.**

- China has driven industrial heat use and continues to dominate global demand. In general, India and China have seen strong growth in process heating, a trajectory that is expected to continue due to increased manufacturing output.
- Conversely, the U.S., EU and Japan have experienced a steady decline in process heat use. Despite this decline, their share of low- to medium-heat use remains large because of existing manufacturing facilities.

**Heat requirements in G-20 countries vary based on industry presence.**

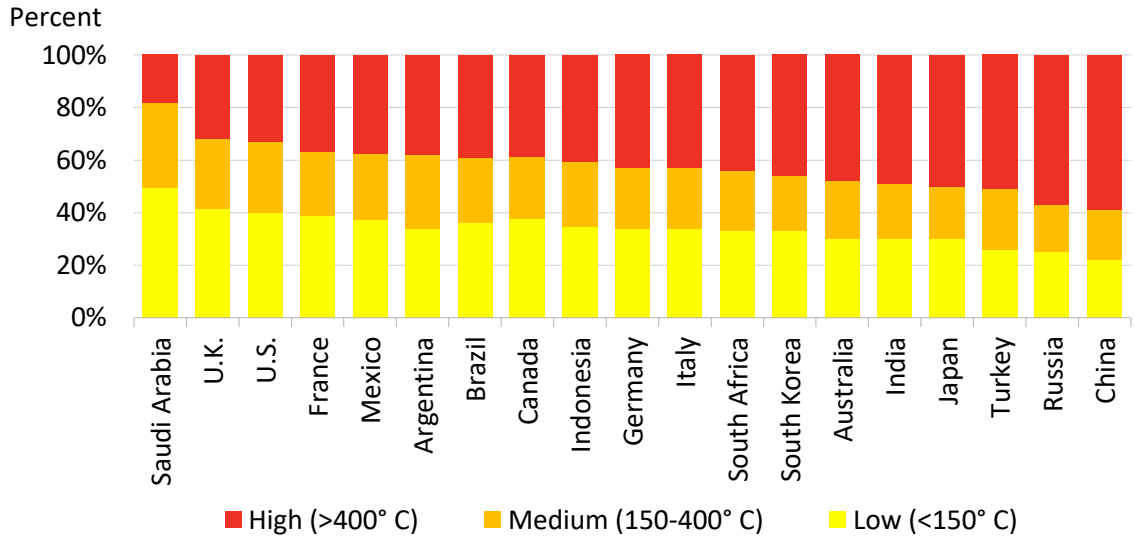
- Low- to medium-temperature heat makes up over half (58%) of total G-20 industrial heat demand on average. This is driven largely by the U.K., U.S., France, Mexico, Argentina, Canada and Brazil. In these markets, over 60% of industrial heat needs require temperatures below 400°C.
- While China has a lower portion of demand for low- to medium-temperature heat (40%), its high absolute demand means that it still represents the largest opportunity for decarbonization.

## Demand for low- to medium-temperature heat by country, 2018




*Source: IEA, IRENA. Note: Based on total energy consumed by industry in each country.*

## Industry heat needs across the G-20 by temperature range, 2018




*Source: IEA, IRENA. Note: Based on total energy consumed by industry in each country.*

# Part 2

## Results of the G-20 ranking

# Ranking methodology

This report ranks the G-20 countries on their ease for deploying renewable technologies for low- to medium-temperature industrial heat. The ranking is based on three main areas of consideration: market conditions, policy and resource availability and climatic conditions.

## Methodology

**Market conditions**

Energy prices, fossil fuel industry presence and renewable technology deployment

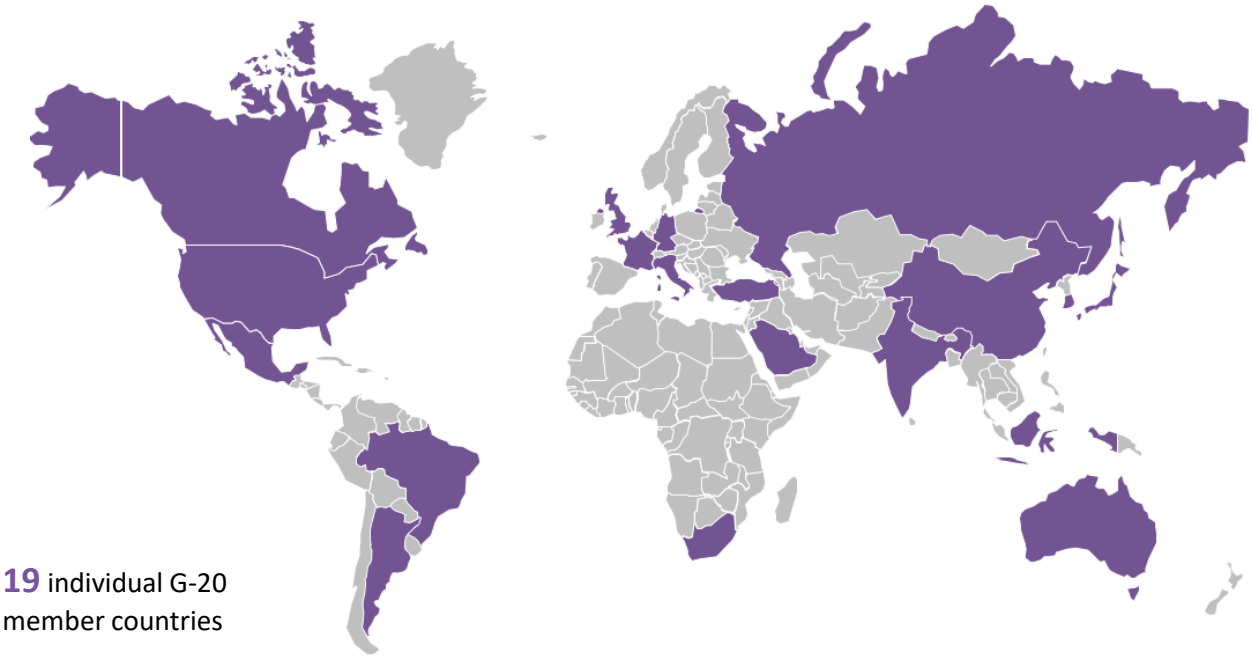
**Policy**

Environmental standards, grants and incentives and carbon pricing schemes

**Resource availability & climatic conditions**

Technology potential and power grid coverage and reliability

## Coverage



**19** individual G-20 member countries

To see all the variables we considered and the Methodology, visit the Appendix.

*Note: The G-20 includes 19 individual countries and the EU. While we did not include every EU country in the analysis, the three individual countries in the EU (Italy, France, Germany) are broadly representative of bloc-level policy.*

# Six countries claimed the top spot for renewable heat

**China, France, Germany, Italy, South Korea and the U.K. rank in the top tier for deployment of renewable heat.**

- The top performers represent the best markets for industrial players looking to transition to renewable heat.
- Countries that scored highly had favorable market conditions (such as low power-to-gas price ratios) and relatively mature markets for renewable heat solutions (indicating a ready presence of installers and maintenance providers). This cohort of countries is also set apart by the strong presence of favorable policies, including prices on carbon.

**The second tier includes Argentina, Australia, Brazil, Canada and Japan.**

- Second tier markets offered favorable – but more challenging – environments for renewable thermal solutions.
- These countries tended to score well in one area, while lagging in others. For instance, they often had historical deployment of renewable heat solutions, but less robust policy and less competitive energy pricing for renewable heat.

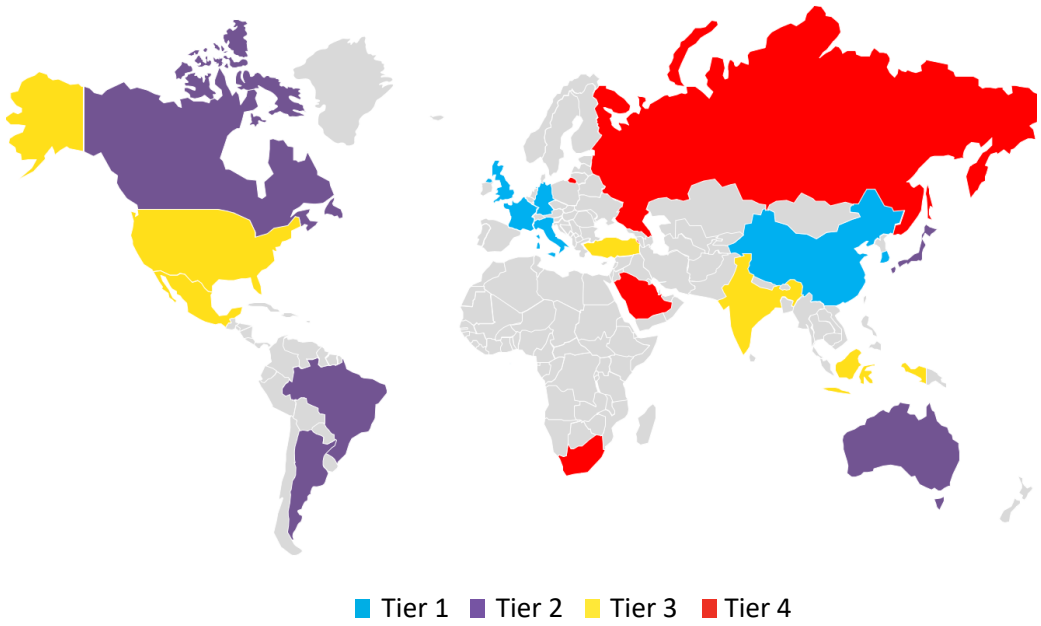
**The third tier includes India, Indonesia, Mexico, Turkey and the U.S.**

- The third tier has limited or no favorable policies which was especially true for the U.S. and Indonesia. Without a clear direction of travel, industrials are less likely to adopt renewable heat technologies.
- Market conditions also tend to be worse in these countries compared to higher tiers.

**The bottom tier consists of Russia, South Africa and Saudi Arabia.**

- Countries in the fourth tier scored poorly in all categories.
- They featured very challenging market conditions. These countries all have a significant fossil fuel presence as well as cheap natural gas, coal and oil. Low-scoring countries also tended to have less electricity grid access, or grids with low renewable power penetration.

## G-20 country scores



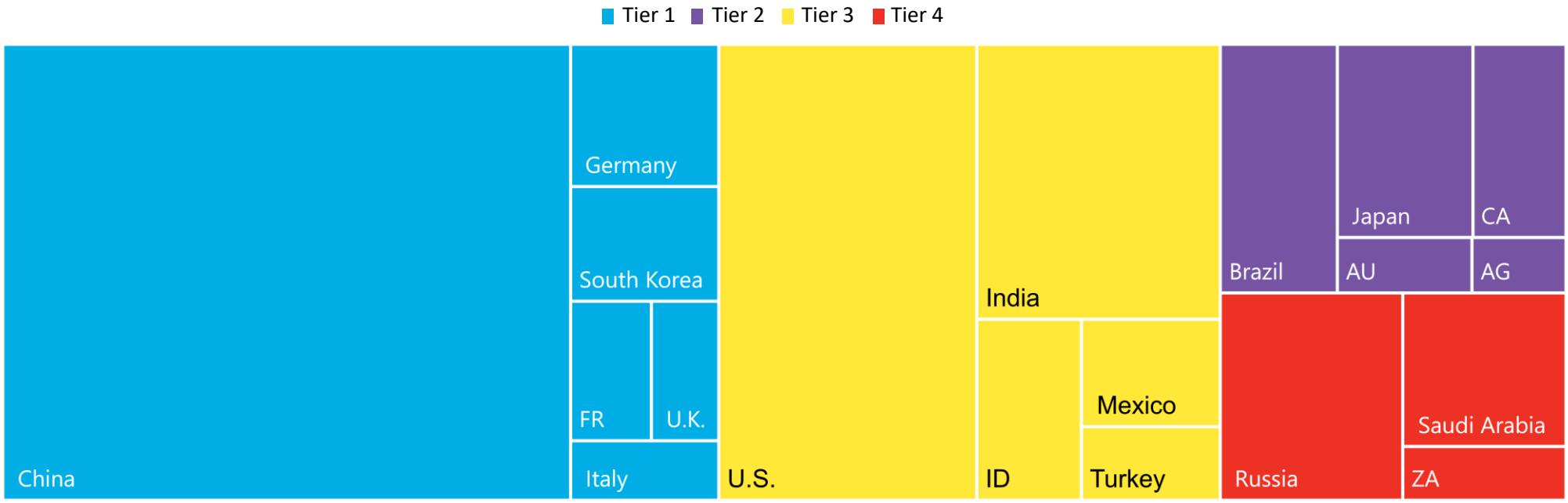

*Source: BloombergNEF.*

# The top tier markets make up almost half of G-20 heat demand

**Large opportunities exist across all G-20 countries.**

- Countries in tier one represent almost half (46%) of all low- to medium-temperature heat demand today, which is a promising sign for industrials looking to decarbonize.
- China is the leading force out of the top performers, with both high demand and a relatively attractive environment to deploy renewable heat solutions.
- Meanwhile, the U.S. and India, who represent the second and third largest portion of demand respectively, have room for improvement. Cheap fossil fuels and very limited policy and regulatory support at the national level are barriers to renewable deployment in both countries. Setting targets and implementing policies will help to create investor confidence.
- Demand from Russia and Saudi Arabia alone exceeds that of the three major economies in the EU. Both countries sit in the lowest performing group.

## Low- to medium-heat demand by tier




*Source: BloombergNEF. Note: AG = Argentina, AU = Australia, CA = Canada, FR = France, ID = Indonesia, ZA = South Africa*

# Understanding the methodology

**No country scored particularly highly on readiness for renewable heat.**

- Even Tier 1 markets scored an average of 19 out of a maximum possible score of 30.

### Market conditions

- Market condition indicators are weighted highest in our ranking due to their impact on potential deployment. Country metrics focused on cost, including the price of existing fossil fuel sources and carbon pricing (if present), as well as past deployment of renewable heat technologies (marked by installed capacity and market presence).
- Tier 1 and 2 countries tended to do well on market conditions.

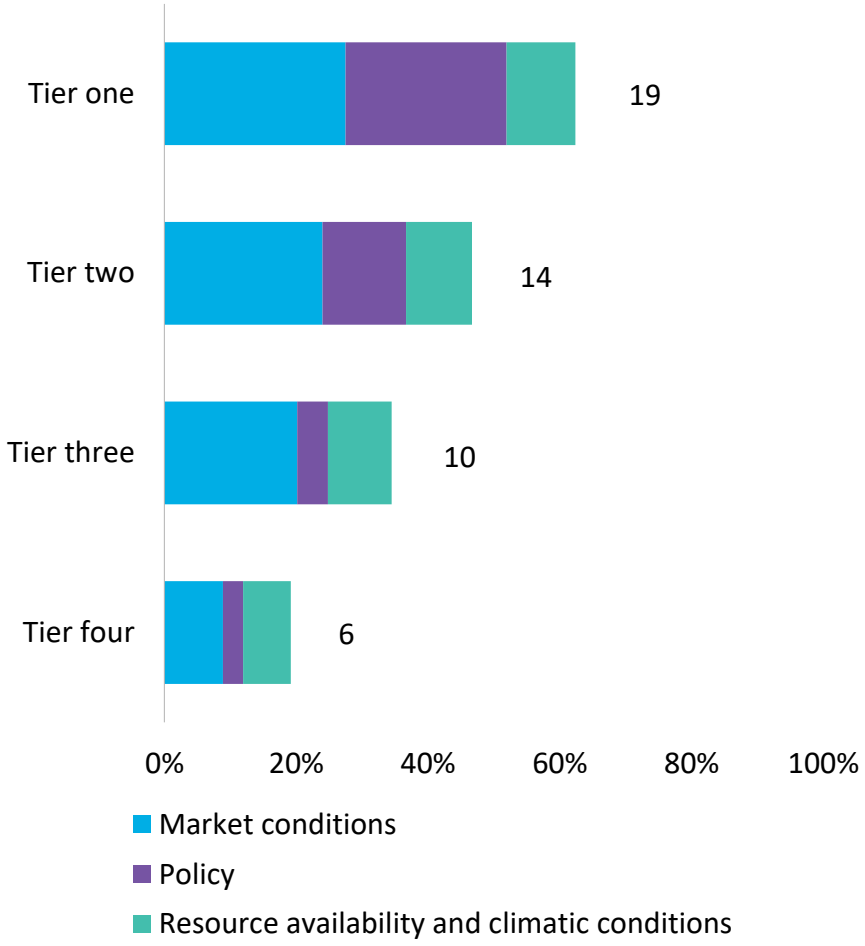
### Policy

- The policy indicator awarded points for the presence of existing policy incentives and frameworks that would support renewable heat. Policies included heat targets, mandatory emission standards for industry, or incentives reducing capital needs and operating costs. Only national policies are covered – state- and city-level policies are excluded.
- These policies will play an important role for deployment in the coming years and therefore got the second strongest weight in the ranking. By and large, only Tier 1 countries performed well on this metric.

### Resource availability and climatic conditions

- Resource availability and climatic conditions indicate the potential to access different natural renewable sources competitively. This indicator has the smallest influence on the overall ranking. Renewable heat solutions, such as bioenergy or geothermal, are hyperlocal. This means the extent to which they can be sourced competitively can vary significantly both between and within countries.

**Average ranking for each tier by indicator**




*Source: BloombergNEF*



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# Commercial viability of renewable heat can be achieved in the near term

**To enable industrials to deploy renewable heat solutions at scale and at pace, all markets need to improve. Countries that want to improve their ranking and the deployment of renewable heat within their borders, should focus first on setting supportive policies.**

- Putting a price on carbon helps industrials identify where fossil fuel combustion is likely to become less cost-competitive.
- Incentives can help increase deployment of innovative and early-stage technologies, such as industrial-scale heat pumps that can reach higher temperatures.
- The International Renewable Energy Agency (IRENA) and REN21 are increasingly focused on promoting supportive policy environments for heat, which raised awareness among member countries. Currently, countries are three times less likely to have specific renewable heat targets in place compared to electricity, according to IRENA — but this gap should begin to narrow.

**Several ongoing market developments will positively affect the competitive environment for renewable heat.**

- Corporate net-zero goals mean that more companies are focused on renewable heat. Such targets cannot be met with power purchase agreements for renewable electricity alone; firms must also address their industrial heating processes if Scope 1 and 2 emissions are to be reduced.
- Mass deployment of renewable heat technologies and market maturity will reduce capital costs. This will increase availability and make technology solutions competitive across different markets.
- Electrification is expected to play a major part in decarbonizing the less energy-intensive industries. To source 100% of their renewable power from the grid, corporates will need access to a reliable, smart grid.
- As power grid operators look to manage the deployment of more intermittent renewable generation, heat loads can be used to help balance supply and demand, which will further help the business case for electrification.

**Financial instruments are needed to support decarbonization.**

- Improving regulatory frameworks that allow for off-balance sheet solutions will maximize corporate sourcing of renewable heat. These would allow assets to be purchased without a corresponding balance sheet liability, which keeps debt-to-equity and leverage ratios low. As with electricity, third party financing solutions with no balance sheet impact are expected to help facilitate the decarbonization of industry.
- Investor interest in carbon-intensive industry is dwindling across many institutional investors. This is likely to reduce the ability of the fossil fuel industry to influence policy and makes financing new fossil fuel infrastructure more challenging. Meanwhile, investors are increasingly excited about industrial decarbonization solutions.

# Part 3

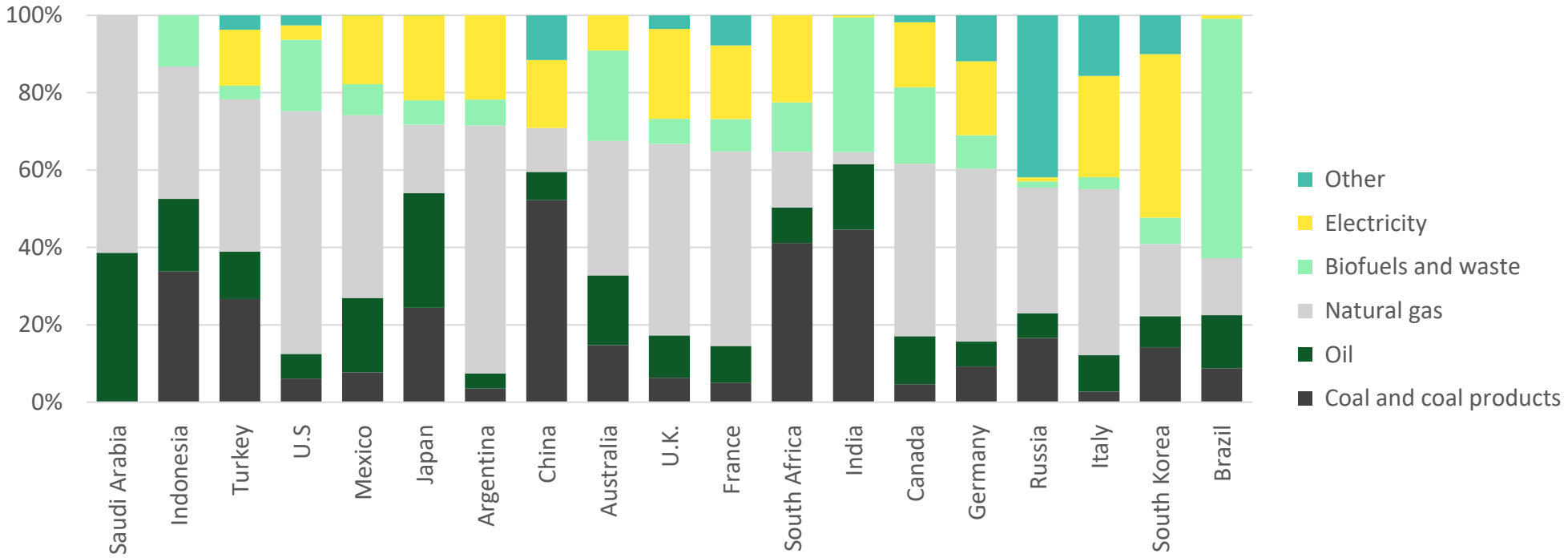
## Renewable heat technology profiles

# Technology-specific insights

**Some G-20 countries have already started to integrate renewable heat technologies, but a large opportunity remains.**

- Energy use across the G-20 varies significantly. Countries such as the U.S., France and the U.K. rely heavily on natural gas to provide their low- to medium-temperature industrial heat. Meanwhile, China, India and Japan still use substantial amounts of coal and oil. Of the small amount of renewable heat technologies being used, bioenergy and electricity currently represent the largest share.
- The potential for different renewable heat technologies varies across the G-20 countries and was not captured in the technology-agnostic ranking. The following section will discuss the opportunity for each renewable heat technology and highlight attractive markets based on technology-specific considerations. It is worth noting that every technology will benefit from attractive energy prices and supportive policy.

## Low- to medium-temperature fuel use across the G-20, 2018




*Source: IEA. Note: 'Other' includes district heat, geothermal, solar, nuclear and wind. IEA balances include combustible fuels consumed by industrial end-users, which are almost entirely used to generate process heat. Electricity use for non-process heat was assumed as 20% of total fuel use in low- to medium-temperature industries and was excluded. Coke ovens and blast furnaces are included in iron & steel, while fuels used as feedstock or in transformation industries (eg, petrochemical refineries) are excluded.*

# Bioenergy

Bioenergy is one of the largest renewable heat sources consumed in industry today. On average, it accounted for 13% of low- to medium-temperature heat in the G-20 in 2018. However, its use is constrained by resource availability and sustainability concerns.

Various forms of bioenergy exist:

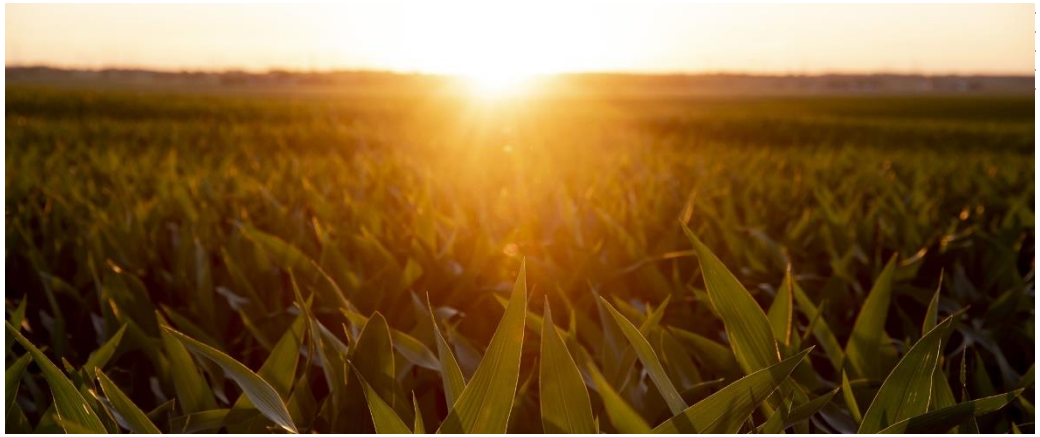
- Direct combustion of biomass waste, residues or by-products collected from another process, such as manure.
- Biogas formed from anaerobic digestion of organic matter, landfill gas recovery systems, gasification or wastewater treatment plants.
- Biomethane, which has higher concentrations of methane, either from 'upgraded' biogas or through the gasification of solid biomass.[1]

**Opportunities**

- The use of bioenergy is currently concentrated in the pulp and paper sector, where residues from the processing of wood products such as black liquor are readily available.
- The food, beverage, and tobacco sector presents an opportunity for greater use of waste agricultural products, including rice husks and sugarcane fibers (bagasse).

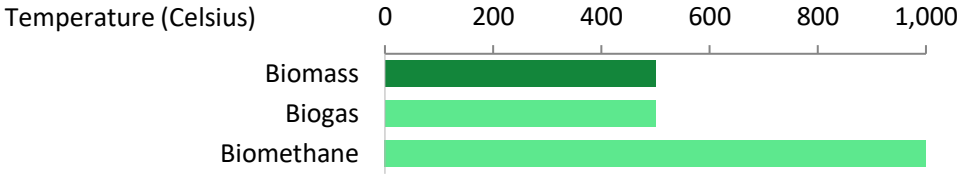
**Challenges**

- Feedstock availability can limit output, while anaerobic digestion also requires consistent feedstock quality.
- There is no clear definition of what constitutes sustainable bioenergy, or agreement on how to calculate associated emissions. Competing needs for land and water resources favour use of waste feedstocks over dedicated energy crops, which limits supply.



*Source: Bloomberg LP*

## Temperature range of bioenergy for heat




*Source: BloombergNEF*

**Factors to look for that support bioenergy adoption**

- Proximity to sustainable feedstock options, such as agricultural residues or organic waste produced on-site or near the facility to reduce transport cost and emissions.
- Combined heat and power opportunities, which bring in added revenue.
- Mature markets, where corporates are willing to take on risks associated with feedstock and plant performance.

**Attractive markets**

| | | | |
|---|---|---|---|
| Brazil | Indonesia | South Africa | China |

[1] *Biomethane is 'pipeline quality' biogas and can be interchangeable with natural gas. It is often called 'renewable natural gas' in the Americas.*

# Electrification

Electricity on average provided 15% of industrial low- to medium-temperature heat use in the G-20. Electrification has significant potential to scale its use and the corresponding emissions will improve as the grid continues to decarbonize.

Various forms of electrification technologies exist:

- Industrial-scale heat pumps combine electricity with heat transferred typically from a waste heat stream. Another option is mechanical vapor recompression. MVR operates like a heat pump, but instead of a refrigerant it compresses water vapor to produce steam.
- Resistance heating, including electric boilers and furnaces, pass an electric current through a material to generate heat.
- Electromagnetic heating – such as microwaves, radiowaves or infrared – uses wavelengths in the electromagnetic spectrum to generate heat within a material.

**Opportunities**

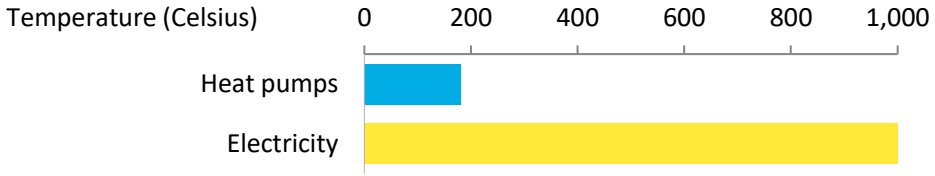
- Electrification is currently concentrated in the food, beverage, tobacco and machinery sectors.
- The chemical, pharmaceuticals and textiles sector all present opportunities for electrification.

**Challenges**

- Some electric technologies are not yet commercially available.
- Price of electricity compared with fossil fuels makes direct electrification cost-prohibitive in many markets.
- Industrial-scale heat pumps are limited to applications under 200°C.
- Some markets may have lower penetration of renewable electricity or barriers to signing power purchase agreements (PPAs).

*Source: Bloomberg LP*

## Temperature range of electrification for heat




*Source: BloombergNEF*

**Factors to look for that support electrification**

- A higher portion of renewables in the grid, or availability of PPAs.
- Favorable power-to-gas price ratio, either through high absolute costs of natural gas or low-cost electricity.
- Accessible, reliable and affordable waste heat for industrial-scale heat pumps.

**Attractive markets**

France | Germany | South Korea | Australia

# Geothermal

Geothermal refers to systems which extract heat from under the earth's surface. Geothermal systems have been largely concentrated in countries with significant amounts of natural geothermal resources.

There are three main types of geothermal energy systems:

- Deep geothermal systems use steam captured and transported from below the earth's surface for direct use.
- Shallow geothermal systems use the same premise as deep geothermal but at shallower depths and lower temperatures. Shallow geothermal is seen as less intrusive and disruptive, but often requires a heat exchanger to boost the temperature for use in industry.
- Enhanced geothermal systems pump water underground to take advantage of the earth's natural temperature gradient. These systems are still under development.

**Opportunities**

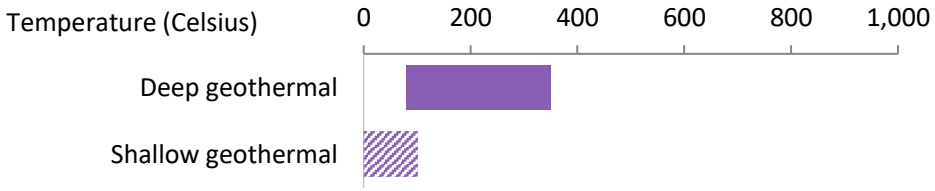
- Geothermal has primarily been used in energy-intensive industry and in countries with access to geothermal resources.
- With increased availability of shallow geothermal technology, more geographic opportunities will emerge. However, the opportunity will still be limited based on achievable output temperature.

**Challenges**

- Region-specific resource availability.
- High upfront costs to develop geothermal sites and drilling risks for deep geothermal sites.
- Shallow geothermal is not yet commercially available and deep enhanced geothermal is still under development.

*Source: Bloomberg LP*

## Temperature range of geothermal for heat




*Source: BloombergNEF*

**Factors to look for that support geothermal adoption**

- Strong existing geothermal markets in high-temperature industry.
- Geothermal generation in the power mix indicates existing technological expertise and resource availability.
- Experience with excavation and drilling, such as from natural gas or oil exploration.
- Use and experience with industrial-scale heat pumps (applicable for shallow geothermal applications).

**Attractive markets**

U.S. China Indonesia Japan

# Solar thermal

Solar thermal refers to systems that make use of energy captured from the sun. Solar thermal is currently a niche market, with limited deployment in low- to medium-temperature industries to date.

Two different forms of solar thermal exist:

- Non-concentrating solar thermal includes flat-plate solar collectors to generate hot water and evacuated tube solar collectors to generate steam.
- Concentrating solar technologies include compound parabolic concentrator technologies. These differ from non-concentrating applications in terms of size and the temperature they can generate. Deployment usually occurs at a larger scale, typically over 50MWth.

**Opportunities**

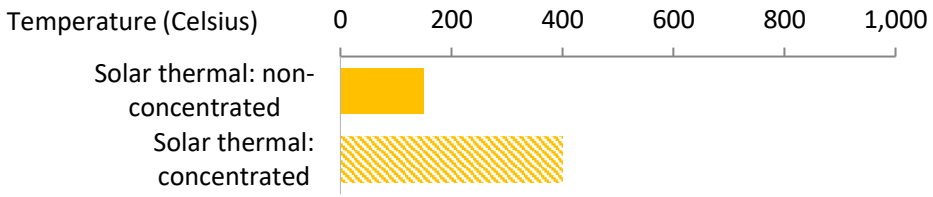
- Deployment has been concentrated in food and beverage, textile and mining sectors.
- Most processes that require low-temperature hot water and are currently using steam could, in theory, use solar thermal.

**Challenges**

- Solar thermal plants are space-intensive. Space constraints at industrial sites and competition from solar PV – which at present often provides better economics – hamper deployment.
- Awareness of and familiarity with the technology is low across the value chain and makes development challenging for industrials. Sophisticated commercial service offerings are limited in many markets due to low market penetration.
- Lack of technological maturity has affected investor confidence in the technology.

*Source: Bloomberg LP*

## Temperature range of solar thermal for heat




*Source: BloombergNEF, IEA-SHC*

**Factors to look for that support solar thermal adoption**

- Higher solar irradiance will boost the utilization rates and economic performance of solar thermal facilities.
- Presence of manufacturing sites that only use low-temperature heat and do not cascade down waste heat from medium-temperature processes.
- For concentrated solar power, climates with limited cloud coverage are key.

**Attractive markets**

China | Mexico | Germany | Australia

# Appendix

## Methodology

# Methodology

This ranking has involved collating new data from primary sources, utilizing proprietary data sets from BloombergNEF, identifying proxies where data was unavailable, quantifying all data and interpreting the relative importance of each variable.

As such, the ranking is an indicator of a country's environment for renewable heat, not an exact determination.

The authors recognize that individual variables such as a particularly high carbon tax, or an especially low gas-to-power price ratio can make a renewable heat project viable in what is otherwise a non-noticeable market. Additionally, resources such as biomass, geothermal and solar thermal are hyperlocal, which leads to varying levels of competitiveness within countries across the G-20.

*Source: Bloomberg LP*

# Metrics used to inform the ranking

| Category | Indicator | Explanation |
|---|---|---|
| Market conditions | Natural gas prices relative to electricity prices | Indicates the economics of switching from natural gas to electric technologies |
| | Absolute price of natural gas | Outlines the potential of fuel switching from natural gas |
| | Presence of coal and oil in industry | Markets with accessible and affordable coal and oil will be more challenging |
| | Absolute carbon price | The level of the carbon price impacts the economics of fossil-based technologies |
| | Existing solar thermal market for process heating | All three indicators showcase the level of in-country availability and expertise in installing and using the technology for industrial end-users |
| | Existing geothermal market in industry and power | |
| | Existing bioenergy market in industry and power | |
| Policy | Energy efficiency incentives on end-products | For more on any of the policy indicators, see BNEF's *G-20 Zero-Carbon Policy Scoreboard 2021* (web). |
| | Renewable heat target or emission target on industrial heat | Targets set direction and clarity for industrial users |
| | Operating cost subsidies on electrification or renewables technologies | Subsidies both upfront and ongoing help to support deployment and mature the supply chain |
| | Upfront cost subsidies on electrification or renewables technologies | |
| | CO2 pricing or fossil-fuel ban for industrial heat (or biggest subsectors) | The presence of a carbon price signals a commitment towards decarbonization |
| | Obligatory standards or mandates on products or companies | Minimum standards or mandates can encourage adoption of renewable heat technologies for these standards to be met |
| Resource availability and climatic conditions | Percent of the country with electric grid access | For more on both indicators, BNEF clients can refer to *Country Data Tool* (web \| terminal) |
| | Renewable share of power generation | |
| | Corporate PPA capacity | Ability to procure renewables supports electrification |
| | Direct horizontal irradiance | Indicator for solar thermal potential |
| | Potential for deep geothermal | Indicates the natural endowment of geothermal resources in a country |
| | Potential for shallow geothermal | |
| | GDP from agriculture and forestry | A proxy for potential access to agricultural residues that are used as a common feedstock for bioenergy |

*Source: various sources, BloombergNEF*

# Market conditions: retail prices key to enable renewable heat

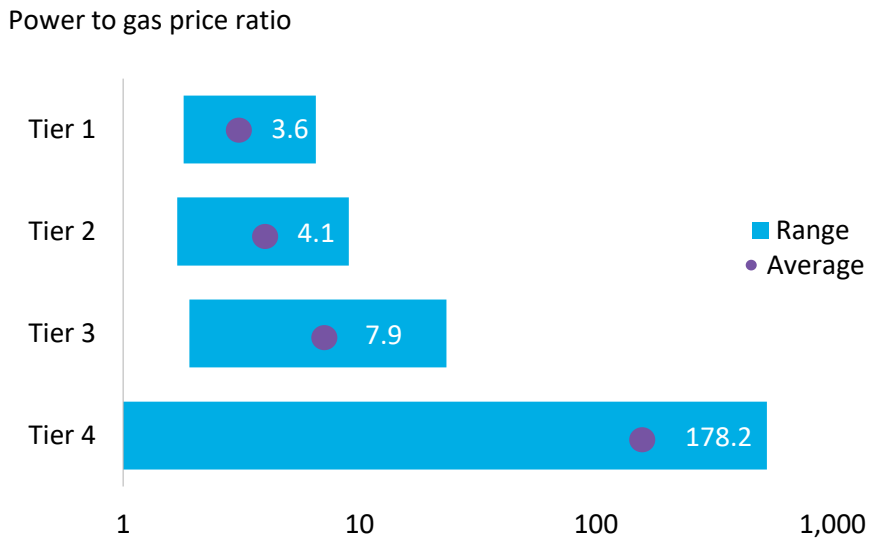
Power and gas prices are among the key metrics to capture how favorable a market is for renewable heat deployment. The average gas price paid by an industrial player, in absolute terms, reflects the economics for fuel switching. Cheaper gas prices would make it more difficult for renewable heating sources to compete. Tier 4 markets have the lowest industrial gas prices on average, followed by Tier 3 markets.

For electrification, a key metric is the ratio between gas and power prices. This is because gas furnaces and electric units – especially heat pumps – have very different efficiencies. Electric resistance heating, for instance, usually has a 100% efficiency of electricity consumption to heat production. For industrial heat pumps, efficiency is captured by a co-efficient of performance. This reflects the amount of useful heat provided by one kilowatt-hour of electricity consumed. A typical range of COPs for industrial heat pumps is 3.5 to 5.5.

A power-to-gas price ratio of at least 1 implies that electric furnaces would cost the same as gas furnaces to operate, while a ratio of between 3 to 5 is enough for heat pumps to compete economically. This means electric solutions were more likely to be cost competitive in Tier 1 and 2 countries.

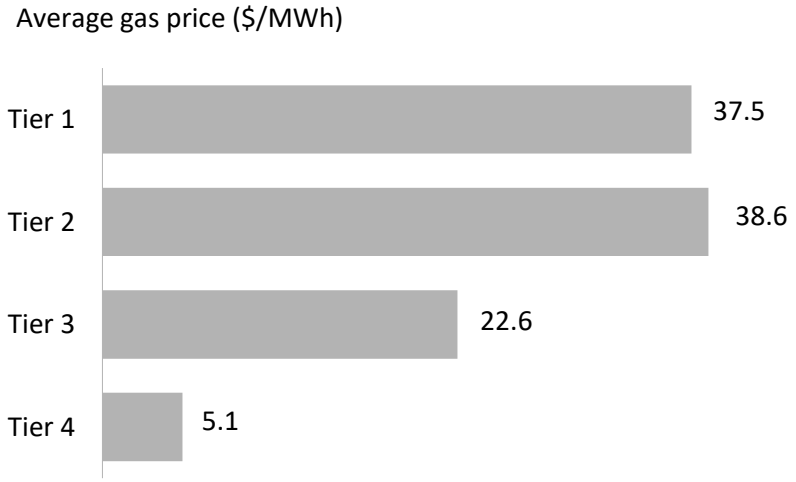
Some G-20 markets – including South Africa, India and China – do not have a lot of natural gas use in industry. In these instances, other indicators such as the presence of coal or oil played a greater role.

## Ratio of power to gas price for industrial players by tier




*Source: BloombergNEF, WBCSD. Note: Logarithmic scale.*

## Average gas price for industrial players by tier




*Source: BloombergNEF, WBCSD*



BloombergNEF | wbcsd

# Policy: upfront cost subsidies are an area to focus for many countries

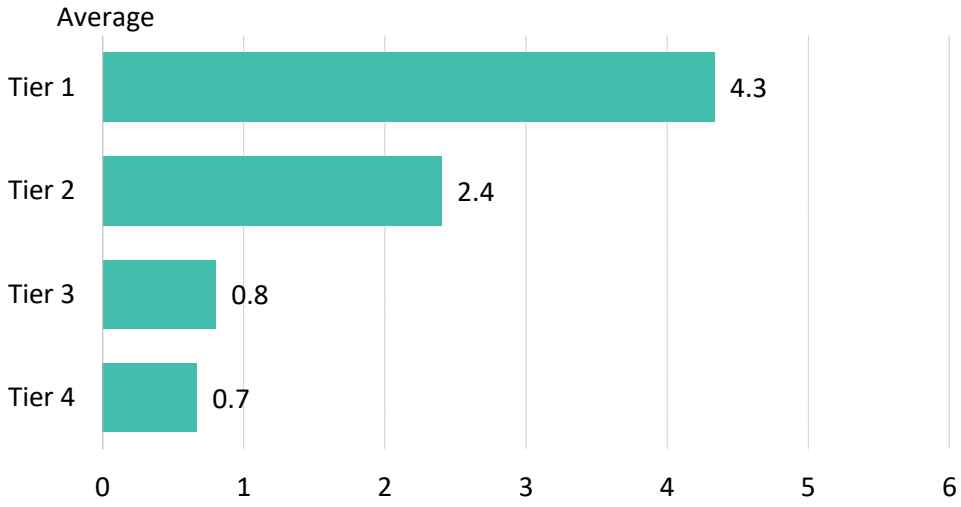
Policy remains a key driver for industrial heat decarbonization because of the poor market conditions in many G-20 markets and will likely play a significant role for many years to come. Within this analysis, G-20 countries who had implemented policies driving decarbonization, such as a carbon price or upfront subsidy scheme for renewables, were awarded points.

Renewable heat targets focused on industrial decarbonization are relatively rare in the G-20. Just four out of 19 markets (21%) have a clear policy in place. These help to signal to market players and investors a government's intended direction of travel and will be important as the sector moves forward.

Tier 1 countries had the most policies implemented, ticking on average four out of the six policies included in this analysis. European countries stood out and make up half of the countries ranked in Tier 1.

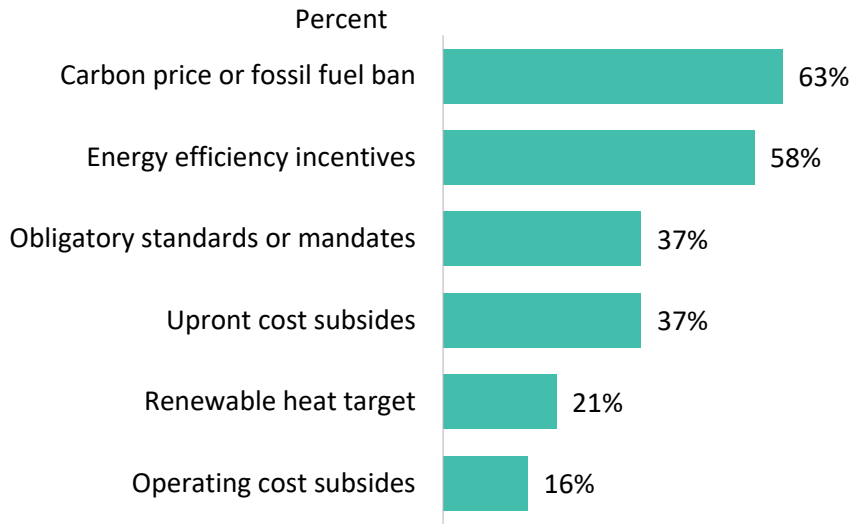
A price on carbon or a ban on the use of fossil fuels should help incentivize renewable heat across all technologies. Some 12 of the 19 individual countries (63%) have such a policy, making it the highest implemented across the G-20. Upfront cost subsidies were only implemented in just over a third of G-20 countries. Subsidies have a significant impact on deployment and should be a policy focus for countries without such a scheme.

## Average number of implemented industrial heat policies by tier




*Source: BloombergNEF, WBCSD.*

## Percentage of G-20 countries with implemented industrial heat policies by policy type




*Source: BloombergNEF, WBCSD.*

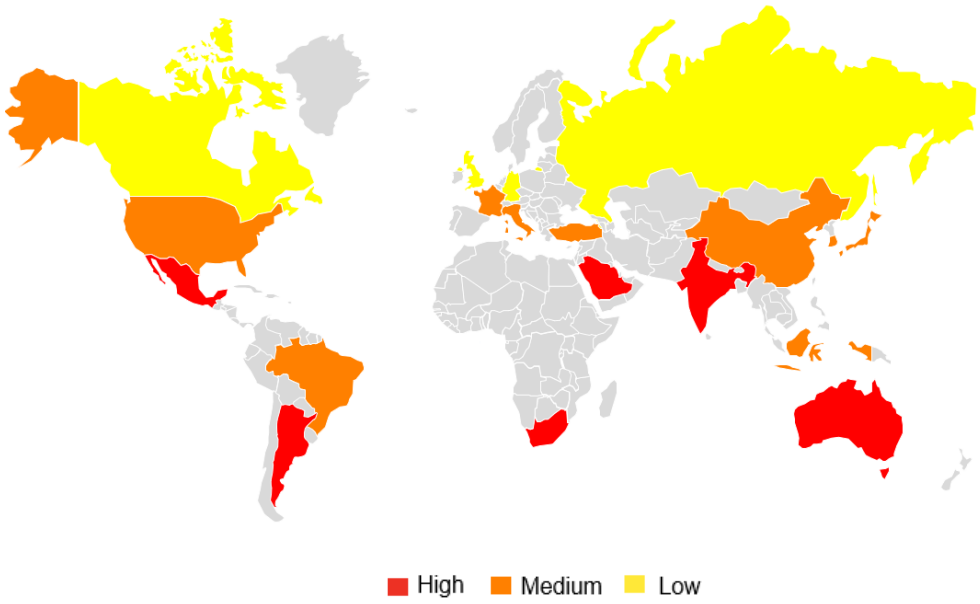
# Resource availability and climatic conditions: part of it is luck, part is effort

For some renewable heat technologies, deployment is linked to specific resources or climatic conditions. Deep geothermal, solar thermal and bioenergy all rely on conditions that may only exist in a certain area. As such, some countries will be better placed to exploit these resources, although there will be a huge variance of availability within countries.

Resource availability and climatic conditions focused on identifying the key factors which enable and support deployment of specific technologies. While some of the metrics come down to the geography and resource, countries were also rewarded for creating an environment for deployment. For example, having a developed PPA market is beneficial as it can support greater electrification.

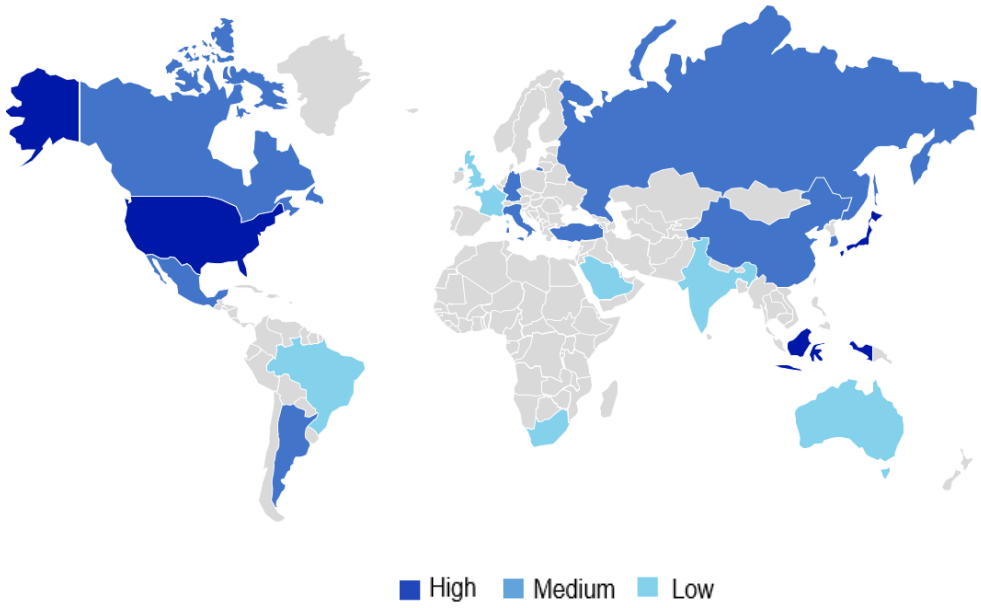
Ultimately, the variety of use cases and technical solutions means each country or even region has a unique optimal path to decarbonize heat.

## Potential for solar thermal across the G-20




*Source: BloombergNEF, WBCSD.*

## Potential for deep geothermal across the G-20




*Source: BloombergNEF, WBCSD.*

# Authors

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