CLIMATE INNOVATION IN THE NORTHEAST, 2000-2020

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Benjamin Gomes-Casseres
Peter A. Petri Professor of Business & Society

with the able research assistance of:
Shan He, MSBA'21
Klodeta Janaqi, MBA'21
Rohan Nagi, MBA'21
Sunny Hong, MBA'19
Jacob Judd, MA'20
Frida Petersen Albert, MA'20

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Foreword

We believe that climate change is everyone's business. At Brandeis University, this means that diverse departments and schools address the challenge in different ways. At Brandeis International Business School, we help young leaders understand the business of climate change and empower them to explore innovative solutions. And we teach them that data is power.

This report presents new data on the companies and people that are leading climate innovation in our region. It complements earlier reports by others that analyze macroeconomic and national data. Our micro-level data show that the business of climate change is becoming more diverse in its industrial activities and in the people who lead it. Climate tech has grown over time to include more solutions and business segments, and its leaders have gradually included more women and minorities. But there is much to do if this industry is to truly become everyone's business.

A team of six graduate students in economics, business and data analytics prepared the analysis, under my supervision. We were advised by business professionals with long experience in clean energy and experts at the Northeast Clean Energy Council and Cleantech Open Northeast. The work was supported by the Asper Center for Global Entrepreneurship at Brandeis International Business School, and IP.com shared their patent data with us. Thank you all!

We hope that this report is a first installment in a longer-term effort to document and understand how the region's entrepreneurs are fighting climate change. The graphs are meant to provoke thinking and discussion, and perhaps will inspire more young leaders to enter the fray. We welcome your involvement in this effort.

Benjamin Gomes-Casseres
Peter A. Petri Professor of Business and Society
Director, Asper Center for Global Entrepreneurship

This report is a current snapshot of the climate tech ecosystem in the U.S. Northeast, which in this study includes the states of Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. It shows, graphically, the industrial activities of 494 startup companies created in the region since 2000, as well as the gender and ethnic identities of the leaders of these companies. The aim of the report is to tease out aggregate patterns in the data, not to test a theory or find causal relationships. We present these patterns here to encourage discussion and further study. Our main findings are:

- Climate startups are everywhere in the region, but concentrated in cities in Massachusetts and New York.

- Companies are widely distributed across "climate tech" sectors, which include core "clean energy" sectors and other sectors that can provide climate change solutions, from agriculture and waste management to software analytics.

- Most companies have under 50 employees; many have under 10. The bulk of total employment is in companies with over 50 employees.

- The pace of new company formation increased before 2010 and has remained high since then. Patents show an increasing pace of invention since 2005. Over time, a few companies have gone public and more have been acquired.

- The distributions of funding and of patents are highly skewed. The top 5% of firms accounted for the bulk of funding and patent filings in every sector.

- Different sectors in the ecosystem have different strengths. Agriculture attracted the most funding, transportation filed the most patents, and energy distribution and generation were strong in both aspects. Most companies were formed in energy generation and information technologies.

- Women represented one-sixth of all company leaders in 2020. This share has been growing gradually in the last decade, reaching one-quarter in the latest five-year period.

- Almost one-quarter of company leaders were ethnic minorities, and a third were minorities or women. These shares, too, have been growing gradually in the last decade.

This study is a first attempt to measure the characteristics of companies and personnel in the Northeast climate tech ecosystem. As such, it has limitations. In particular, the data for very recent years is likely incomplete due to reporting lags, and our sample surely does not cover the full population of companies. We assume that the sample is representative of the population in broad strokes, but there is no way to fully test this assumption. We hope that future studies can build on what we offer here.

Section I
**Startup Companies in Climate Innovation, 2000-2020**

The exhibits in this section give a snapshot of the startup companies involved in climate innovation in the Northeast, based on publicly available data in Crunchbase, Pitchbook and other sources. A total of 494 companies are included, using a broad definition of "climate tech" that reflects multiple ways in which innovators are responding to climate change. These companies were active in 2020, were founded in the preceding 20 years and are still privately-held companies. They are usually not brand-new startups, as almost all show evidence of revenues or funding. Startups that were acquired or that went public over the years are excluded from this snapshot and are shown separately in one chart.

Variables measured are:

- Location
- Founding dates
- Sectors
- Employment
- Funding
- Patents

Further details about sources and methods are in Section III of this report.

Exhibit 1 | **Climate startups are everywhere in the region, but concentrated in cities in Massachusetts and New York.**
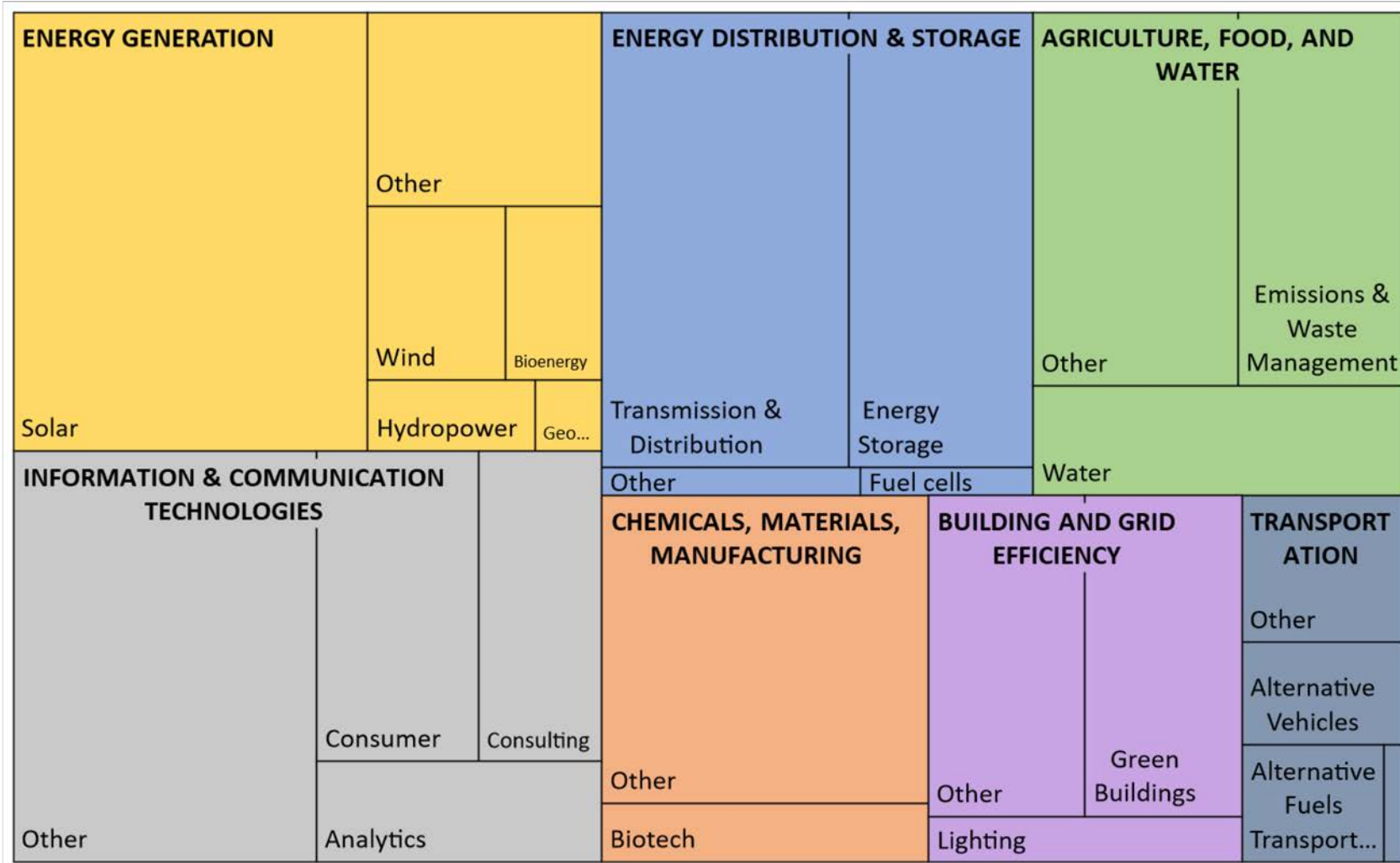
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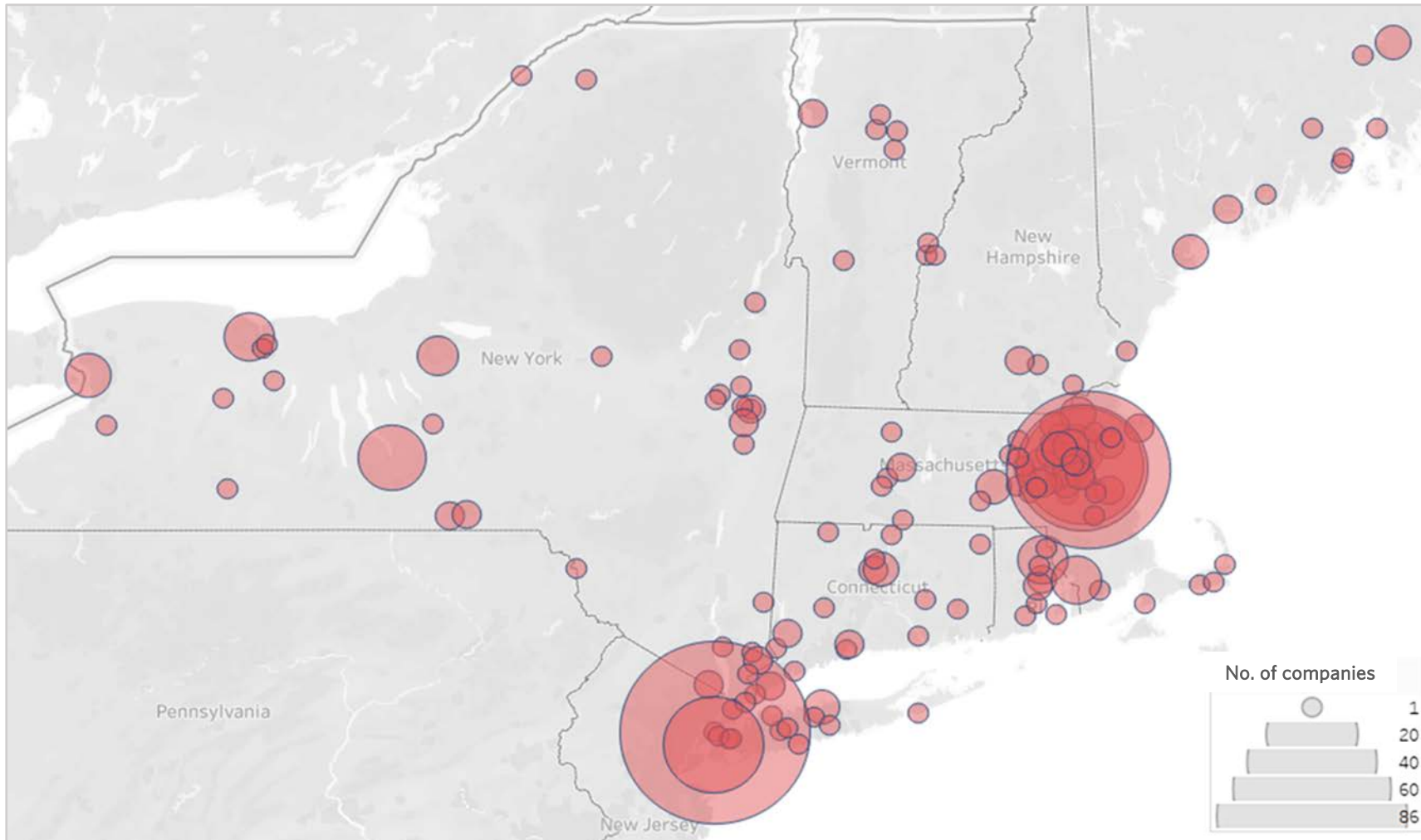
This chart shows where companies in our database are located. Dot size is proportional to the number of companies in that location.

- Companies are mostly located in large and mid-size urban centers.

- The bulk of the companies are located in the Boston area and New York City area.

- The remaining companies are spread out evenly across all states in the region.

Notes: Based on 488 companies for which location data were available.

No. of companies

○ 1
20
40
60
86

6

Exhibit 2 | Most businesses entailed energy systems and solutions.

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This chart is a word cloud of the business descriptions of the companies in our database. It gives an impression of the kinds of businesses in our sample. The size of each word reflects how often it appeared in these business descriptions. Common words that are not reflective of the substance of the business are not included.

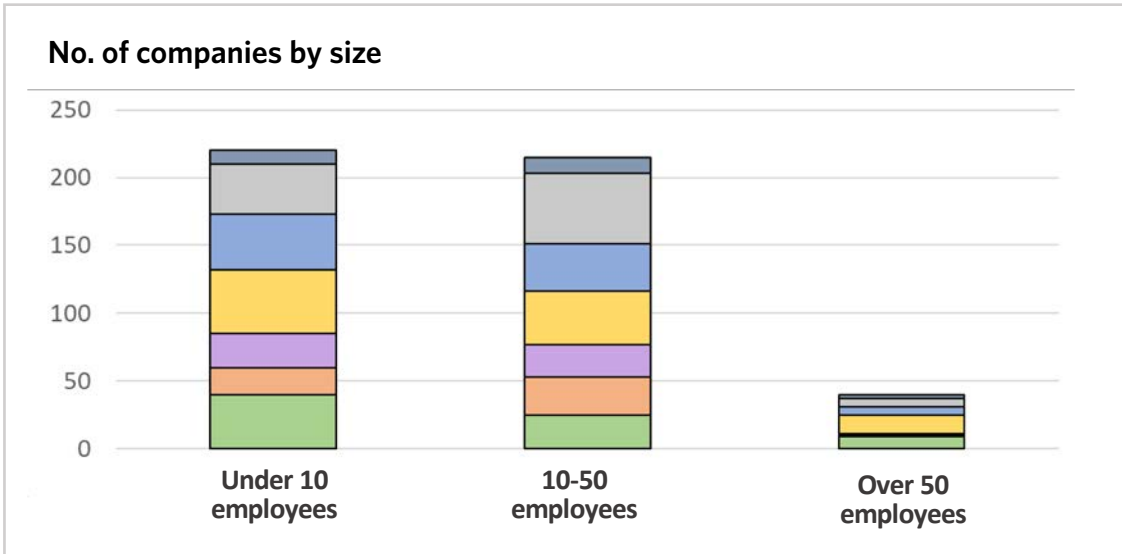*Notes: Based on 431 companies for which a business description was available.*

This chart shows the number of companies in each of the sectors and subsectors used in our study. We modified the NECEC classification scheme to show more categories beyond traditional "clean energy" sectors. All the companies included are involved in solutions to climate change.

- Companies are widely distributed across sectors.

- "Clean energy" sectors (e.g. Generation, Distribution, Efficiency) have as many companies as newer "climate tech" sectors (e.g. Ag, Chem, ICT).
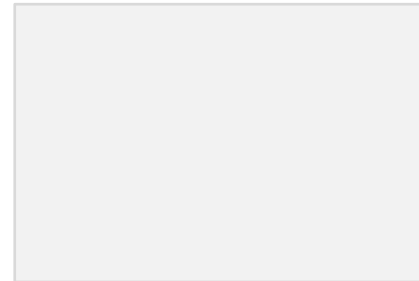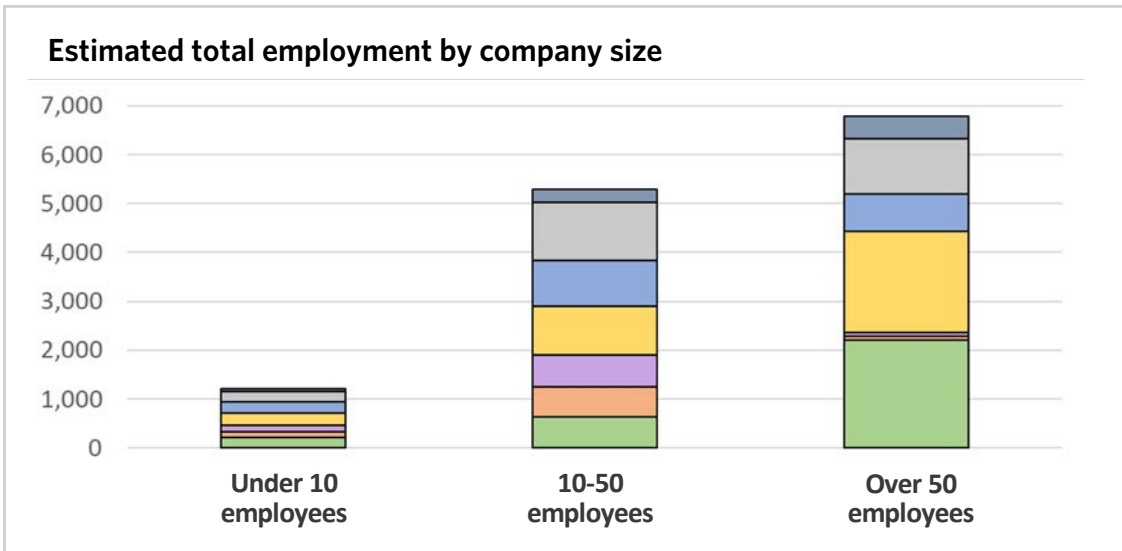
Notes: Based on 494 companies.

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No. of companies by size

Legend:
- ☐ Energy Generation
- ☐ Energy Distribution & Storage
- ☐ Information & Communication Technologies
- ☐ Agriculture, Food, and Water
- ☐ Chemicals, Materials, Manufacturing
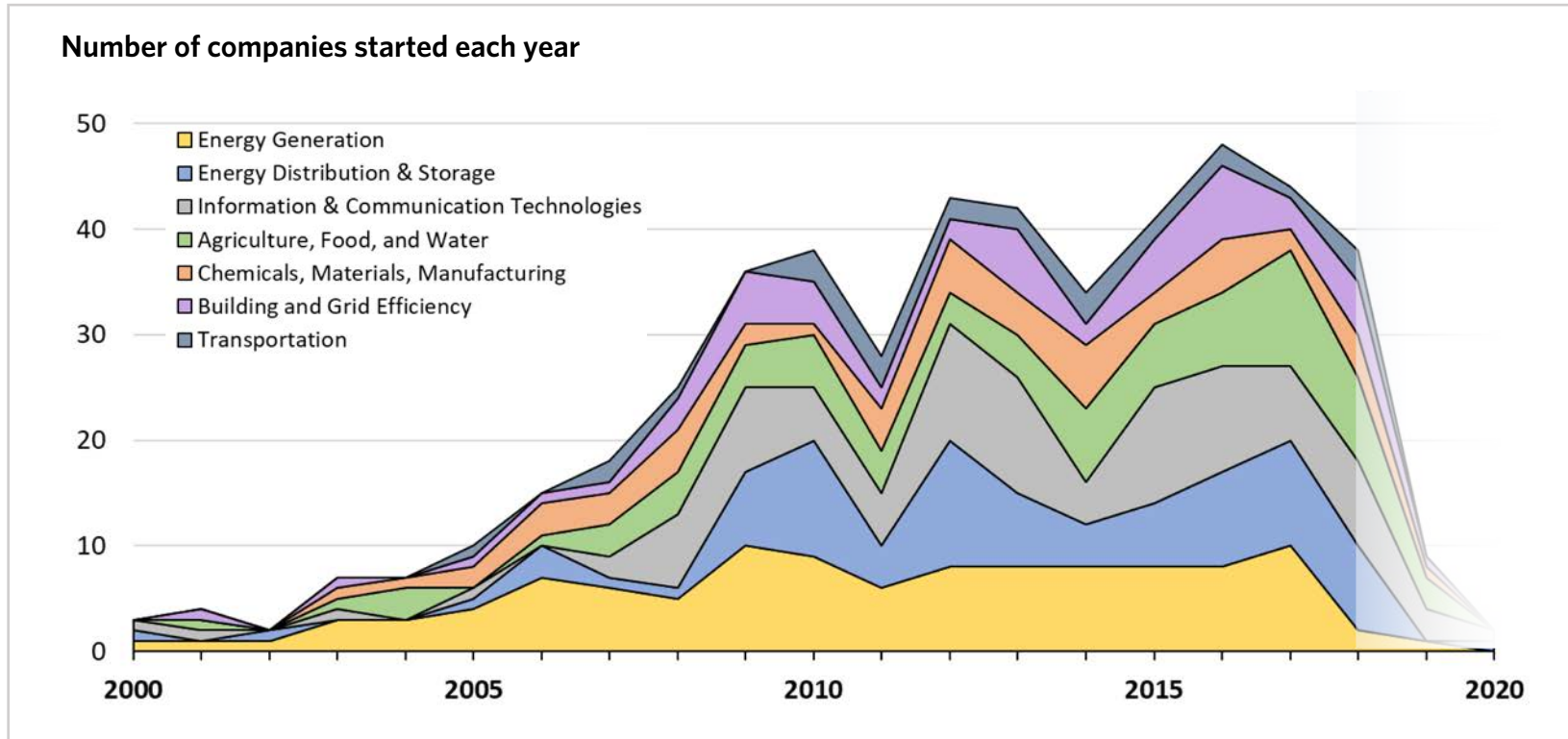- ☐ Building and Grid Efficiency
- ☐ Transportation

These charts show the number of people employed in the companies. This does not represent all the employment in climate tech — just in the startups themselves.

- Most companies have under 50 employees; many have under 10.

- The bulk of total employment is in companies with over 50 employees.

Estimated total employment by company size

Notes: Based on 475 companies for which employment data were available.

Exhibit 5 | The pace of new company formation increased before 2010, and has remained high since then.

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Number of companies started each year

Legend:
- Energy Generation
- Energy Distribution & Storage
- Information & Communication Technologies
- Agriculture, Food, and Water
- Chemicals, Materials, Manufacturing
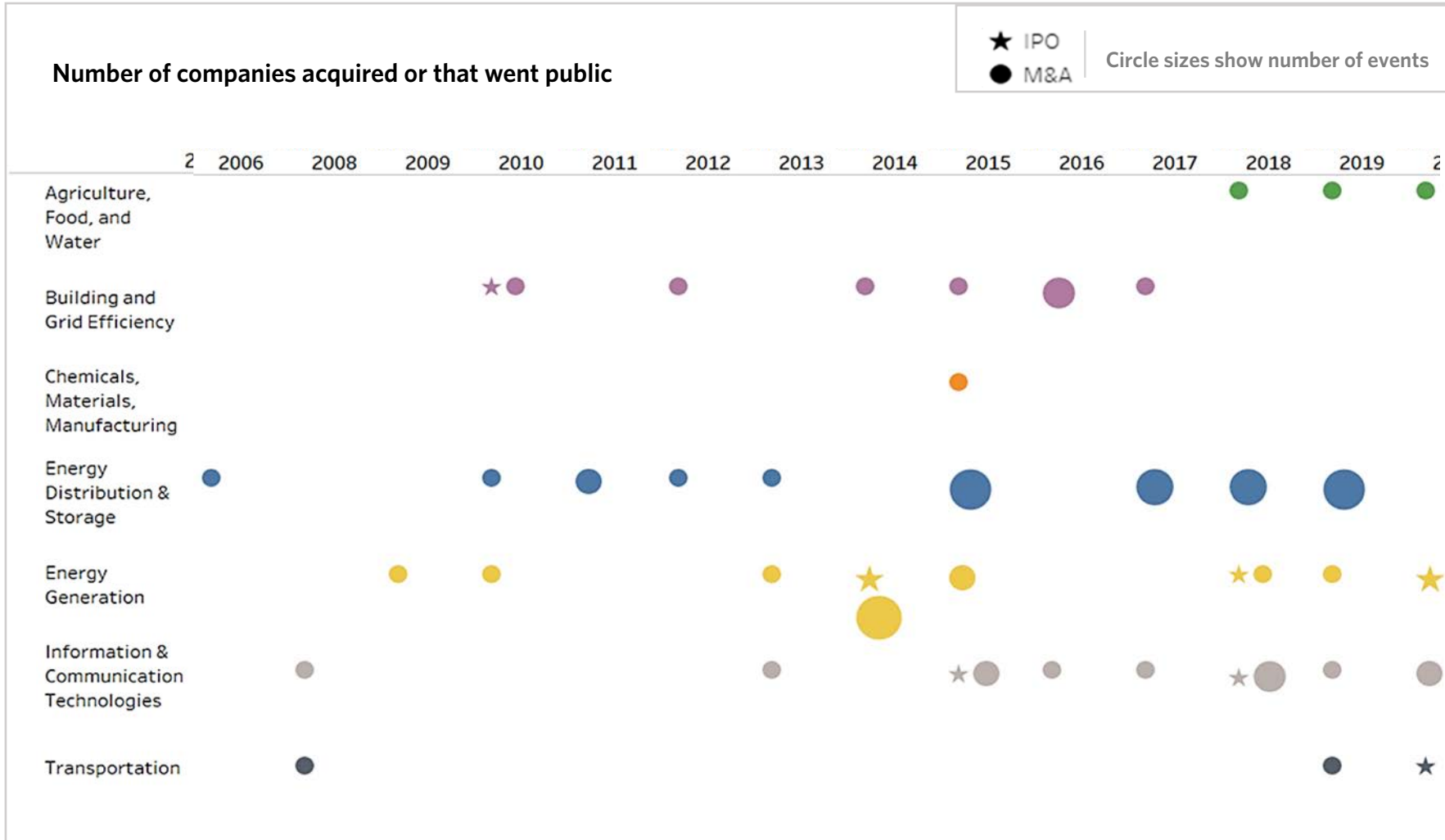- Building and Grid Efficiency
- Transportation

This chart shows how many companies still active in 2020 were founded in each prior year. Data for the last two to three years are incomplete, because new companies often do not yet show evidence of business activity, such as revenue or funding, and thus are not in our sample.

- The pace of new company formation rose rapidly between 2005 and 2010.

- From 2010 onward, the pace of new company formation remained high, with moderate ups and downs.

- The pattern echoes industry analysis that sees the growth of clean tech move from Wave 1.0 to 2.0/3.0 (Day, 2020).

Notes: Based on 494 companies. Data for the last two to three years are incomplete, because new companies often do not yet show evidence of business activity, such as revenue or funding, and thus are not in our sample.

Exhibit 6 | Companies in all sectors have been acquired or gone public.

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Number of companies acquired or that went public
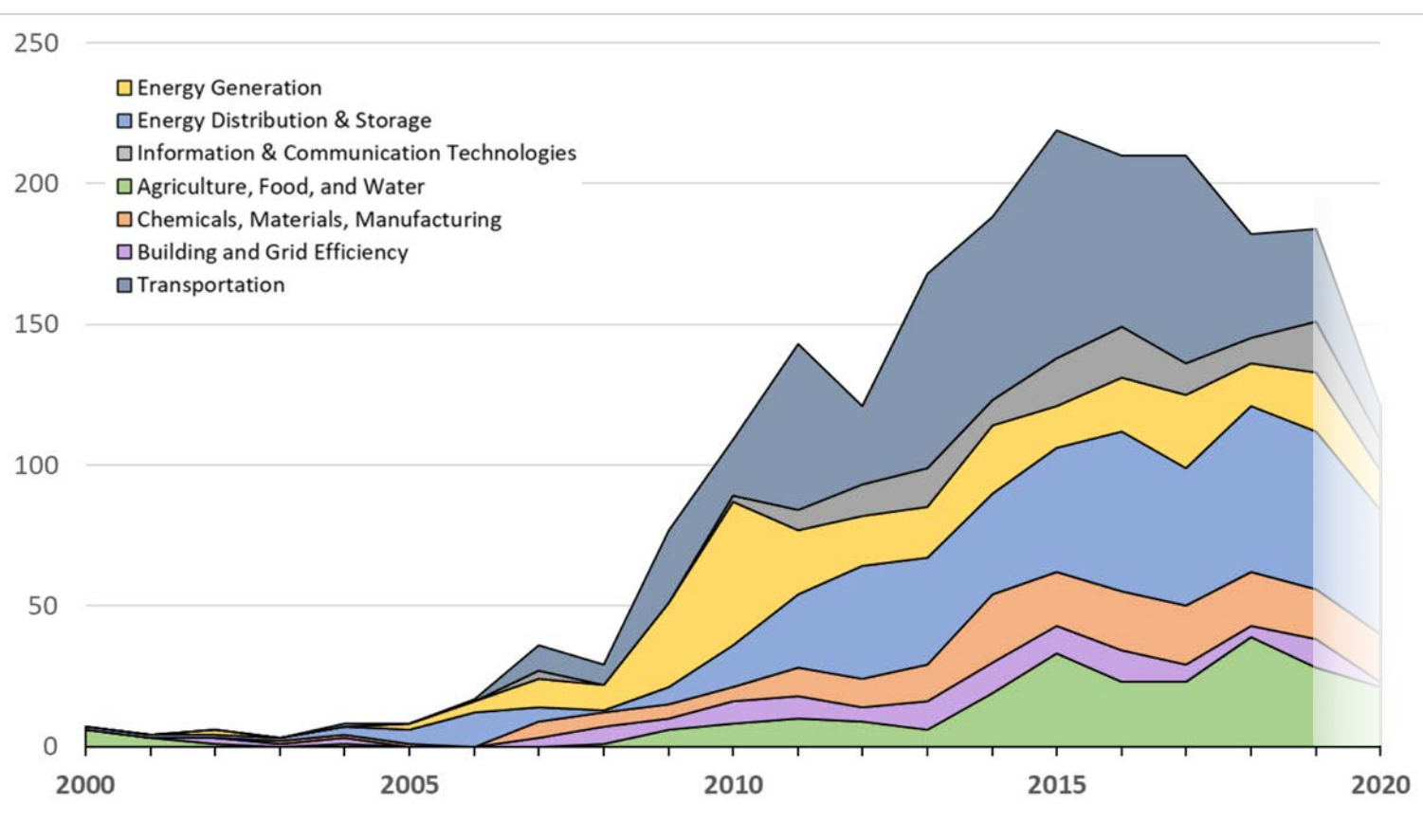
★ IPO
● M&A   Circle sizes show number of events

This chart shows the companies that were acquired or that went public since 2005. These companies are not included in our dataset for the rest of the analysis.

- There has been a sustained pace of acquisitions and IPOs in core "clean energy" sectors.

- Acquisitions and IPOs increased in other "climate tech" sectors in later years.

Notes: Based on a sample with information on 52 acquisitions and nine IPOs. These data are not used in the rest of the analysis, which covers only companies that are still private.

Exhibit 7 | Patents show an increasing pace of invention.

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Number of U.S. patent applications per year

Legend:
- Energy Generation
- Energy Distribution & Storage
- Information & Communication Technologies
- Agriculture, Food, and Water
- Chemicals, Materials, Manufacturing
- Building and Grid Efficiency
- Transportation

This chart shows the number of U.S. patent applications filed by companies in each sector.

- The rate of patenting rose rapidly from 2005 until at least 2015, and has remained high after that.

- Data for 2019-2020 may be incomplete due to reporting lags.

Notes: Based on 2,045 patents of 176 companies that had patents. The chart includes patents issued and pending.

Exhibit 8 | In each sector, a handful of companies lead in funding.

	Agriculture, Food, & Water	Chemicals, Materials, Manufacturing	Building & Grid Efficiency	Energy Generation	Energy Distribution & Storage	Information & Communication Technologies	Transportation
Total Co's in Sector	75	50	48	108	87	101	25
Top 5%	4	3	3	6	5	6	2
% of Sector Funding	92%	42%	58%	87%	55%	56%	67%
	Indigo Ag	Anellotech	RENEW Energy	Harvest Power	VIONX Energy Corp	FINsix Corp	Superpedestrian
	Ginkgo Bioworks	Amastan Tech	OLEDWorks	United Wind	General Compression	FreshAir Sensor	Zagster
	Hydration Labs	Sweetwater Energy	Nano-C	Comm. Fusion	SolidEnergy Systems	Ecovent Systems	
	Cambrian Innovation			Ogin	Ambri	Sealed	
				1366 Technologies	CIMCON Lighting	CoolChip Tech	
				Ocean Renewable PC		Sungage Financial	

This table lists the top 5% of companies in each sector by total funding.

- The top 5% accounted for the majority of funding in nearly every sector.
- The top four companies accounted for almost all funding in the Ag sector.

Exhibit 9 | In each sector, a handful of companies lead in patenting.

	Agriculture, Food, & Water	Chemicals, Materials, Manufacturing	Building & Grid Efficiency	Energy Generation	Energy Distribution & Storage	Information & Communication Technologies	Transportation
Total Co's in Sector	75	50	48	108	87	101	25
Top 5%	4	3	3	6	5	6	2
% of Sector Patents	58%	34%	69%	57%	52%	57%	86%
	Indigo Ag	Anellotech	Nano-C	Malta	Form Energy	Ogin	WiTricity Corp.
	Ginkgo Bioworks	LiquidPiston	OLEDWorks	Leading Edge Crystal	24M Technologies	NBD Nanotech	Ethanol Boosting
	Oasys Water	Sweetwater Energy.	WexEnergy	Loci Controls	Nanoramic Labs	CrowdComfort	
	Divert			1366 Technologies	General Compression	FINsix Corp	
				ZeroPoint Clean Tech	Sendyne Corp.	MPOWERD	
				Safe Hydrogen		Pellion Tech	

This table lists the top 5% of companies in each sector by total patents.

- The top 5% accounted for the majority of patents in nearly every sector.
- The top two companies accounted for almost all patents in Transportation.

Exhibit 10 | Companies are widely distributed across sectors, but . . .

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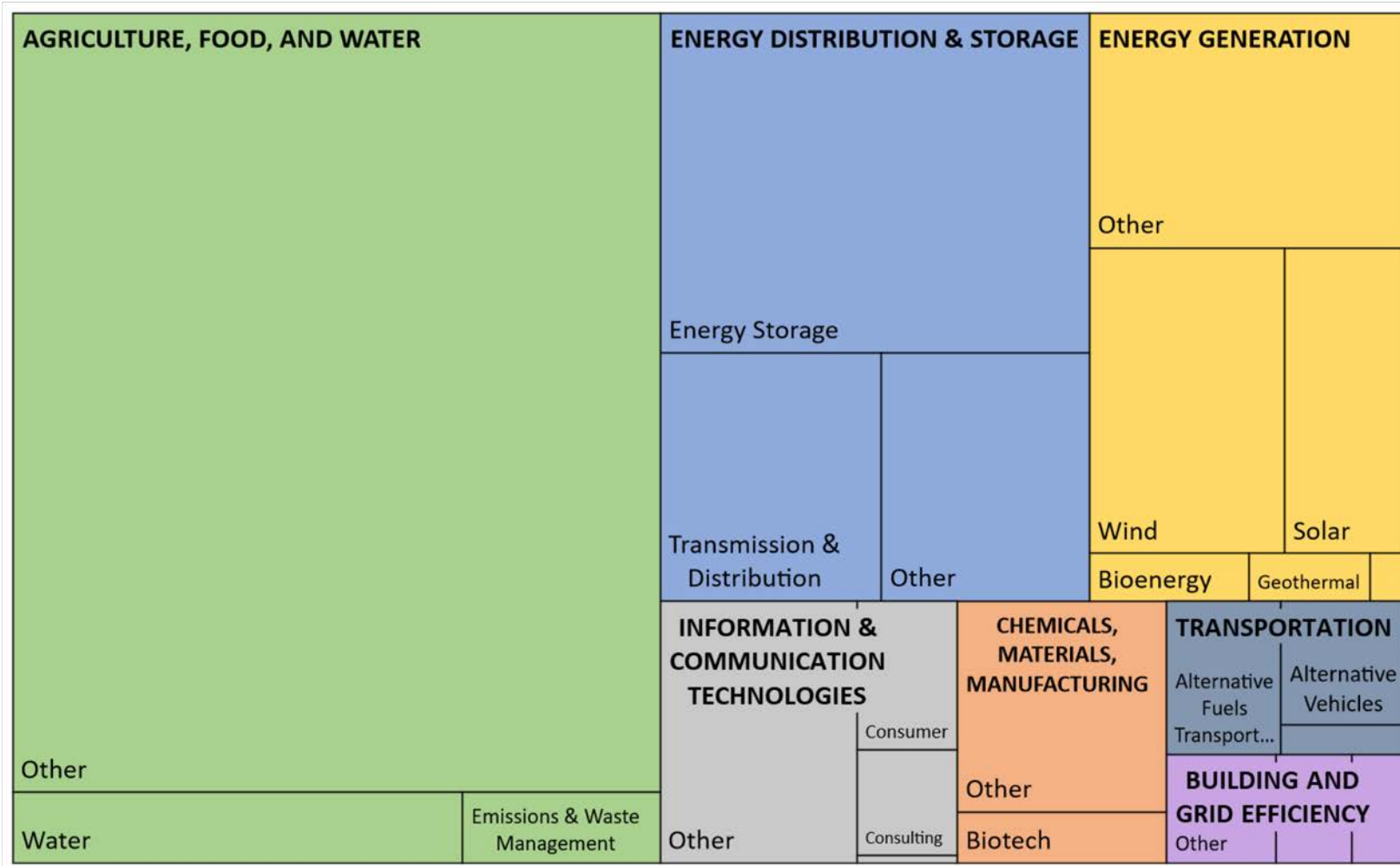**Area proportional to *total number of companies***
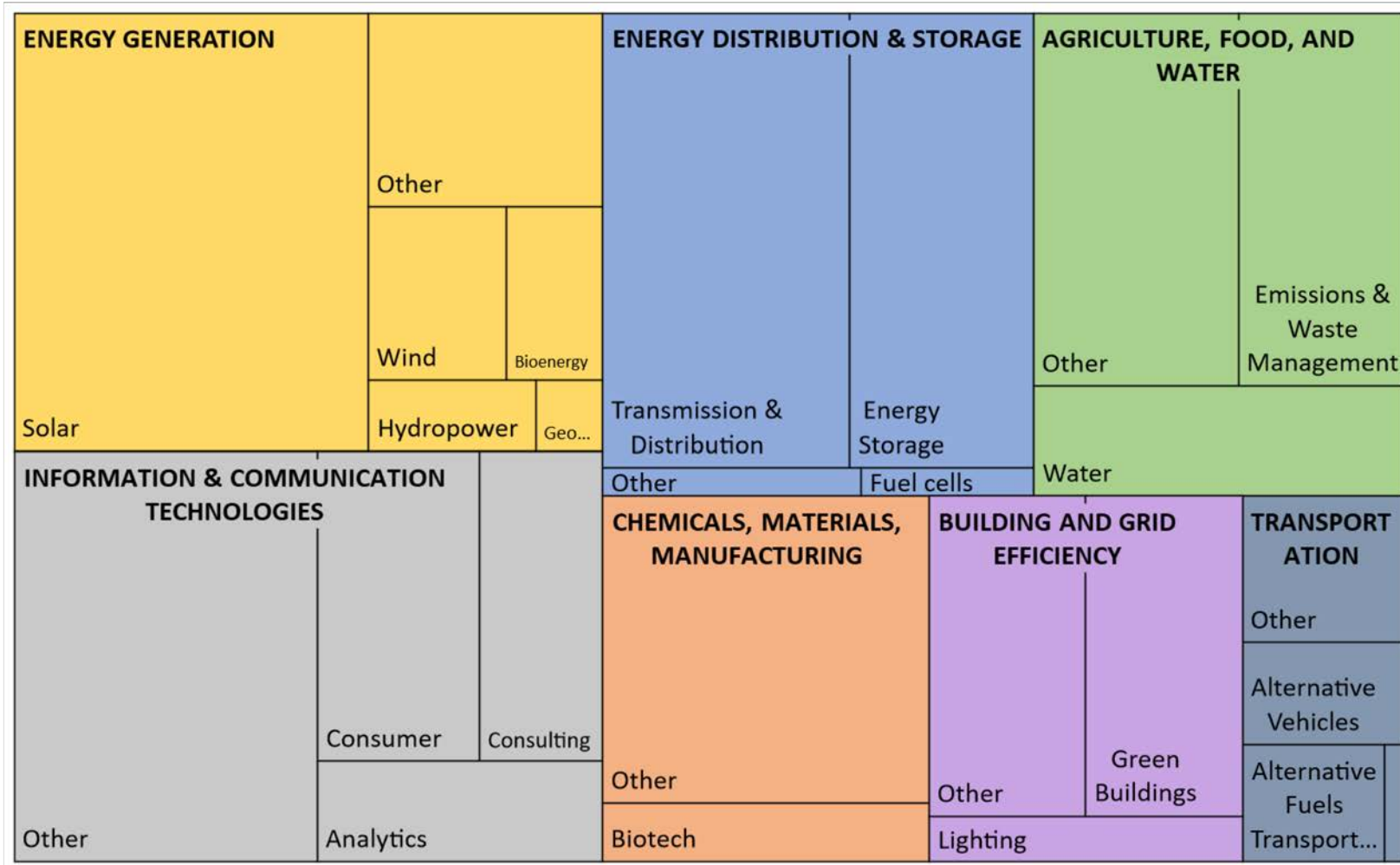
This is the same chart as in Exhibit 3. It is shown again here to facilitate a "blinking" visualization when scrolling to the next two pages, which show funding and patenting activity in the same format.

- Note the even distribution of companies across sectors here.

- Note the changes in the diagram when scrolling to the next two exhibits.

Notes: Based on the full data set of 494 companies.

Exhibit 11 | . . . the distribution of funding is different, and . . .

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Area proportional to *total funding*

This chart shows the total funding of companies in each sector, using the same format as in the preceding and following pages.

- Almost half the total in the industry went to Agriculture, Food, and Water, out of proportion to the number of companies, as shown in the preceding page.

- Energy Generation, and Distribution & Storage received funding proportional to their numbers.

Notes: Based on 273 companies for which funding amounts were available.

16

Exhibit 12 | . . . the distribution of patents is different still.

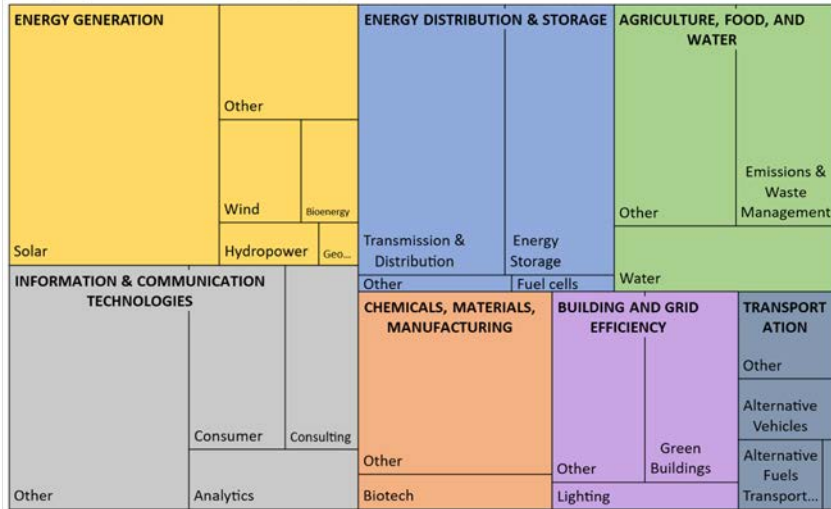**Area proportional to** *total U.S. patents filed*
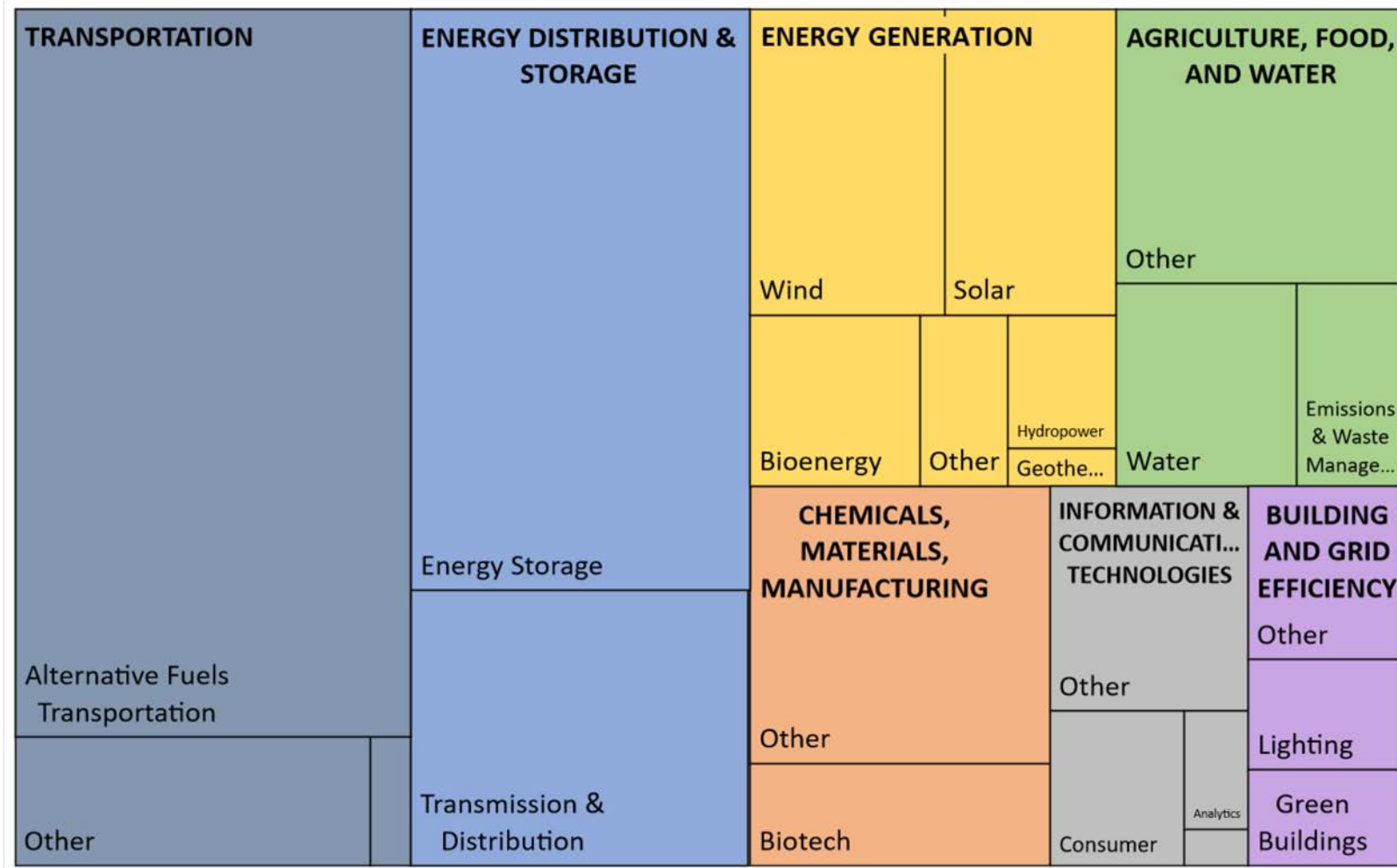
This chart shows the total U.S. patent applications filed by companies in each sector, using the same format as in the preceding two pages.

- Almost half the total in the industry went to Transportation and to Energy Distribution & Storage.

- The Transportation sector had more patents than any other sector, which were concentrated in a couple of companies, as shown in Exhibit 9.

Notes: Based on 184 companies that had patents.

No. of companies (from Exhibit 10)

Legend:
- ☐ Energy Generation
- ☐ Energy Distribution & Storage
- ☐ Information & Communication Technologies
- ☐ Agriculture, Food, and Water
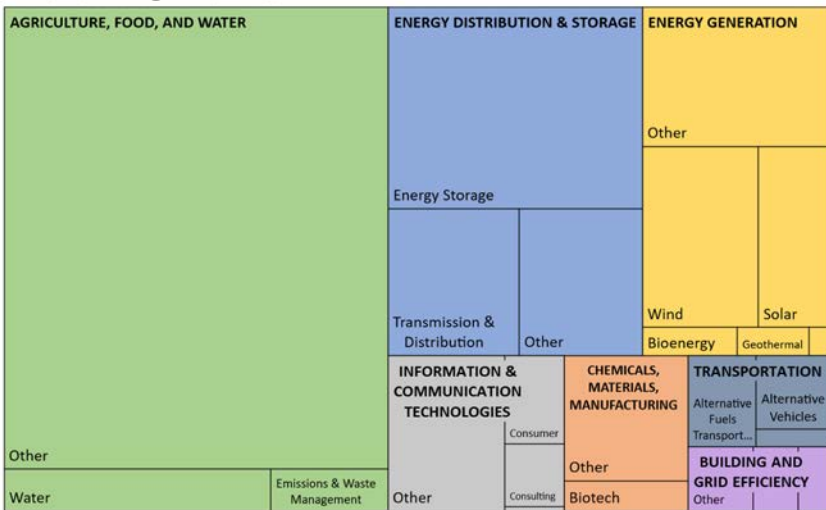- ☐ Chemicals, Materials, Manufacturing
- ☐ Building and Grid Efficiency
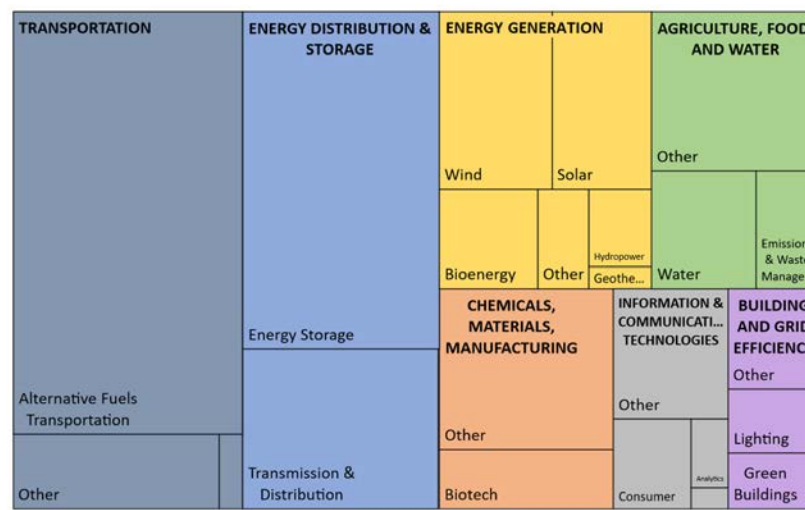- ☐ Transportation

Area of blocks is proportional to:
- Number of companies in each sector
- Total funding of companies in each sector
- Total U.S. patents applied for by companies in each sector

Total funding (from Exhibit 11)

Total U.S. Patents (from Exhibit 12)

This exhibit shows the same three charts as in the three preceding exhibits, to facilitate comparison on one page.

- Both funding and patenting patterns are more lopsided than the general distribution of companies.

- Different sectors dominate in each view, with different sectors ranking as the biggest.

- Energy Distribution & Storage and Energy Generation are ranked second and third in all views.

  Notes: See notes in X10, X11, and X12.

Section II
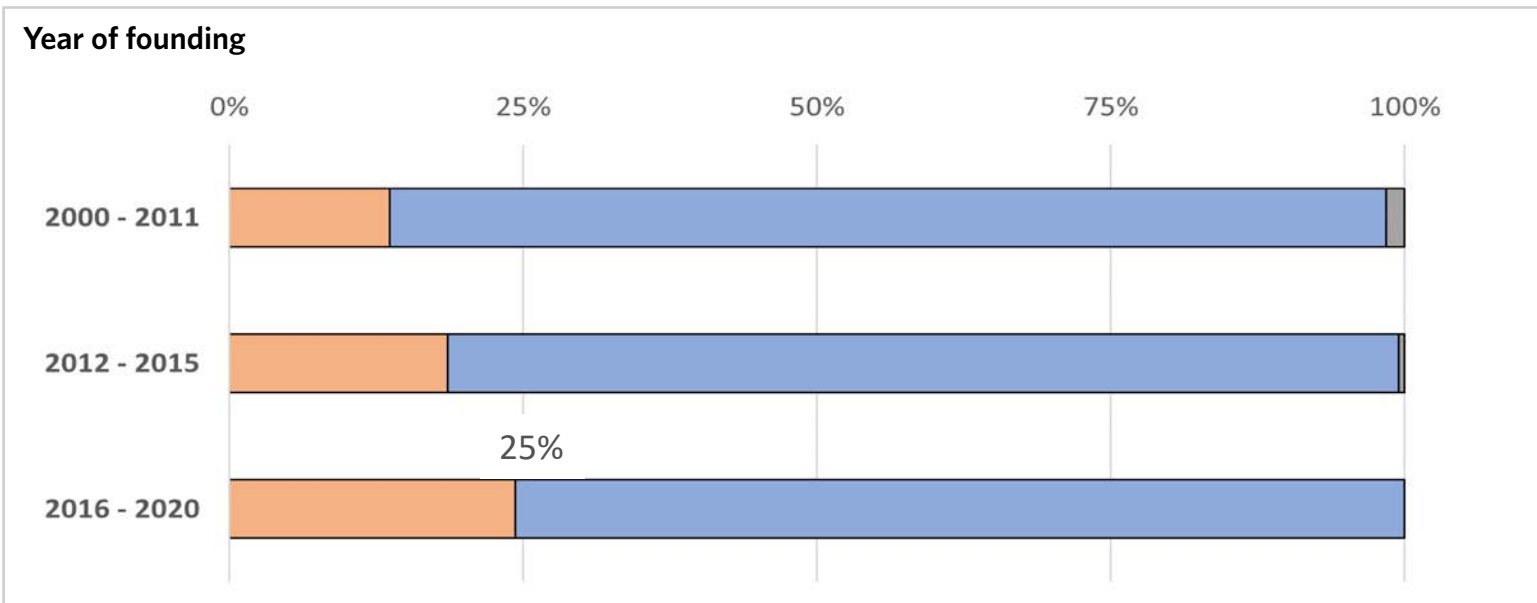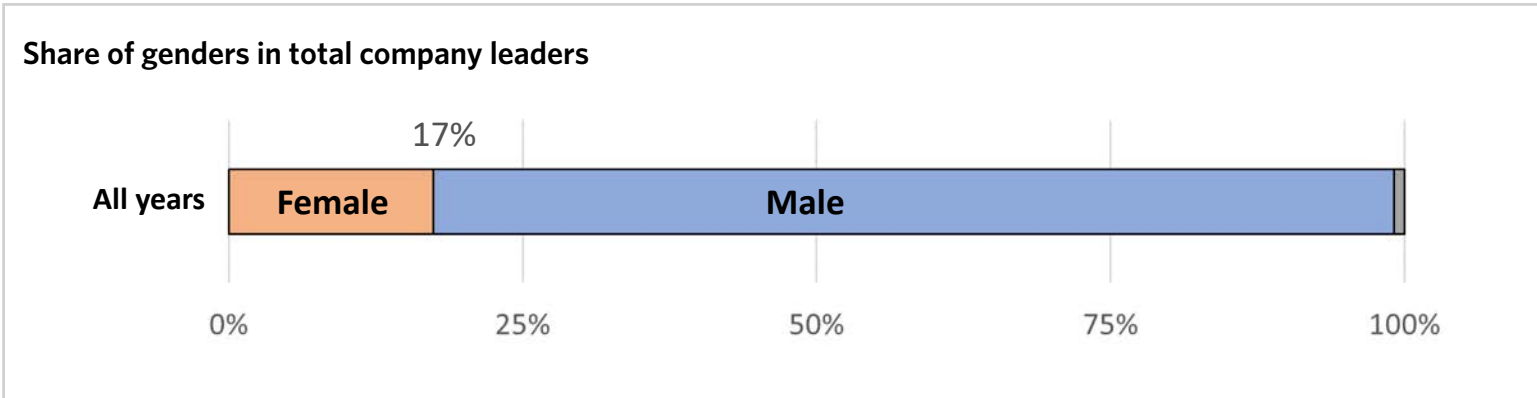**Leaders of Startups in Climate Innovation, 2000-2020**

The exhibits in this section describe the top personnel in the startup companies in the data. Data on personnel is available for 214 companies and 557 company leaders. The sample for which personnel data are available is similar to the total sample of companies, with a slight bias toward older and more highly funded companies. The charts show these variables:

- Gender
- Ethnicity
- Education

Data on gender and education were available in Crunchbase. The Sources and Methods section explains how we classified personnel by ethnicity.

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Share of genders in total company leaders

17%

All years | Female | Male

0%   25%   50%   75%   100%

Year of founding

0%   25%   50%   75%   100%
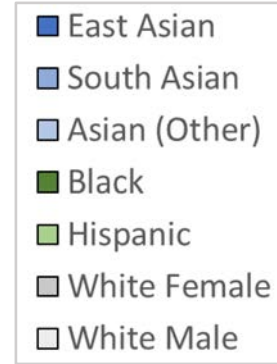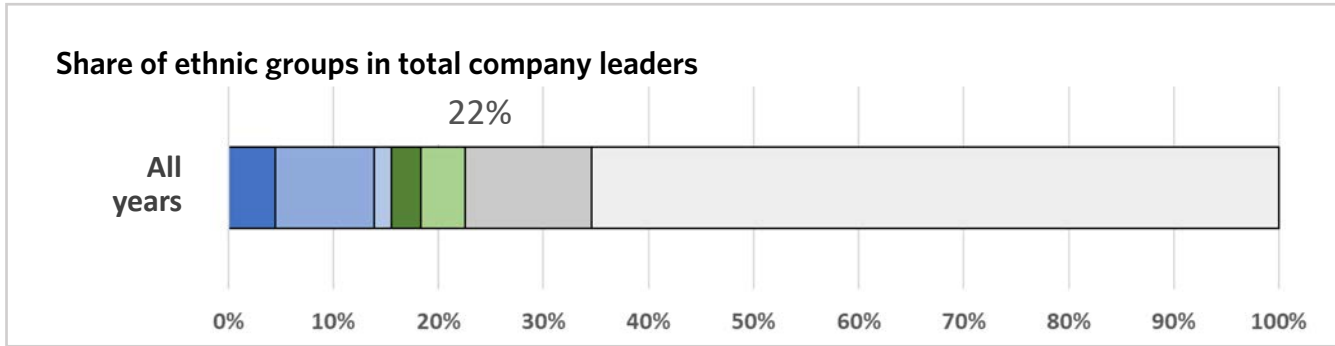
2000 - 2011

2012 - 2015

25%

2016 - 2020

These charts show the shares of Males and Females in the leadership of the companies in the data. Leadership positions include founders, top management and some middle management, as reported by Crunchbase.

• Females represented 17% of overall company leadership on average over the two decades.

• The share of Female company leaders has been increasing gradually, reaching 25% in companies founded in the last five years.
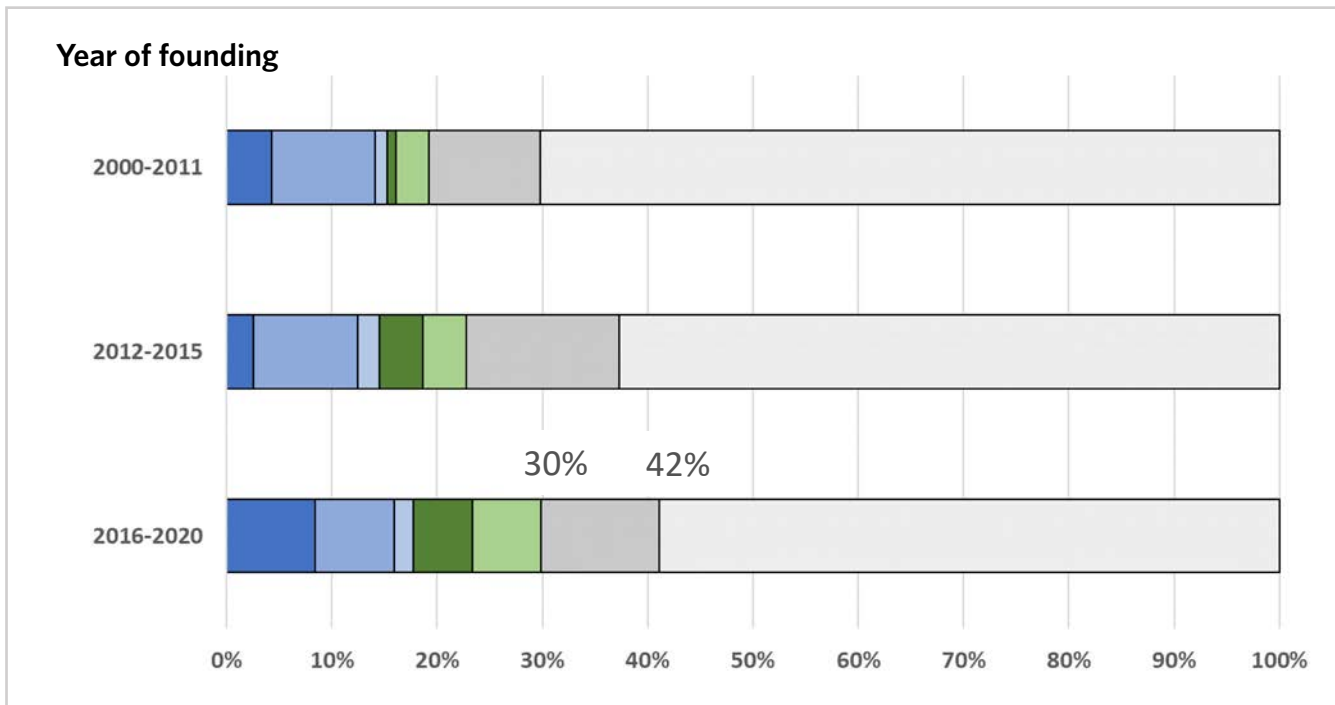
Notes: Based on 214 companies and 557 company leaders. Bar chart for 2000-2011 is based on 256 leaders in 93 companies; that for 2012-2015, on 194 leaders in 78 companies; and that for 2016-2020, on 107 leaders in 43 companies.

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Share of ethnic groups in total company leaders

Legend:
- East Asian
- South Asian
- Asian (Other)
- Black
- Hispanic
- White Female
- White Male

These charts show the shares of ethnic groups in the leadership of the companies in the data. Leadership positions include founders, top management and some middle management, as reported by Crunchbase.

- Ethnic minorities represented 22% of overall company leadership on average over the two decades.

- The share of ethnic minorities has been increasing over time, reaching 30% in the last five years.

- The share of minorities plus women reached 42% in the latest period.

Notes: Based on 214 companies and 555 company leaders. Bar chart for 2000-2011 is based on 256 leaders in 93 companies; that for 2012-2015, on 194 leaders in 78 companies; and that for 2016-2020, on 107 leaders in 43 companies.

Exhibit 16 | **Three-quarters of startup leaders have higher education degrees from universities in the Northeast region.**

	Number of all company *leaders* with degrees from each school	Number of company *founders* with degrees from each school
Massachusetts Institute of Technology	**41**	**25**
Harvard University	**17**	**9**
University of California	16	12
Dartmouth College	**13**	**1**
Columbia University	**11**	**10**
Stanford University	8	5
Northeastern University	**7**	**4**
Tufts University	**6**	**2**
Cornell University	**6**	**-**
Brandeis University	**5**	**4**
Boston College	**5**	**-**
University of Rochester	**5**	**-**
Babson College	**4**	**4**
University of Massachusetts	**4**	**4**
Princeton University	4	3
University of Maryland	4	3
University of Pennsylvania	4	3
Yale University	**4**	**2**

This table shows the higher-education degrees of startup leaders, where data were available. Schools in the Northeast region are bolded. Both undergraduate and graduate degrees are included. Ranking shown is by leaders count, followed by founders count if leaders count is a tie, and alphabetical for ties on both counts.

- Three-quarters of the degrees of company leaders and founders are from schools in the region, shown here in bold.

- MIT accounts for one-quarter of the degrees of leaders and founders.

Notes: Based on 216 companies for which data on education of employees were available.

Section III
Sources & Methods

This section details how we collected and classified the data in the exhibits.

I. **Company data** were collected on these variables:

- Founding year
- Sectors and subsectors
- Total funding as of 2020
- Employment range
- Location of headquarters
- Acquisition or IPO year, if any

II. **Personnel data** were collected on these variables:

- Functions: founders and top management
- Gender
- Ethnicity

III. **Patent data** were collected on these variables:

- Patent applications per year for each company
- Status of patent applications

25

We collected company data in two phases. An initial set of 274 companies were identified manually from public sources. We examined press listings of top companies, investor portfolios, participant lists in accelerators, membership lists of sector organizations, and the like. An additional 220 companies were identified on Crunchbase and included if they had at least three sector keywords that reflected the range of sectors we defined as climate tech.

The sectors included were those shown in Exhibit 3. We include core "clean energy" sectors, such as energy generation, distribution, storage and efficiency, as well as sectors that were a bit further afield but still represented solutions and responses to climate change, such as transportation, agriculture, food, water, waste management and information technology geared to climate solutions (Hawken, 2017). As a result, we think of the data set as representing companies in "climate tech."

The companies in these climate tech sectors were included if they had the following characteristics:

• Active in 2020
• Founded in 2000-2020
• Privately held
• Headquarters in New England states and New York
• Evidence of business activity, usually revenues or funding

Crunchbase (www.crunchbase.com) was the primary source of data on companies and on company personnel. The contents and use of this database are well documented in the academic finance literature (Raina, 2019). These data were supplemented by data from other industry and public sources. The last retrieve of Crunchbase data analyzed in this report was January 2021.

Data for 2018-2020 may be incomplete for several reasons. First, there is a lag in when new information appears on Crunchbase. Second, there is a lag in when newly founded companies show business activity that would cause them to be included. For example, a new company formed in 2020 may still be without funding or revenue, or these are not yet reported, and thus is not likely to be selected for our sample.

The personnel data were collected from the Crunchbase database, a commercial vendor, and further categorized by our team using established research techniques.

From Crunchbase we collected the names of any personnel associated with each company. Crunchbase doesn't provide personnel for all companies and tends to have more information on larger, older companies than on younger, smaller companies. When personnel information is available for a company, it is usually on founder/owners, top management and sometimes board members and other management. Usually, no more than a dozen names are associated with each company, so the personnel data do not represent total employment in these companies, but just what we call "company leaders." These data also do not represent total leaders in climate tech sectors overall, as it doesn't include public companies and the many service providers to the industry; many of those are larger than the companies in our data. We are only measuring the characteristics of leaders of companies that are still in startup phase. In all, we collected data on 559 company leaders.

To categorize the company leaders by gender, we used information provided by the Crunchbase listing itself, supplemented by our own research on the very few entries missing a gender classification. For the missing entries, we used LinkedIn and other information on the web to estimate the gender expression of the company leaders.

To categorize the company leaders by ethnic group, we used a technique well-known in the academic literature, which is to estimate ethnicity from first and last names (Kerr, 2008a and 2008b; Foley and Kerr, 2013; Gompers and Wang, 2017). In our process, we started with the Python routines provided by NAMSOR (www.namsor.com), a commercial provider that is used by academic and official entities. The NAMSOR routines match names with varying degrees of certainty to four ethnic groups — White, Black, Hispanic and Asian. We then validated every name manually, to verify or modify the ethnic-group matches, and to separate the Asian category into East Asian, South Asian and Other. Our team was itself ethnically diverse, so we were familiar with the common names in each group.

We collected patent data from the InnovationQ platform of the commercial vendor, IP.com (https://ip.com/products/innovationq/), which assembles U.S. patents in all classes. We collected data on patent applications, issued patents, pending patents and abandoned patents.

To assemble these data, we matched the names of the companies in our data set with names of the organizations in the InnovationQ database. Our companies are "assignees" on the patent applications that we included. For each application, we have a number of variables, not all of which were used in the analysis presented in this report.

The charts in this report showing the sectoral composition of patents reflect the business sectors of the companies that own the patents, not the technology of the patent itself. Patent technology classes are notoriously hard, if not impossible, to match to industrial sectors. Our method has the advantage of showing where the patents are likely to be put into practice.

The patent data for the last few years may be incomplete. The patent process, and therefore the data we see from it, has inherent reporting lags. The date of an invention may be several years before a patent is applied for, and then there are more years before it is issued or rejected, followed by a lag in public reporting. Furthermore, as explained above, our data on new company formation is likely incomplete in later years; this means that data on any associated patents would also be so.

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Principal Investigator:
Benjamin Gomes-Casseres,
Peter A. Petri Professor of Business & Society
Director, Asper Center for Global Entrepreneurship

Research Assistants:
Shan He, MSBA'21
Klodeta Janaqi, MBA'21
Rohan Nagi, MBA'21
Sunny Hong, MBA'19
Jacob Judd, MA'20
Frida Petersen Albert, MA'20

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Asper Center Advisor:
Mitch Tyson

About the Asper Center for Global Entrepreneurship:
The Asper Center for Global Entrepreneurship provides a diverse range of learning experiences through courses, seminars and conferences, internships, business plan competitions, field visits and meetings with global entrepreneurs.

The center was established at Brandeis International Business School by Leonard J. Asper '86, the current CEO of Anthem Media Group and the former president of CanWest Global Communications, Canada's largest media conglomerate. He led efforts in 2004 to create the Asper Forum and the Asper Award for Global Entrepreneurship, presented to an entrepreneur who achieves outstanding success in the global marketplace through creative marketing and business strategies.

About the Northeast Clean Energy Council and Cleantech Open:
NECEC is the premier voice of businesses building a world-class clean energy hub in the Northeast, helping clean energy companies start, scale, and succeed with our unique business, innovation, and policy leadership. The organization includes the Northeast Clean Energy Council, a nonprofit business member organization, and NECEC Institute, a nonprofit focused on industry research, innovation, policy development, and strategic communications. The organization's innovation program includes Cleantech Open Northeast, the Northeast affiliate of the national cleantech accelerator Cleantech Open, and Cleantech Navigate, which provides cleantech startups with curated connections to mentors, test sites, customers, corporate partners, and investors. NECEC brings together business leaders and key stakeholders to engage in influential policy discussions and business initiatives while building connections that propel the clean energy industry forward.

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Thank you.