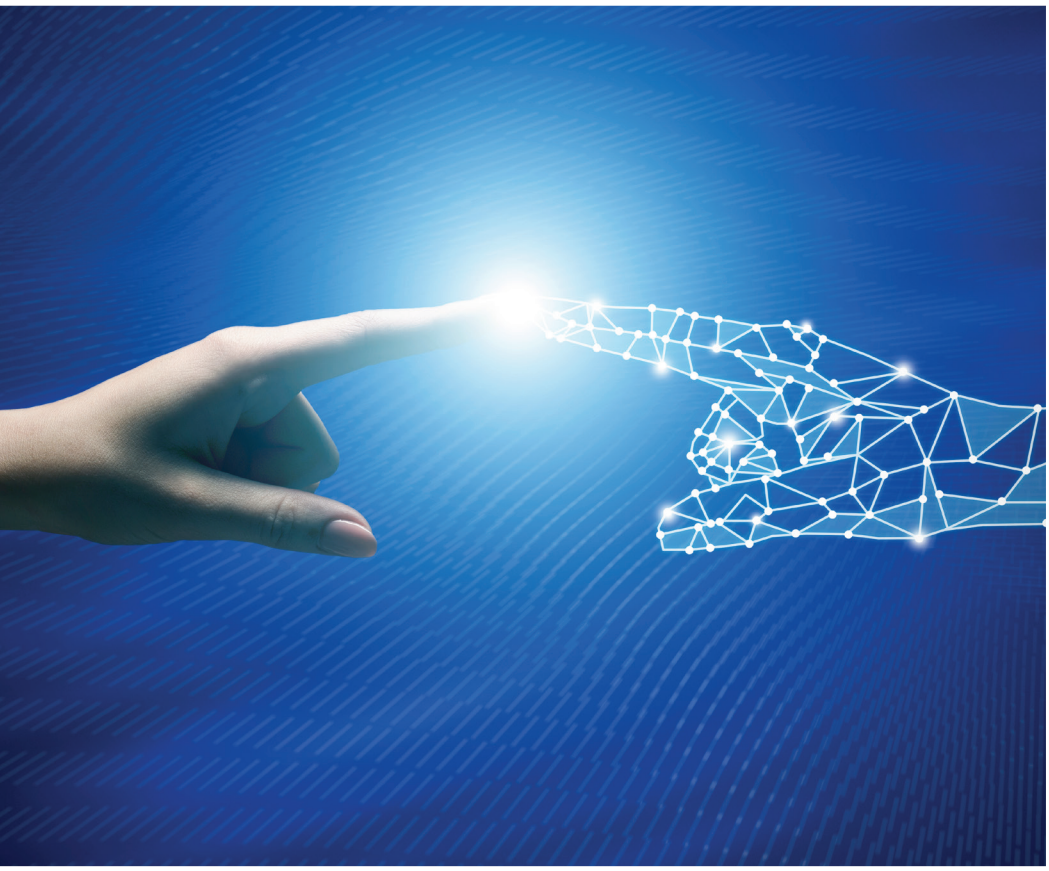
Vermont Technology Council



May 2022

2022 Vermont Science and Technology Plan

BUILDING VERMONT'S SCIENCE AND TECHNOLOGY ENTERPRISE

VERMONT TECHNOLOGY COUNCIL MISSION

The Vermont Technology Council is a self-sustaining, independent organization established in 1993 that advocates for science and technology-based economic development. It strives to integrate the efforts of the private sector, higher education, and government to build a strong, vibrant, and flexible economy based on science, technology, innovation, and entrepreneurship in Vermont. The Council also serves as the State Committee for the Vermont Established Program to Stimulate Competitive Research (EPSCoR) and is responsible for writing the State Science and Technology Plan.

VERMONT

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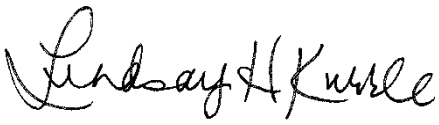
May 17, 2022

The State of Vermont welcomes this 2022 Science and Technology Plan developed by the Vermont Technology Council. As we emerge from the COVID-19 pandemic, Vermont is poised to make considerable advances in building up our tech sector. These are exciting times for science and technology in Vermont, and we need to amplify the progress in this area. This is why the Scott Administration has initiated a Technology-Based Economic Development program this year to support Vermont's Small Business Innovation Research and Small Business Technology Transfer (SBIR/STTR) applicants in our effort to catalyze the growth of more technology firms in Vermont.

As the Secretary for the Vermont Agency of Commerce and Community Development (ACCD), I hear from Vermonters about the hopes and aspirations they have for our tech economy all the time. Workforce, access to capital, broadband, and housing are challenges we are working to address across the state. I believe the suite of recommendations in this report will help us meet the challenges we face in further developing Vermont's tech sector.

Using the 2022 Science and Technology Plan as one of our guides, we can ensure that the future of Vermont's tech ecosystem is a bright one. We urge everyone to read it and draw on its vision to inform our drive toward Vermont's innovation-fueled future.

Sincerely,



Secretary Lindsay Kurrle
Agency of Commerce and Community Development

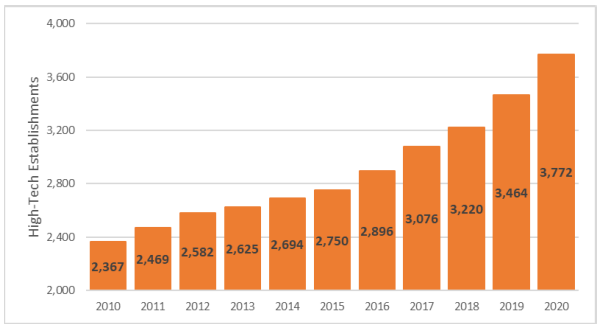
INTRODUCTION

I. Vermont's Science & Tech Economy, Present and Future

This 2022 version of the Vermont Science and Technology (S&T) Plan is being released during what is hoped to be the tail end of the worst global pandemic since 1918. The disruptions to the state's economy, health care system, and peoples cannot be overstated. With large shifts in the labor markets that have not been seen since World War II, the time is now to revisit the state's current capacity and re-envision what a green and digital future looks like for the state of Vermont.

Like many regions of the United States, Vermont is poised to take advantage of the data and digital revolution by growing the number of science and technology organizations and jobs in the state. Coupling this potential with Vermont's established reputation for excellent environmental stewardship, high quality and accessible health care, and an eye toward sustainability, the state can emerge as a leader in building a green and digital rural economy.

The numbers tell an interesting story. The number of high-tech firms[1] operating in Vermont grew dramatically from 2,367 in 2010 to 3,772 in 2020, an increase of almost 40% (see Figure 1). The biggest growth areas in terms of employment during this time were computer manufacturing (63.6% annualized growth 2010-2020), pharmaceutical preparation manufacturing (26%), software publishing (11.2%), analytical laboratory instrument manufacturing (8.3%), computer equipment wholesalers (6.1%), and marketing consulting services (5.1%)[2,3]. Although the size of these industries remains small in comparison to larger states, the growth in these sectors is indicative of Vermont's growing position as a digital technology hub. In addition, the number of science and technology-related occupations in such areas as software engineers and computer and data scientists jumped by 3% to 12% over this 10-year period[4]. With a strong core of advanced manufacturing firms such as Global Foundries, GS Precision, OnLogic, General Dynamics, GE Aviation, and Agilent, the state is seeing an unprecedented growth in early-stage companies like BETA Technologies, and start-ups such as Benchmark Space Systems, Vernal Biosciences, and CoreMap Medical. Vermont has seen a huge uptick in venture capital in the last two years, seeing a 442% change in VC investments between the two years prior to the pandemic (2018) to post two years (2022)[5]. While the increase in start-ups and early-stage companies is encouraging, there is an established recognition that many Vermont businesses, including our thriving creative, arts, tourism and recreation sectors are facing challenges in scaling to the global marketplace. They have increasing needs for upgraded digital marketing capacities and expertise in data analytics to improve their access to markets outside Vermont.



Source: JobsEQ
Figure 1: Number of High-Tech Establishments in Vermont

The drivers of this growth in the science and technology industry and occupations can be chalked up to wider national trends relative to the growth of these sectors. But they are also likely driv-

en by efforts of Vermont's science and technology, venture capital and start-up, and higher education communities to grow Vermont's innovation ecosystem, as over the past decade, more intentional efforts have been made to cultivate ecosystems across the state to better support technology and innovation.

Part of this growth also lies in the attractiveness of Vermont as one of the best places to live and work in the country, a sentiment that has only increased during the COVID-19 pandemic. During the pandemic, Vermont saw an influx of remote workers and entrepreneurs seeking a better lifestyle. This was likely particularly the case for data scientists and software engineers, who may have greater ability to work remotely. The increase in young families moving to small and remote towns all over Vermont has brought an increase in number of students in local schools that had not seen an increase in population like this in decades. And these generations of new Vermonters will be looking for opportunities to build their careers and remain in Vermont. While this influx has led to an extensive growth in the cost of homes, with the median price of home jumping by 20% in just the past three years[6], it has also led to a sense of optimism in the future of the state as a land of opportunity in which one can pursue a career and maintain a healthy work-life balance. A key to that work-life balance is the state's working landscape and extensive tracts of conserved and recreational lands. A vision of a high-tech Vermont that still manages to sustain its ethos of environmental stewardship and healthy communities is emerging.

As the US economy adjusts to the changes in the labor force and workplace environments resulting from the pandemic, the state of Vermont is poised to grow its green and digital economy, not only within the state's major population center of Chittenden County, but across all corners of the state. Over the last seven years, the state has seen growth in the number of co-working spaces, makerspaces, and innovation hubs springing up across the state. With funding from the Economic Development Administration (EDA) and the Federal Reserve of Boston respectively, the Center on Rural Innovation (CORI) and the Vermont Council on Rural Development (VCRD) are working with communities across the state to focus on building and maintaining the digital economies of Vermont's smaller, more rural regions. Stakeholders from these communities have a deep appreciation that the growth of rural, digital economies requires additional amenities, not just widespread access to broadband. Communities are implementing initiatives designed to attract and sustain technology start-ups and firms that also consider workforce retention factors like attainable housing, childcare, and thriving arts, food and drinking establishments. The mission of these regional efforts is striving to be both holistic and inclusive.

Vermont's science and technology ambitions do not align well with the skills and capacity of the state's existing workforce. Many Vermonters are unprepared to take advantage of the data and digital revolution at our state's doorstep. As was noted in the state's 2019 Science and Technology Plan, the key limiting factor to the growth

of the science and technology sector lies in the lack of a qualified or available workforce. There are simply not enough Vermonters prepared to fill positions in the tech sector. Greater effort is needed to create coordinated responses to meet these needs. Our state's K-12 education system needs to increase the computational literacy of our young people by providing additional pathways to STEM careers, including formal and informal educational opportunities in computer and data sciences, and encouraging students to enroll in these programs and pursue occupations to meet the needs of the state. Greater attention is needed to develop accessible and affordable upskilling and training opportunities as well. Many Vermonters that were forced to leave the state to find a job in their field could be willing to come back once the state can offer the necessary infrastructure and technology they need to work remotely. In addition, our state needs to improve the data literacy of our policy makers, our small business owners, and our economic developers by providing access to state-of-the-art data services, informatics, digital archives, and training.

There are simply not enough Vermonters prepared to fill positions in the tech sector.

A second major thrust to grow Vermont's science and technology workforce lies in attracting and retaining new workers to the state. Vermont's higher education system, especially the University of Vermont (UVM), the Vermont State Colleges System (VSCS), Middlebury College, Norwich University, St. Michael's College, and Champlain College, attract new talent to the state every year. Improving the capacity of Vermont's educational institutions to proliferate high-quality paid internship and apprenticeship experiences will increase the likelihood that college graduates stay in Vermont. There is also widespread agreement that Vermont can do more to build a more diverse, welcoming, and inclusive culture, with the recognition that to grow the state's economic sustainably, we will need to diversify our communities by welcoming newcomers from all backgrounds, regardless of the origins of their birth, the color of their skin, political disposition, lifestyle choices, religion, or educational background.

There are other external events besides the post-pandemic disruptions to the labor force and workplace that will drive Vermont's future. The realities of climate change include the need to mitigate greenhouse gas emissions through the expansion of renewable energy options, to adapt to climate change using remote sensing technologies that predict drought and floods and manage depleted ecosystems services sustainably, and to anticipate the disruptions from climate change to the lives of people presently not living in the state. The realities of climate migration are very real and playing out across the small towns of Vermont as people flee climate change-induced extreme events to find sanctuary in the Green Mountains. The "Climate Economy," a term advanced by VCRD in recent years, is already upon us. That economy is built upon bolstering the state's science and technology infrastructure and advancing the values of sustainability, resiliency, and equity. Other external trends that will very likely continue to alter the Vermont science and technology landscape include the expansion of broadband to all corners of the state, the introduction of 5G and other advanced communication technologies, and an increasing attention being paid to diversifying our workforce.

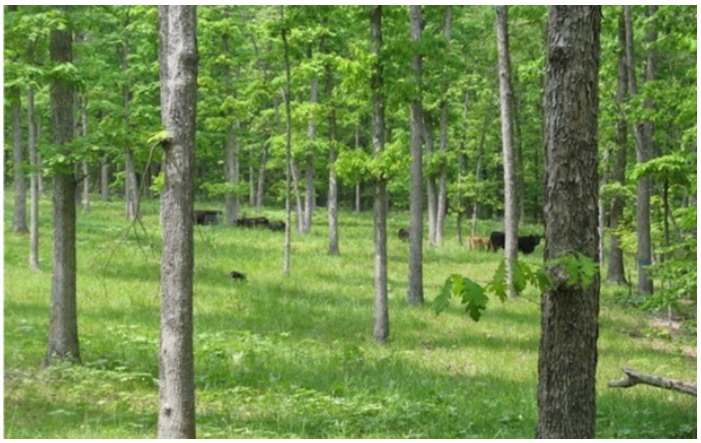
II. Industry Growth Areas

Vermont's green and digital economic potential is built on the foundations of five industry growth opportunities. These sectors include:

i. Renewable Energy

The adoption of the Vermont Comprehensive Energy Plan (CEP) in 2016 established the goal for Vermont to obtain 90% of its energy from renewable sources by 2050. This plan follows on Vermont's leadership in the integration of smart grid technologies, paving the way for increased uses of net metering to better support the integration of renewable energy into the electricity grid. The Vermont Clean and Resilient Energy Consortium (VCREC), led by the University of Vermont, has been established to coordinate research and development opportunities among higher education institutions, energy distributors, and renewable energy producers both within and outside Vermont's borders. Dynapower, founded in 1963, has been a leader in the transition to renewable energy systems and continues to innovate, while a number of Vermont-grown start-ups have also seen great success in this area. For example, KORE/Northern Reliability has experienced tremendous growth in the differentiated renewable energy sector. BETA Technologies has raised substantial venture funding for their small- to mid-scale electric vertical take-off and landing (eVTOL) aircraft[7], and Packetized Energy, which develops electric grid management software, recently had a successful acquisition by EnergyHub[8] and plans to expand its operations in Vermont[9]. With the state's industry, research institutions and public policy makers leading the way, Vermont is poised to grow its renewable energy footprint.

ii. Regenerative and Sustainable Agriculture



With an extensive legacy of sustainable and regenerative agriculture, Vermont farmers and forest managers, supported by UVM Extension and investments from the state of Vermont's Ecosystem Services Pilot program, are leading efforts to advance technologies that support enhanced sustainability of our natural resources, greater soil health, and improved water quality. Some of these technologies include unmanned aerial vehicles (UAVs) equipped with cameras, spectrometers and other sensors to monitor forest, crop and soil health, innovative nutrient management and monitoring practices, and sustainable, net-zero energy use systems such as closed loop agriculture, carbon neutral forestry, solar powered sugaring, and anaerobic digesters. And while Vermont's dairy farm industry continues to contract, there has been growth in the production of other livestock and diversified crops[10]. Technology can play a key role in helping farmers and forest managers adopt regenerative practices using precision agriculture and agroforestry technologies that will help sustain economic viability and environmental resilience. Although not all the progress can be attributed to the increased use of technology, Vermont continues to lead the way in the incorporation of technology for small- and medium-sized farms and the working forest economy, with a strong emphasis on producers owning and using their own data to inform practice.

iii. Advanced Manufacturing

Vermont has been a leader in advanced manufacturing dating back to the Industrial Revolution when the town of Springfield was known nationally as "Precision Valley" because of the cluster of precision manufacturing firms in the area. Today, Vermont manufacturers employ 9.5% of all Vermont workers and exported $2.69 billion in goods in 2017, almost 71% of the value of all Vermont exports[11]. Vermont possesses the infrastructure needed to support the "factory of the future," that includes additive manufacturing (3D printing); semiconductor fabrication; design and integration of new materials and products from nanotechnology science; artificial intelligence; augmented reality; virtual reality; big data analytics; IoT (Internet of Things); cloud computing; robots & cobots; automation of processes; material handling; machine maintenance; warehousing; transportation; supply chain management; and more. Supported in part by the efforts of the Vermont Manufacturing Extension Center (VMEC) and the Vermont Technical College (VTC), the Vermont Manufacturing Collaborative (VTMC) has built a new Advanced Manufacturing[12,13] Center, that houses some of the most up-to-date additive, 3-D printing equipment not only in the state, but in the region. These investments, made possible by Senator Leahy, anchor the state's ability to train technicians to support the growth of the advanced manufacturing sector in Vermont.

iv. Biotechnology

Vermont is home to a burgeoning bioscience and medical device industry, anchored in part by the research undertaken at UVM's Larner College of Medicine and College of Engineering and Mathematical Sciences. Over the past 10 years, Vermont's medical device manufacturing industry grew by 4% to 8%, and more recently, there is significant interest in harnessing patient data for diagnostics. There are a number of networks supporting the bioscience industry in Vermont. For instance, the UVM Center for Biomedical Innovation serves as a space to incubate new biosciences technologies, the work of the Vermont Biomedical Research Network (VBRN) connects the bioscience research community to industry, and the Vermont Biosciences Alliance promotes the growth and connectivity of bioscience industry.

v. Digital Technology, Data Analytics, and Marketing

The recent success of artificial intelligence and data-focused companies, the expanded collection of data by governments, and the increased federal support for research on digital technologies, data analytics, and intelligent systems[14] has created a critical mass of expertise that could benefit from cross-sector collaborations. State leaders have recognized this trend. In 2018, the Vermont Legislature passed S.269 (Act 205) that made Vermont one of the first states to setup a legal framework for blockchain-based limited liability companies (BBLLCs) and commissioned a study on the potential use of blockchain technology in government records[15]. The city of South Burlington has since set up pilot projects to use blockchain technology to record property transactions[16] and to poll their residents for input on public policy questions such as proposed construction projects, affordable housing, and city budgets[17]. Also in 2018, H.378 (Act 137) established an Artificial Intelligence Task Force to make recommendations on the responsible growth and use of artificial intelligence in Vermont companies and government[18]. The Norwich University Applied Research Institutes (NUARI) and the Senator Leahy Center for Digital Investigation and Cybersecurity at Champlain College have provided the basic and applied research to fuel a growing cybersecurity industry in Vermont. Companies in this cluster include Outpost24 (formerly Pwnie Express), NuHarbor Security, and SOOS. Finally, the growing digital marketing needs of Vermont extend across all sectors, including retail, value-added food and drink, sustainable outdoor recreation, and tourism. Seemingly any business looking to market its goods and services will need to take advantage of digital technologies and have expertise in data analytics.

III. Cross-Cutting Functions

The support of these industry growth areas will entail pursuing several distinct, but inter-related, cross-cutting efforts that provide the basis for the goals and strategies outlined later. These cross-cutting functions focus on explicit activities common to most science & technology initiatives.

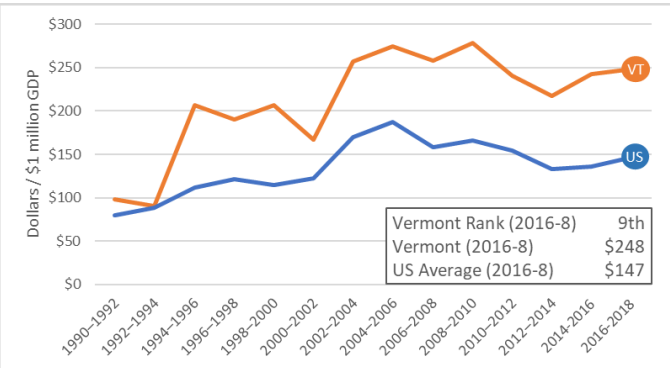
i. Workforce development

As noted in all recent Vermont S&T Plans and underscored again in recent data, the growth of Vermont's science and technology sectors is seriously limited by the lack of a qualified and available workforce[19]. All sectors of the Vermont economy suffer from such workforce shortages, but it is especially critical in STEM fields. The unemployment rate for STEM careers in Vermont is just 1.2%, less than half the U.S. STEM unemployment rate of 2.5%1. While targeted workforce development initiatives have been advanced by groups like the Vermont Talent Pipeline in the areas of nursing and construction, concerted effort is needed to support the growth of Vermont's green and digital economy.

ii. Educational alignments

Closely related to overcoming the workforce shortages is alignment within Vermont's educational infrastructure. With the restructuring of the Vermont State Colleges System (VSCS), the establishment of UVM's Office of Engagement, re-missioning of the UVM Professional and Continuing Education unit, and the tremendous influx of funding from the federal government to support training and upskilling, there is an opportunity for undertaking a collective approach to educational alignment with a particular focus on the building of STEM-related skills. This need for greater alignment should be coupled with efforts to attract jobs seekers in order to grow the population and better educate them as they settle in Vermont.

iii. Research infrastructure



Source: NSF S&E Indicators 2022
Figure 2: Average Annual Federal SBIR and STTR Funding per $1 Million of Gross Domestic Product, by state: 1990-2018

Vermont is fortunate to have many creative and innovative inventors, some of whom tinker away in their garages while others render their discoveries in one of Vermont's many university and college research labs. Vermont continues to have one of the highest Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) funding rates per GDP in the country (see Figure 2) and Vermont small businesses received 25 SBIR/STTR awards in 2020; an impressive total for the 2nd smallest US state by population[20]. Our flagship research university, UVM, has recently cracked the top 100 public universities for total research expenditures according to data on the Higher Education Research and Development Survey (HERD), while the Vermont Established Program to Stimulate Competitive Research (EPSCoR) and VBRN continue to facilitate network ties between research facilities across the state. In addition, the Vermont Advanced Computing Center (VACC), with support from Senator Leahy and investments from UVM and the National Science Foundation, offers access to high-performance computing (HPC) services to businesses and institutions across the state of Vermont. Leveraging these assets is a critical feature of our S&T strategy.

iv. Uses of digital and intelligent system technologies

The discovery of new technologies tells only one part of the S&T development story. Effective expansion of technology firms in the state hinges on the widespread integration of digital and intelligent systems technologies in all facets of Vermont's private, public, and nonprofit sectors. For instance, the Vermont creative sector has pioneered and embraced the use of digital technologies[21] not only for the distribution of their works, but also in the creation of new works. One such technology is LoLa (low latency networking), which allows Vermont musicians and other artists to collaborate with their peers in other Internet2 connected communities with imperceptible network latency. Big Heavy World and The Vermont Young Writer's Project have been among the leaders in this sector. This integration requires widespread access to high-speed broadband. It also requires an effective suite of programming and technical assistance, including cybersecurity, to support widespread adoption of these technologies into practice.

IV. The Plan

The 2022 Vermont Science and Technology Plan was developed with substantial feedback from a wide variety of stakeholders across the state. Leaders of technology firms, economic developers, regional planners, educators, and service providers were invited to contribute input into the vision, mission, and goals and strategies laid out in this document. Initial surveys were distributed through various networks of businesses and service providers to assess the efficacy of the proposed mission, vision, and strategies. A draft of the plan was then posted on a public-facing website to solicit feedback on it. In total, surveys and invitations to comment were distributed to over 750 Vermonters. Comments were received during the public comment period from about 30 different Vermonters. The strategic vision, mission and strategies that appear in this final plan is the result of the consensus that emerged out of this public engagement process.

VISION

Vermont is a state that fosters innovation through the advancement of a green and digital economy that is equitable, accessible, and sustainable.

MISSION

Create and sustain healthy, inclusive, and resilient ecosystems that support a vibrant and prosperous economy in a sustainable environment for all Vermonters through the development and implementation of science, technology, innovation, research & development, entrepreneurship, lifelong learning, training, and talent development pathways.

GOALS AND STRATEGIES

Creating and sustaining healthy, inclusive, and resilient S&T ecosystems requires a holistic approach, including training a skilled workforce, supporting the research and development (R&D) pipeline, nurturing a tech-savvy and inclusive culture, and building the infrastructure in which that ecosystem can thrive. The following goals and underlying strategies were developed to provide focus and identify existing efforts that could be built upon to accomplish our vision.

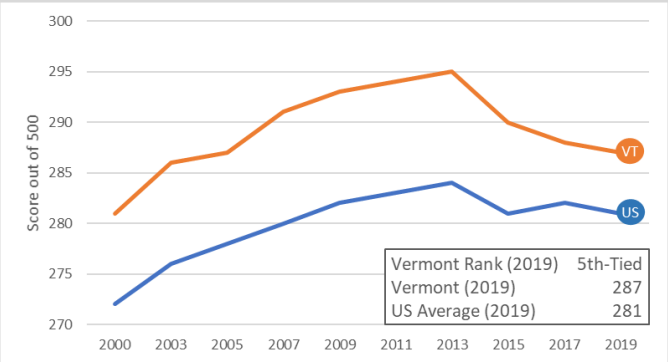
GOAL 1: Workforce Development

Increase the number of Vermonters employed in S&T

Strategy 1a

Improve the diversity of educational pathways to STEM-related careers

Despite eighth grade student performance in mathematics ranking 5th in the nation (see Figure 3), the percentage of Vermont workers employed as scientists and engineers is just 4.46% of the total workforce, 32nd in the US (see Figure 4). One significant factor in this lack of STEM-related workers in Vermont is that according to 2019 National Center for Education Statistics data, 44% of 18- to 24-year-olds, about 3,300 young Vermonters, are not enrolled in a degree-granting postsecondary institution. A concerted effort is needed to increase the diversity of pathways for students to transition from aptitude in foundational STEM disciplines, such as mathematics, to a career in a STEM field.

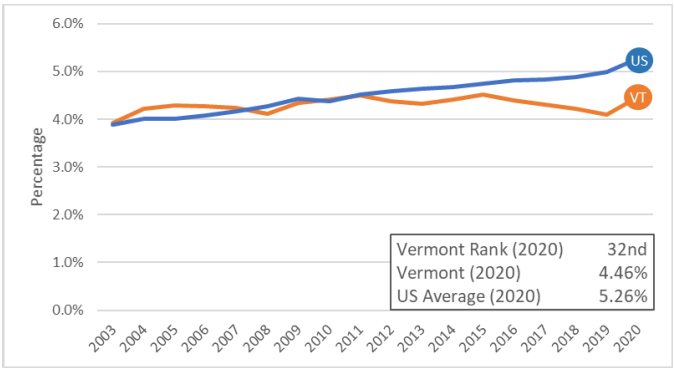


Source: NSF S&E Indicators 2022
Figure 3: Eighth Grade Mathematics Performance, by state: 2000-2019

A multifaceted strategy is needed to increase the potential for Vermonters to thrive in the digital economy includes: creating an effective public awareness campaign highlighting the evolution of STEM education opportunities that appeal to 21st century students at all levels of eduction; updating curricula so students can discuss, understand, and address real-world challenges; encouraging and requiring current science and math teachers to explore further professional development in their content areas, including mas-

tery of the latest developments in the computer and data sciences; increasing the overall number of well-prepared science and math teachers; and developing STEM certificate programs to formalize accreditation toward STEM jobs.

Many K-12 schools are unable to offer specialized, advanced STEM courses because of the lack of certified STEM educators in the state. The National Science Foundation Robert Noyce Scholarship and Gaining Early Awareness and Readiness for Undergraduate Programming (GEAR UP) Champlain Research Experience for Secondary Teachers (CREST) programs at the University of Vermont, the Vermont Mathematics Initiative (VMI), and secondary teacher licensure programs at Northern Vermont University have helped increase the number of STEM educators in Vermont, but there is still a critical need, especially in the computing and data sciences. In addition, educational institutions across the state (K-12, career and technical education (CTE) centers, and higher education) should increase their focus on technology utilization and integration across all subjects. Partnerships with the Tarrant Institute and the Vermont Advanced Computing Center (VACC), would help educators utilize and integrate technology into their curricula. CTEs offer pathways to high-skill, high-demand, high-wage STEM-careers and their curriculum should be expanded to allow 9th through 12th graders to enroll in their curricula full-time. Vermont's growing network of high school and community maker spaces can also provide complementary hands-on educational experiences. Other current efforts that provide specialized STEM learning opportunities, such as the VBRN's support of faculty and student research at primarily undergraduate teaching higher education institutions, Vermont EPSCoR, First Robotics, the Vermont STEM Fair, the Governor's Institute of Vermont, STEM dual enrollment courses, CTE centers (i.e., Fast Forward), The Vermont Academy of Science and Technology (VAST) at Vermont Technical College (VTC), and the Burlington Code Academy, provide additional educational pathways. These pathways to S&T careers, as well as additional pathways to make careers in S&T available to an even wider range of students of all ages, serve as real assets to the state.



Source: NSF S&E Indicators 2022
Figure 4: Individuals in Science and Engineering Occupations as a Percentage of All Occupations, by state: 2003-2020

In addition, workers in Vermont who are highly skilled, or have high skill potential, need increased opportunities to continuously improve their skills as lifelong learners. Statewide programs like Advance Vermont and the Vermont Talent Pipeline provide operational and strategic support to workers and workforce development specialists alike. Specialized programs focusing on retraining, education, mentorship, and career support for technology-enabled careers, such as Vermont Technical College's Office of Continuing Education and Workforce Development (CEWD) programs or Northern Vermont University's Center for Professional Studies courses, ease entry or reentry into the highly skilled employment market. Access to these much-needed initiatives efforts can be improved with tuition scholarships and grants, funds for books, childcare, and other programs specifically designed to remove barriers. A substantial opportunity exists to increase the number of science and technology workers by developing new programs and increasing the awareness of existing programs that prepare students to join the technical workforce. In particular, increasing the awareness and accessibility of these programs within traditionally marginalized communities, such as new Americans and people with disabilities, transitioning from incarceration, or recovering from substance use, could help address Vermont's aging workforce and declining birth rates and provide Vermont with much needed S&T talent.

A multifaceted strategy is needed to increase the potential for Vermonters to thrive in the digital economy.

Maximize the opportunities for internships, cooperative programs, and other applied training programs with S&T companies

A critical stage in the workforce development continuum is the transformation of STEM knowledge acquired in a classroom to marketable skills employers need and related career paths. Providing students with the opportunity to complete internships, cooperative programs, or other applied training programs with Vermont companies helps to fill this developmental gap. These programs also expose interested students to a spectrum of careers and help them develop an appreciation for the numerous employment opportunities in the state. It is also an opportunity for employers to identify their future workforce. Students that participate in these programs return to their classrooms with insights about the skills they need to be competitive once they graduate, influencing their choice of courses and encouraging changes in curriculum that may be needed. This effort will also facilitate dialogue between employers and educators, providing the opportunity to better understand their respective needs.

Several applied training opportunities are available throughout the State, such as Northern Vermont University's Learning and Working Community, VBRN's summer undergraduate research internships, UVM's College of Engineering and Mathematical Sciences (CEMS) Cooperative Education Program, apprenticeship programs at Vermont Technical College (VTC) and the Community College of Vermont (VCC), and internship programs at virtually all higher educational institutions in the State, but more are needed to ease this transition from classroom to workplace for STEM students. In addition, statewide clearinghouse platforms, where employers can post opportunities for internships and short term, entry-level positions and students can find them, are needed.

GOAL 2: R&D Pipeline

Increase research and development (R&D) activity in the State of Vermont with a focus on early-stage companies and entrepreneurs

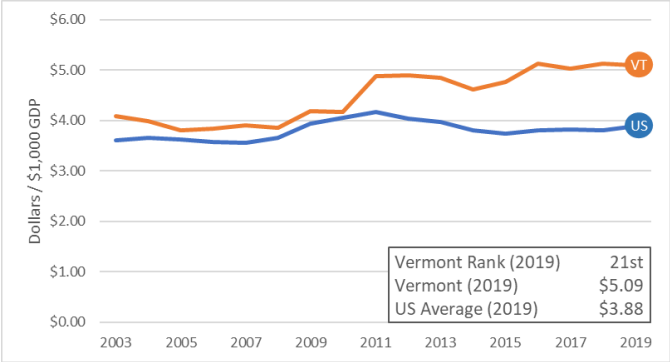
Strategy 2a

Encourage and facilitate opportunities for R&D collaborations across sectors with clear and consistent policies for contractual relationships, such as sponsored projects and joint proposals, and management of intellectual property

While institutions of higher education are often where new knowledge and tools are created, and governments enable critical research infrastructure, it is the private sector that typically apply these innovations to create economic impact and improve lives. Thus, collaboration across sectors is crucial to reaping the full benefits from science and technology innovation. Companies at any stage of development and in any industry, as well as government, could benefit enormously by utilizing existing expertise, laboratories, and facilities offered at Vermont-based academic campuses, including many core facilities such as VTMC's Advanced Manufacturing Center at VTC, UVM's Vermont Advanced Computing Center (VACC), and the UVM Larner College of Medicine's Center for Biomedical Shared Resources (CBSR). Enhanced outreach to publicize faculty expertise, technology available for licensing, and physical resources at Vermont institutions of higher education is encouraged. This information should be proactively shared with the private sector, government, and between and within institutions.

There are a number of effective initiatives across the state that have expanded cross-sector R&D collaborations and demonstrate the potential of these cross-sector partnerships, including the online database of core facilities maintained by the Vermont Biomedical Research Network (VBRN), commercialization efforts by University of Vermont Innovations, Pilot and STTR Phase (0) Awards that foster private sector-higher education collaboration from Vermont EPSCoR, the Agency of Commerce and Community Development's Technology-Based Economic Development (TBED) Program, and the partnership between the University of Vermont Medical Center and Biocogniv to develop a rapid, highly sensitive COVID-19 test using artificial intelligence technologies. Increased facilitation of these collaborations and outreach to overcome the hurdles to cross-sector collaboration is needed, including providing focused attention on overcoming the barriers to commercialization and intellectual property (IP) that can occur in complicated collaborative R&D arrangements.

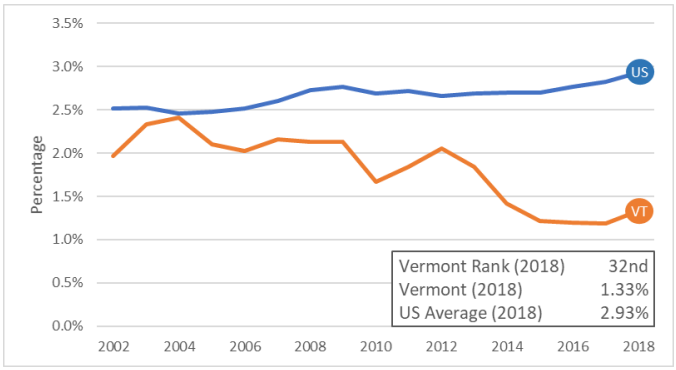
Develop a stronger support system to assist higher education and the private sector in securing increased federal- (including SBIR and STTR) and state-funded grants and contracts, private sector contracts and funding, and foundation support for R&D



Source: NSF S&E Indicators 2022
Figure 5: Academic R&D per $1,000 of Gross Domestic Product, by state: 2003-2019

Increased R&D across all sectors of the Vermont economy will support innovation and the creation of new knowledge, leading to the growth of existing companies and the creation of new ones. Academic research and development (R&D) funding activity in Vermont is relatively strong (see Figure 5). However, there is a substantial opportunity for growth in R&D across the entire Vermont economy, which includes R&D performed by academic, industry, government, and non-profit institutions (see Figure 6). The University of Vermont and Norwich University have strong research enterprises – particularly in the biomedical and cybersecurity areas respectively – that must be well supported. However, more coordinated effort is needed to grow the volume of R&D awards performed by the state's other higher education institutions and the private sector. Programs like Vermont EPSCoR should support grant proposal writing involving principal investigators from outside UVM. A plan to increase the research efforts across all higher education in areas such as engineering, computer science, social science, and the physical sciences should also be developed.

Providing high-level technical and financial support for grant seekers will produce more competitive applications and help guide novice grant applicants. The technical assistance provided by the Vermont Small Business Development Center (VtSBDC) and the funding support through the state of Vermont's TBED Program provide support for entrepreneurs and inventors. Specifically, VtSBDC's Innovation and Technology Commercialization services assist grant seekers in understanding and completing the preparation, analysis, process, and procedures needed to meet the stringent requirements to qualify for, submit, and win grants and contracts, such as federal SBIR/STTR awards. One way to provide additional support would be to offer matching funds for participation in programs that prepare grant seekers for federal competitions such as the Vermont EPSCoR SBIR/STTR Phase (0) program. Effectively transitioning an idea to a commercially viable product very likely requires a continuum of support and collaboration with existing higher education research institutions and companies.



Source: NSF S&E Indicators 2022
Figure 6: R&D as a percentage of Gross Domestic Product, by state: 1991-2018

Increased support for early-stage funding of start-up companies is essential. Many of these companies have high-quality, well-protected intellectual property that serves as their basis and are less likely to have traditional assets to serve as collateral.

Sustain a comprehensive suite of supportive business services to help businesses scale their products and services from R&D, through commercialization, to the global marketplace

While the number of science and technology firms in Vermont grew by 40% between 2010 and 2020, the growth in the number of workers at these firms did not keep pace (see Figure 7). This implies that while new companies are getting off the ground in Vermont, they are having difficulty adding a significant number of employees and scaling their businesses. If this difficulty is not addressed, Vermont risks seeing these companies move out-of-state and losing the momentum of such an opportunity for economic growth.

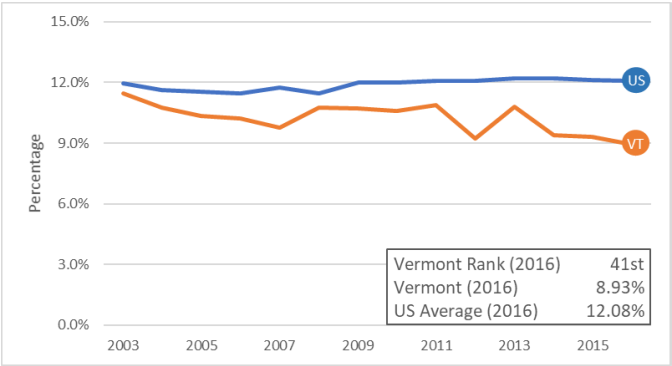
To address this challenge, and other challenges facing S&T businesses, the Vermont S&T ecosystem should support a suite of services that accelerate business growth including the provision of capital for mid-stage, growth-focused companies, digital marketing technical assistance, and data analytics services so that businesses can better understand their customer base and discover potential new markets. Hula and the Vermont Center for Emerging Technologies (VCET) both which offer co-working space, office space for start-ups, and gathering place for entrepreneurs and investors, provide excellent opportunities for Vermonters to connect with fellow inventors and investors. These and other venture capital enterprises including FreshTracks Capital, the Dudley Fund, and others should continue to court investors in startups that have become more prominent in recent years[22]. VtSBDC and VMEC provide a range of business support services for companies pursuing more traditional growth strategies. Creating even more opportunities to access services and to informally engage with others will not only be valuable for science and technology firms, but also early- to mid-stage businesses in sectors across the Vermont economy. In addition, these businesses should benefit from the strategic and unprecedented investments in broadband across the state by gaining the technical capacity to access high performance computing capacity.

GOAL 3: Culture

Create a statewide culture of S&T knowledge development, use, and acceptance that invites Vermonters of all backgrounds and identities to participate in the S&T ecosystem

Strategy 3a

Grow a culture of computational and data literacy through the dissemination of the benefits of rigorous scientific research and technology development relative to the societal, economic, technical, and environmental future of Vermont



Source: NSF S&E Indicators 2022
Figure 7: Employment in High Science, Engineering, and Technology Employment Establishments as a Percentage of Total Employment, by state: 2003-2016

Vermont, and indeed the entire world, is experiencing an age of rapid and intense societal, technological, and environmental change. However, many Vermonters have struggled with recent changes including the transition to a more remote workforce, the increased use of digital technologies, the warehousing of our personal data, and the local effects of climate change. Many of these struggles are due to the lack of resources to both understand the changes and then adapt to or mitigate the changes. Advances in science and technology, along with cross-sector partnerships, can help build understanding of the effects of these changes on Vermonters and create solutions to help them adapt.

One way to better understand and address change is the use of S&T to effectively collect, analyze, and communicate data. However, this requires infrastructure, both physical resources and expertise, to collect, store, analyze, and visualize the data, and shift our statewide culture to more fully incorporate scientific and technological innovation into our assessment of and responses to change. While Vermont has built infrastructure for some types of data such as the Department of Environmental Conservation's monitoring efforts and Vermont's COVID Dashboard, there is a need for data management resources, analysis tools, and expertise to incorporate other types of data, such as those found in local media sources, oral histories, and data archives. All these types of data, in combination with S&T, can be effective in policy making when analyzed and presented in a way that gains the public's trust. Thus, the creation of a more comprehensive, cross-sector data infrastructure, like those found in the Vermont Futures Dashboard, will enhance our ability to understand and address changes that affect Vermonters and could, with time, create a culture of appreciation for the benefits that S&T can bring.

Strategy 3b

Nurture a more welcoming and inclusive culture by more deeply integrating diversity, equity, and inclusion (DEI) goals into the S&T ecosystem

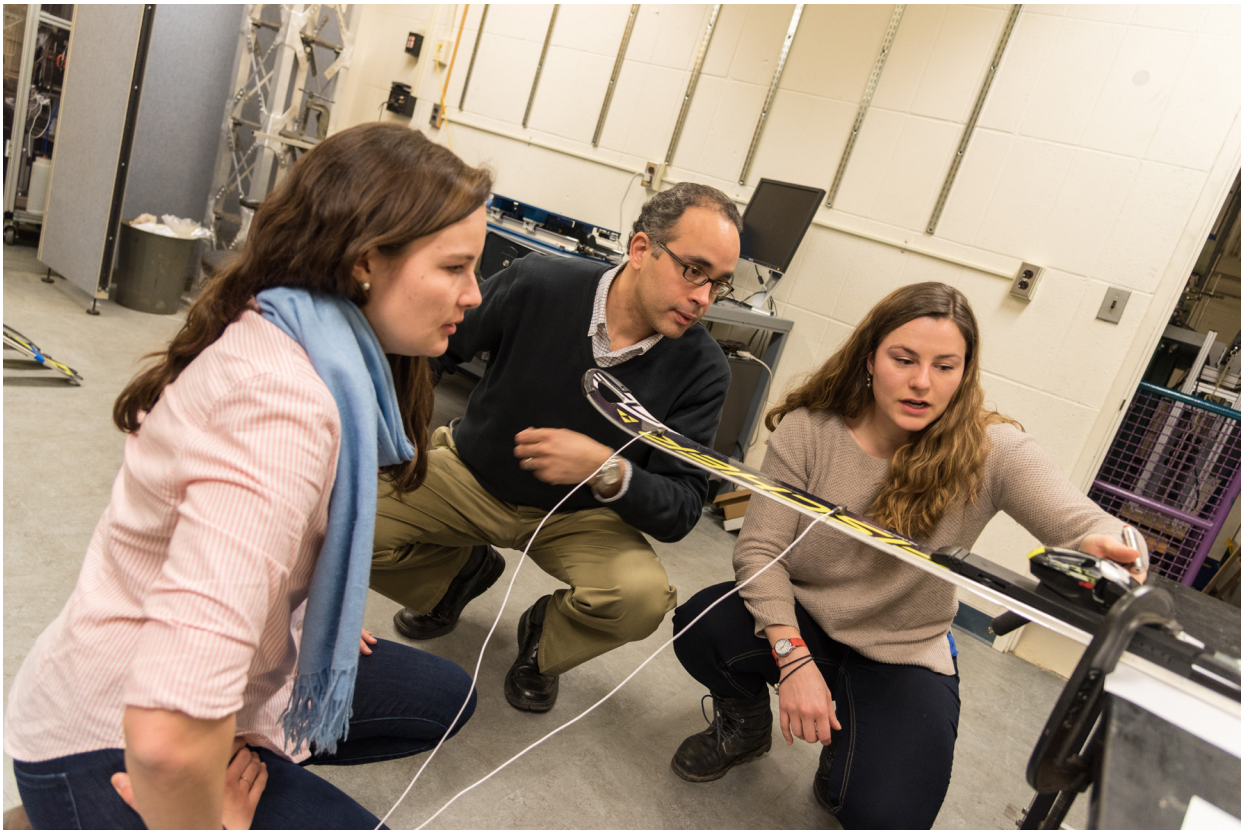
The national science and technology ecosystem, as a whole, overwhelmingly consists of white cisgender males. In addition, the state of Vermont ranks second to last in racial and ethnic diversity, with a population that is 94.2% white[23]. Combined, this can make the Vermont S&T ecosystem extremely unattractive to underrepresented groups, resulting in challenges in attracting talented workers to the state.

Fortunately, Vermont's robust refugee resettlement program, through the U.S. Committee for Refugees and Immigrants, commitment to social equity, and progressive social safety net have helped Vermont attract some diverse S&T talent. In addition, the growing strength and public profile of organizations and programs that support underrepresented groups in business, science, and technology such as Vermont Works for Women, the Women's Investor Network, the Vermont Women Fund, the Center for Women & Enterprise, the Vermont Commission on Women (VCW), HireAbility Vermont (formerly VocRehab VT), The Vermont Association of Business Industry and Rehabilitation (VABIR), the Vermont Office of Veterans Affairs, The Vermont Professionals of Color Network, VtSBDC's Community Navigator Pilot Program (CNPP), and employer DEI programs has helped to build inclusive communities within the S&T ecosystem, providing mentorship and support.

The Vermont S&T ecosystem should increase support for organizations that assist underrepresented groups, ensure fair hiring practices, promote DEI in institutions and organizations across the state, and condemn and take decisive action against behavior contrary to our DEI values to make Vermont attractive to all S&T talent, regardless of background and identity. In addition, explicit programs designed to support and welcome underrepresented groups into the state's start-up, entrepreneurship, and digital economy communities are needed. Investment funds directly targeting these groups are needed, as are training and development programs designed to make space for and give voice to new entrepreneurs from diverse backgrounds and identities.

Capitalize on Vermont's collaborative culture and existing S&T networks and institutions to strengthen and grow the prominence of the S&T ecosystem

In recent years, the number of S&T-focused networks and institutions in the state has grown tremendously. Several new S&T-focused coworking spaces, makerspaces, incubators, accelerators, and innovation hubs have joined an already rich economic development ecosystem including Regional Development Corporations (RDCs), Regional Planning Commissions (RPCs), and CTE centers. These networks build community by providing a forum, physical or virtual, for the exchange of ideas where new business partnerships and peer and mentor-protégé relationships can be formed. They also create opportunities to bring the S&T ecosystem together to learn new skills and to network. For instance, The MINT, a makerspace in Rutland, has developed a series of classes to teach community members how to use their tools and provides a meeting space for several clubs for different types of makers. These institutions are especially important for early-stage S&T companies and those in more rural parts of the state where the rest of the S&T ecosystem is not readily accessible. Now that a critical mass of these institutions has been established across the state, they should be promoted as focal points for the Vermont S&T ecosystem and provided resources so they can support the ecosystem with innovative programming and collaborate with peer organizations on shared initiatives. The Vermont Tech Jam career and tech expo is one example of an initiative that continues to create community and provide a showcase for the Vermont S&T ecosystem[24]. Enhanced statewide coordination efforts between regions, between service providers and state agencies, and between service providers and higher education institutions, such as the Vermont Clean and Resilient Energy Consortium (VCREC), and collaborations with neighboring states and federal programs, such as the National Institute of Standards and Technology (NIST) Manufacturing Extension Partnership (MEP), are needed to better serve regional and statewide workforce and business services needs.



Identify and address the gaps in statewide infrastructure that are critical for building and maintaining a vibrant S&T ecosystem

Strategy 4a

Improve the availability of housing and community amenities

Despite Vermont's ample natural resources and strong sense of community, the state has difficulty attracting and retaining a S&T workforce. This is challenge made evident by a ranking of 41st in the nation for the percentage of our workforce in S&T establishments (see Figure 7). Vermont's small population leads to fewer statewide resources for economic development, fewer job opportunities, and a smaller S&T ecosystem, especially when compared to other East Coast locales. These challenges, in addition to lower salaries (25.6% lower in the high-tech industry vs. the national average[24]), the rising cost of living, underdeveloped transportation infrastructure, and the scarcity of housing and other community amenities such as childcare, office space, essential services, and entertainment options in many parts of the state has made Vermont less attractive to S&T talent. As a result, too much S&T talent leaves Vermont for places with greater resources and a larger ecosystem, and companies find it difficult to recruit talent from out of state. The foundational elements of the Center on Rural Innovation's Rural Innovation Initiative (RII) Toolkit[25] provides a useful framework for identifying externalities vital to a robust S&T ecosystem. Deficiencies in housing, transportation, and community amenities[26] must be addressed through statewide policy so that Vermont companies can compete with S&T companies nationwide for the limited pool of S&T talent.

To address the amenities gap, more effort is needed to attract a diverse array of capital to fuel new housing, small businesses, and creative enterprises. "Patient" or "slow" capital investments need to be leveraged with federal and state grants and guaranteed loans to support mixed-use growth in downtowns. One such program that could be leveraged for improving our infrastructure and community amenities is the Northern Border Regional Commission's State Economic & Infrastructure Development Investment Program[27].

Ensure that the state's cyberinfrastructure meets the growing needs of the private and public sectors

Cyberinfrastructure is critical for Vermont to be competitive regionally, nationally, and globally in today's data-focused and computationally intensive S&T enterprise. Broadband inter- and intra-state connectivity is required for economic development as well as for cutting-edge research, computation, and education. All sectors of the economy require significant bandwidth and low latency communication to conduct R&D and move large data sets between organizations within the state and globally. Thus, it is important to consider connectivity at multiple institutional levels, including large industry and university campuses, small businesses, community anchor institutions (local governments, libraries, and schools), and individual residences to enable reliable communication for work, school, essential services, and entertainment.

Continued support for private and public sector collaborations to build a robust cyberinfrastructure are encouraged. One example of this collaboration within higher education is the Northeast Cyberinfrastructure Consortium (NECC), a high bandwidth research and education network funded by the National Science Foundation and the National Institutes of Health through Vermont EPSCoR and VBRN. NECC connects research and educational institutions in Vermont, New Hampshire, Maine, Rhode Island, and Delaware for shared research centers and cloud computation projects. Another example is the establishment of the Communication Union Districts (CUDs), which create municipal entities to build last-mile infrastructure to connect all home and businesses within their member towns to high-speed fiber networks. The establishment of the Vermont Community Broadband Board (VCBB) in 2021[28] holds promise for the acceleration of universal community broadband across the state.

While broadband access is of critical importance across Vermont, other types of cyberinfrastructure can catalyze S&T growth as well. Collaborative data center initiatives, such as the Massachusetts Green High Performance Computing Center (MGHPCC) and the Ohio Supercomputing Center (OSC), allow institutions to share the cost of cyberinfrastructure capital and support and foster cross-institutional collaborations as well as collaboration with the private sector. These statewide resources, supported by multi-institutional collaborations, provide one model for increasing the resources available to our own Vermont Advanced Computing Center (VACC) to expand its educational, research, and business support services. UVM already maintains state-of-the-art data center facilities that house the VACC and the statewide Vermont Unified Community Anchor Network (VT UCAN) and has room for expansion. Another critical component of cyberinfrastructure are initiatives and communities that bring together computing and technology to form a critical mass of expertise. BTV Ignite, part of the nationwide US Ignite initiative[29], Code for BTV and Code for UV, local Code for America brigades[30], Vermont Code Camp, and the UX Burlington and Northeast Arc Users Group (NEARC) conferences are examples of these communities.

CONCLUSION

The growth trajectories for the science and technology sector for Vermont are promising but limited in large part due to the state's small population and rural nature. The disruptions brought on by the COVID-19 pandemic signal more widespread and longer lasting movements of the labor force. As Vermont has seen an uptick in new remote workers, it is possible for Vermont to attract new workers to the state, especially those who value the state's working landscape. Very real barriers persist, including limited cyber and housing infrastructure and a homogeneous population less familiar with diversity.

The goals and strategies laid out in this report are designed to build capacity to support the growth of the state's science and technology sector while maintaining the quality of life and healthy environment that is woven into Vermont's culture and landscape. By investing resources into further advancing the state's workforce development programs; research and development pipeline; a statewide culture that supports science and technology knowledge development, equity, and inclusion; and housing, community amenities and cyber infrastructure, we believe Vermont's green and digital future is within our grasp. This future will take concerted and coordinated effort to achieve.

DATA / FIGURES

National Science Foundation – Science and Engineering (S&E) Indicators 2022
The data provided in these graphs are available from the National Science Foundation at https://ncses.nsf.gov/pubs/nsb20221. All Vermont rankings are out of 51, which includes the 50 states and the District of Columbia.

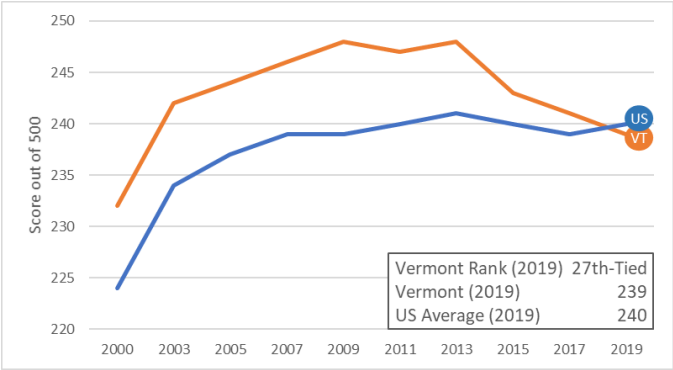


Figure 8: Fourth Grade Mathematics Performance, by state: 2000-2019

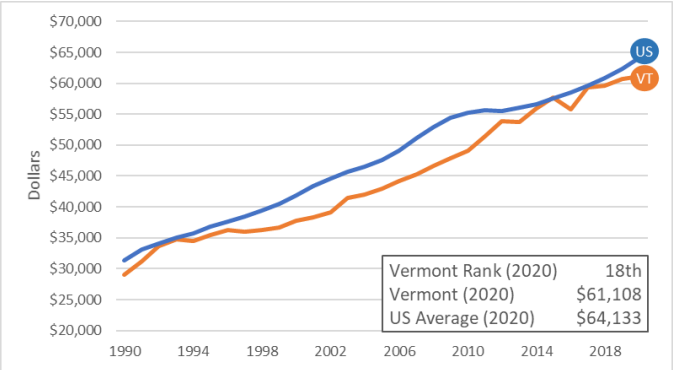


Figure 9: Public School Teacher Salaries, by state: 1990-2020

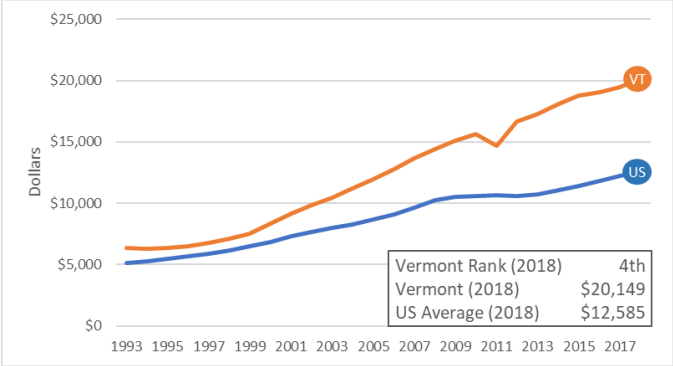


Figure 10: Expenditures per Pupil or Elementary and Secondary Public Schools, by state: 1993-2018

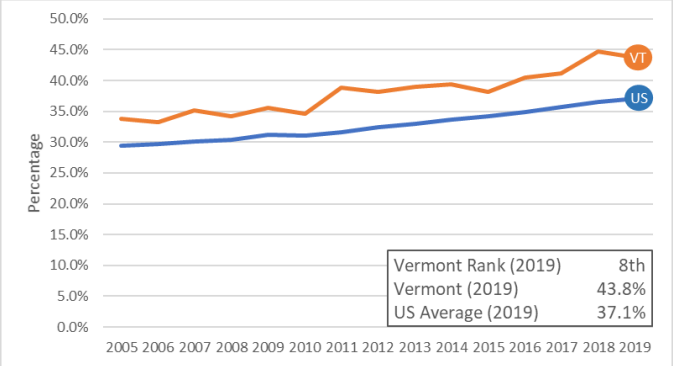


Figure 11: Bachelor's Degree Holders among Individuals 25-44 Years Old, by state: 2005-2019

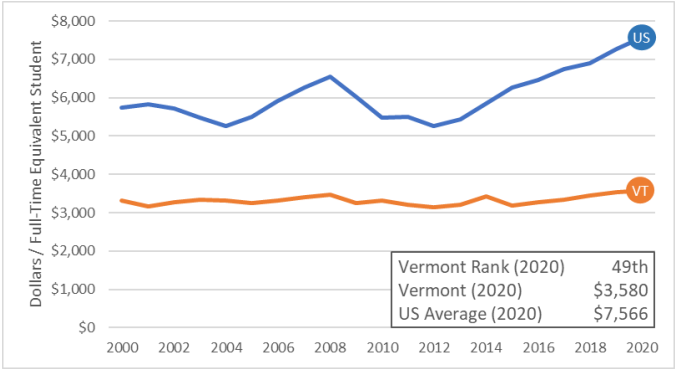


Figure 12: State Support for Higher Education per Full-Time Equivalent Student, by state: 2000-2020

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Prepared and Approved by the Vermont Technology Council, May 2022
The Science and Technology Plan prepared by the Vermont Technology Council is acceptable to the Vermont EPSCoR jurisdiction.

Frank Cioffi, Council Chair