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Institute for Management & Innovation Review by Students

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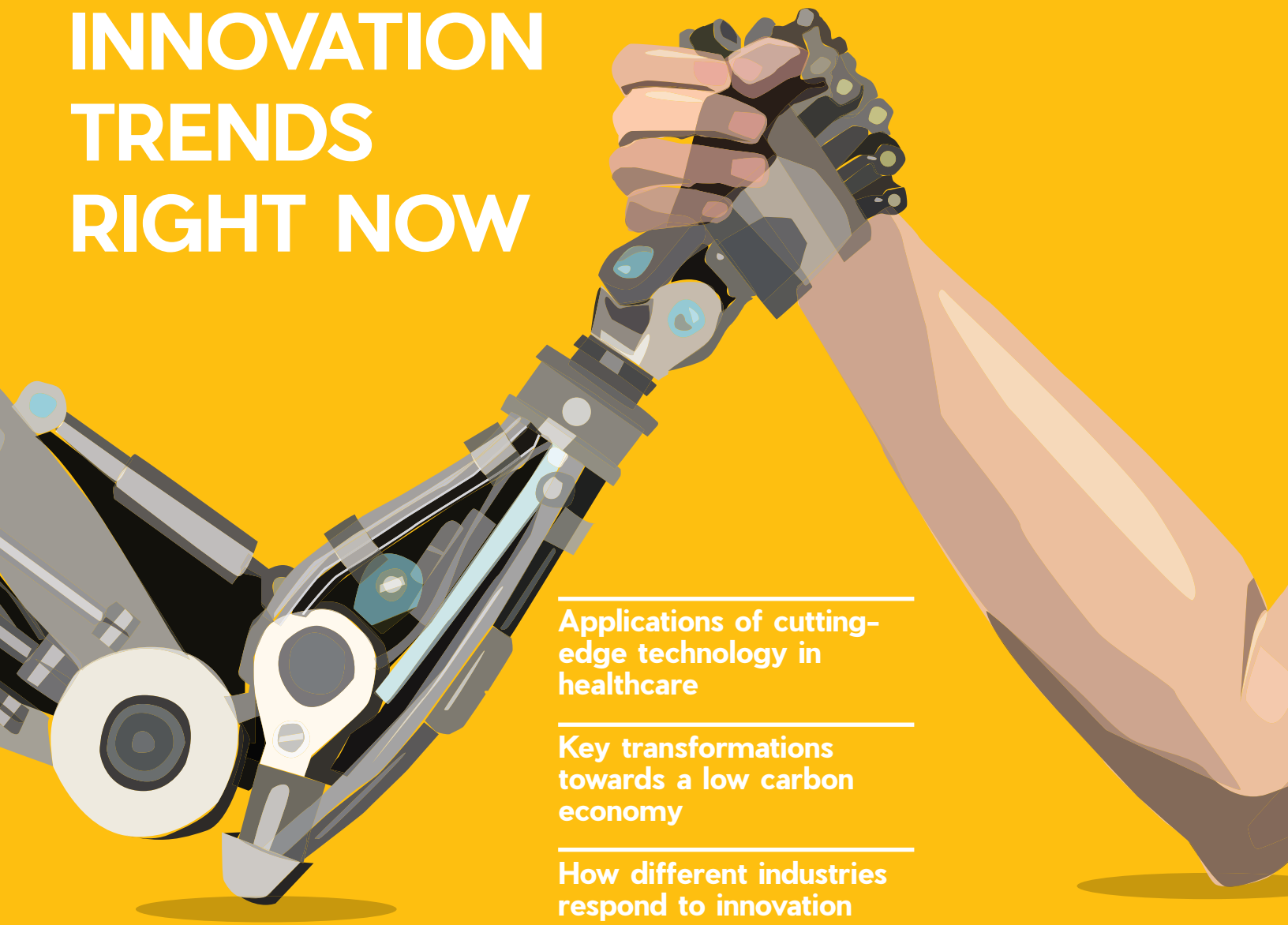

Applications of cutting-edge technology in healthcare

Key transformations towards a low carbon economy

How different industries respond to innovation

Institute for Management & Innovation
UNIVERSITY OF TORONTO
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A FEW WORDS

Hello!

First of all, thank you for checking out the inaugural edition of IMI Review by Students (IMIRS).

The founding editors are students from the Class of 2019, Master of Science in Sustainability Management program at the Institute for Management & Innovation(IMI). We are very excited to present to you IMI's first student magazine, a collaborative effort among faculty, staff, and students across IMI's graduate programs.

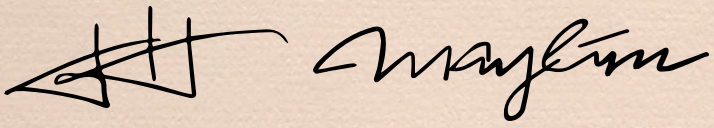
Within the first few weeks of starting our studies, we realized we belong to a much larger and incredibly diverse graduate-studies family at IMI. Throughout our first year here, we had multiple opportunities to produce and observe interesting research and projects. Naturally, we wanted to create a platform for everyone to share their brilliant ideas and voices, and this magazine was born.

A common need we share as graduate students is one to effectively translate our understanding of a topic to a broader audience. IMIRS (read as immerse) allows us to share our different areas of studies, passions and perspectives with our classmates, faculty, and a wider community. We hope this cross-departmental platform will foster further experimentation and collaboration between our programs, alumni, and faculty.

Of course, all of this would not have been made possible without the enormous support and commitment from all of the people involved: most notably our authors, design & editorial team, program coordinators and our IMI directors. Being able to work with a group of such intelligent minds was one of our biggest, and most humbling, rewards.

Under the theme of our first edition, Emerging Innovation and Technology, we will highlight some of the latest advancements in blockchain, artificial intelligence, and vertical farming -- among other intriguing trends.

We hope you immerse yourself in what the next pages have to offer.



Jesse Hudecki & May Lim
Founding Editors
Institute for Management & Innovation Review by Students (IMIRS)

FROM THE DIRECTOR'S DESK

As IMI enters into its 5th year since its establishment in 2013, the timing seems appropriate for our student body to come together to spotlight their research and ideas in the form of the inaugural IMIRS. I have had the pleasure, as the Director of IMI and the IMIRS Faculty Editor, to read and edit the articles in this issue. The articles in this fully student-initiated and run publication, cover a wider range of topics that are foremost in our students' minds. The topics in this issue include blockchain technology application in health, alternatives to meat consumption, and sustainable cannabis production. These articles are forward-looking – seeing far into the future for each of the issues raised, reflecting the aspirations and concerns of the students.

The IMIRS represents student collaboration at its best. In this issue, the Master of Biotechnology (MBiotech), Master of Management of Innovation (MMI), and Master of Science in Sustainability Management (MScSM) programs are represented as the students worked together to design the publication, and solicit and edit the articles in this first issue. The hope is that the sharing of their respective classroom learnings with students outside their programs, as well as with the outside community will transpire. The IMIRS provides a fitting platform to do so, for exchange cross-disciplinary knowledge and showcasing the diversity of IMI students in terms of backgrounds, professions, and ideals.

I hope all of you readers out there will experience the optimism and determination of the student contributors as you peruse this issue. And that like me, you will also eagerly await the next issue!

Yours sincerely,

Soo Min Toh

Faculty Editor, IMIRS
Director, IMI

INNOVATION IN TECHNOLOGY

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CONTENTS

HOW BIG TECH IS DISRUPTING HEALTH CARE

By Carlo Borghesi

We live in an age with unprecedented levels of information, convenience, and control at our fingertips. Practically at will, anyone with a smart device and internet connection can socialize, work, shop, play, receive education, stream endless audio and video content, and generally sustain themselves without having to leave the house – or without having to leave their bed.

However, even in 2018, patients in Canada's healthcare system must venture far from their own bed when they become sick. The requirement to sacrifice rest and relaxation to seek proper medical attention is not a technological one – online appointment scheduling, web-based prescription services, remote sharing of medical records, and virtual physician consultations can be accomplished with technologies about as advanced as MSN Messenger. Rather, the spread of these innovations has been hindered by the industry's regulatory complexity and slow moving, government-funded nature.

While universal healthcare in Canada certainly deserves its praise, it is disappointing to see a system fundamental to our livelihoods fall so short of its potential. For patients and doctors alike, the free flow of health information is restricted, health services are inconvenient and time-demanding, and when all is said and done, patients often pass through the system having had little say or control in their own health outcomes. Why can't modern advanced technologies be used to make healthcare as streamlined, convenient, and tailored to our needs as the complex services packed into our smart devices? Fortunately, Big Tech companies like Apple, Amazon, and Google are asking the same question.

Apple made headlines recently after announcing they would equip their iOS smart devices with full electronic health record (EHR) access for patients and physicians.[1] This is significant because in many places, like Ontario, a patient's health records – which include appointments, bloodwork, imaging, prescriptions, and vaccinations – often exist scattered and isolated between the databases of various healthcare institutions.[2] This can make it difficult to see the complete picture of a patient's health, potentially resulting in important medical information being overlooked. Apple plans to solve this problem by partnering with major healthcare providers and EHR companies to streamline all patient health records into one easily accessible app. With key stakeholders like John Hopkins Medicine, Cedars Sinai, Epic, and Cerner already on board, Apple is well on their way to enabling vast improvements in coordinated care, reduced redundancies in appointments, test orders, and prescriptions, and more informed and collaborative health discussions between patients and physicians.[1]

Apple's peaceful entry into healthcare starkly contrasts with Amazon's anticipated path of destruction in the pharmacy industry. According to reports, the e-commerce giant is exploring the addition of online sale and home-delivery of pharmaceutical drugs to their core business.[3] Combined with the company's additional ambitions in telemedicine, this raises some interesting possibilities for healthcare disruption.[4] Amazon has the technological capabilities to create a future where patients can virtually consult with their doctor and receive a prescription at their front door shortly afterwards. From the perspective of patients, providers, and payers alike, such a stay-at-home patient care model would provide several advantages over the current system, including reduced unnecessary in-person visits, increased space in clinics and hospitals, and controlled spread of infectious disease. In addition, Amazon's website could record and monitor the distribution of prescriptions, providing insights into patient compliance while similarly minimizing unnecessary refills and prescription fraud. Of course, much of this is speculative.[3] Amazon has yet to reveal their true plans for the pharmacy industry, but with the tech giant already having acquired wholesale pharmacy licenses in at least a dozen states south of the border, incumbent pharmacies would be wise to stay tuned.[5]

Google has put resources on even more healthcare projects than its rivals Apple and Amazon, ranging from early drug discovery all the way to patient care. Perhaps this is unsurprising, as it comes at a time when pharma and healthcare companies are clawing over each other to integrate advanced technologies like AI. Put simply, Google's expertise is in high demand. For instance, Google Deepmind, the company who created artificial intelligence that taught itself how to beat any human player at Go, is now working on several projects with the U.K.'s national health service.[6] Additionally, Calico, Google's life-extending research and development subsidiary, and Verily, Google's Big Data subsidiary, have formed partnerships with major pharmaceutical companies, including AbbVie Inc. and GlaxoSmithKline.[7,8,9] The above partnerships represent only a few among several others, and many interesting early-stage innovations – glucose-sensing contacts, bioelectronic medicines, wrist watches to track clinical trial data, artificial intelligence to diagnose medical images, and powerful health data analysis tools, to name a few – have been born.[9,10,11,12] Whether Google can transcend itself and become a true force in healthcare remains to be seen, but with the direction the industry is headed, the company is undeniably well-positioned to compete.

This article has provided only a brief overview of the ways Big Tech is actively disrupting healthcare. Other tech companies, such as IBM, Telus, and Uber, have similarly entered this space.[13,14,15]

One may wonder why the tech industry is suddenly taking such a vested interest in human health – the answer is not altruism, it is Big Data. Through executing strategic, data-driven initiatives in healthcare, like Apple's streamlined health records or Amazon's prescription drug sales, companies can generate a massive amount of healthcare and patient data. This data, which can be used internally or sold to other companies, is extremely valuable as it allows companies to perform extensive research into our lives. With artificial intelligence increasingly performing this research for companies, the value of this data is increasing exponentially.[16]

Giving profit-driven companies this much insight and control over our health will understandably make many uncomfortable. Big Data will shed light on many different ways for companies to profit off our health, and as Valeant pharma has adequately demonstrated, it only takes one creative strategy to inflict devastating damage on vulnerable groups of patients. Now of course, in an age where many Snapchatters are willing to give away their real-time location on a map with a virtually identical caricature of themselves, not everyone will share such privacy concerns. Similarly, perhaps for the majority of people, these risks may be highly preferable to the otherwise hopeless acceptance of having to stew in infested waiting rooms for even basic healthcare services. Even for the skeptics, there is not much that can be done to stop it. Healthcare needs an update, and Big Tech is here to provide it.

About the Author

Carlo is a MBiotech graduate student as well as an Editor of IMIRS. He joined the IMIRS team because of his interests in science, writing, and innovation, and contributing to the inaugural edition of this magazine allowed him to explore these interests all at once. Currently, He is currently completing an internship in Medical Affairs at the pharmaceutical company Boehringer Ingelheim. Outside of work, Carlo enjoys reading, playing guitar, playing soccer, and hanging out with friends.

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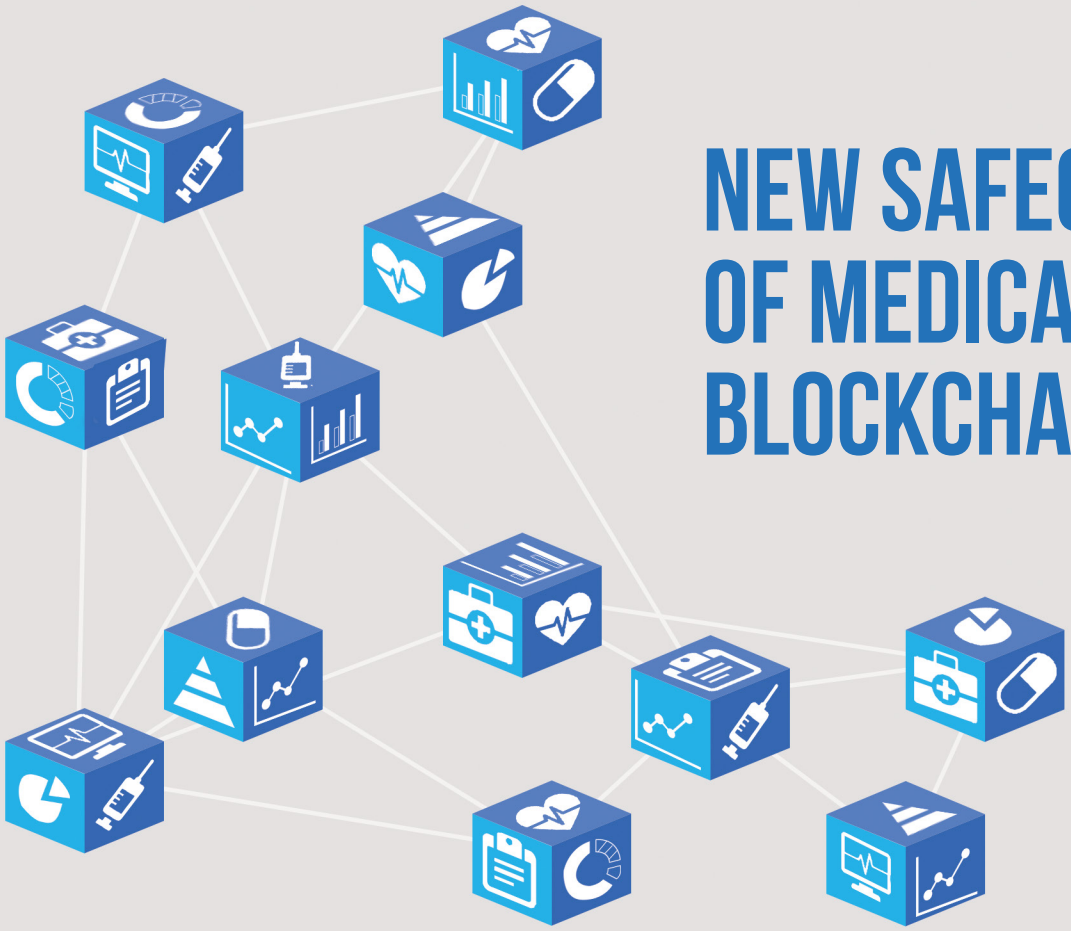
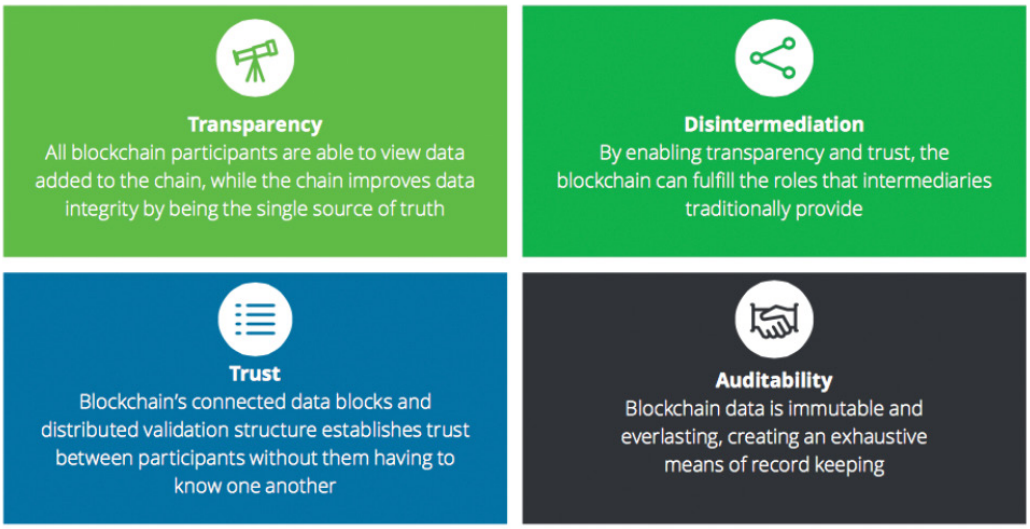


NEW SAFEGUARD OF MEDICAL DATA: BLOCKCHAIN

By
Alexandra Garbe
& Philip Szwiec

The blockchain universe has burgeoned in recent years, and blockchain technology is being hailed as one of the next game-changing, disruptive technologies. Put simply, blockchains are distributed ledgers that are sequential lists of transactions with identical copies that are shared, synchronized, and maintained among the members of a network.[1] There is no central mediator that owns or controls the data inscribed in a blockchain; instead, the multiple parties in a network that have access to the data agree to update the records in the ledger on a regular basis. Each record in the chain includes a timestamp and cryptographic signature, and records can only be added, but never removed, through networked member consent. All members in a given network have access to the data required to audit the transactions on the chain, which ensures that the inscribed data is historically accurate. Blockchains are therefore decentralized, immutable, private, and trusted properties that are fundamentally disruptive.



Properties of Blockchain

Blockchains are commonly known for their applications in the financial industry, owing to its preliminary applications for decentralized digital currencies like Bitcoin. However, blockchains have unlocked potentials far beyond cryptocurrency applications due to their digitized and decentralized nature. The impact of blockchains will be realized across a myriad of fields in the near future, but this article looks at the impacts that blockchain has on healthcare through electronic medical records (EMR).

Application of Blockchain to Electronic Medical Records

Many applications for blockchain technologies are being analyzed and actualized in healthcare, including the management of clinical trial records and insurance claims, as well as preventing prescription drug fraud.[2] However, a clear gap in the healthcare industry, and one that presents an ideal application for blockchain, is the EMR.

CRITERIA FOR IDEAL BLOCKCHAIN USE CASE	EMR EXAMPLE
1) There are multiple stakeholders contributing	Various doctors, nurses and pharmacists at different institutions may all contribute to a patient's medical record.
2) Parties need to trust that the information is valid	A specialist needs to know that the information provided by a primary care physician is accurate before they can administer a certain test or medication (e.g. patient's allergy list).
3) There are intermediaries that could be removed to improve efficiency or trust	Expensive data mediators are used to establish trust and connect researchers to patient data.
4) There is a need for reliable track of activities/ auditing of transactions over time	Physicians can track records over time and patients can track who has viewed, added to or has access to their data.
5) There is a need for enhanced security to protect the data	Health information is confidential and there has been a rise in the number of patient health data breaches.

It is widely acknowledged that EMRs, and technology developments in healthcare in general, are lagging due to slow adoption, regulatory hurdles and bureaucratic inefficiency.[3] A primary goal of current innovations in healthcare is to ensure that patients can exercise more control and autonomy over their own information, so that patients are at the center of their own medical and healthcare decisions. It is imperative that patient privacy is maintained and access to data is only given to relevant parties throughout the implementation of this goal. In addition, the pertaining information should be complete, accurate and interoperable among various providers, and any new technologies used to facilitate technological intervention in EMRs is cost efficient.

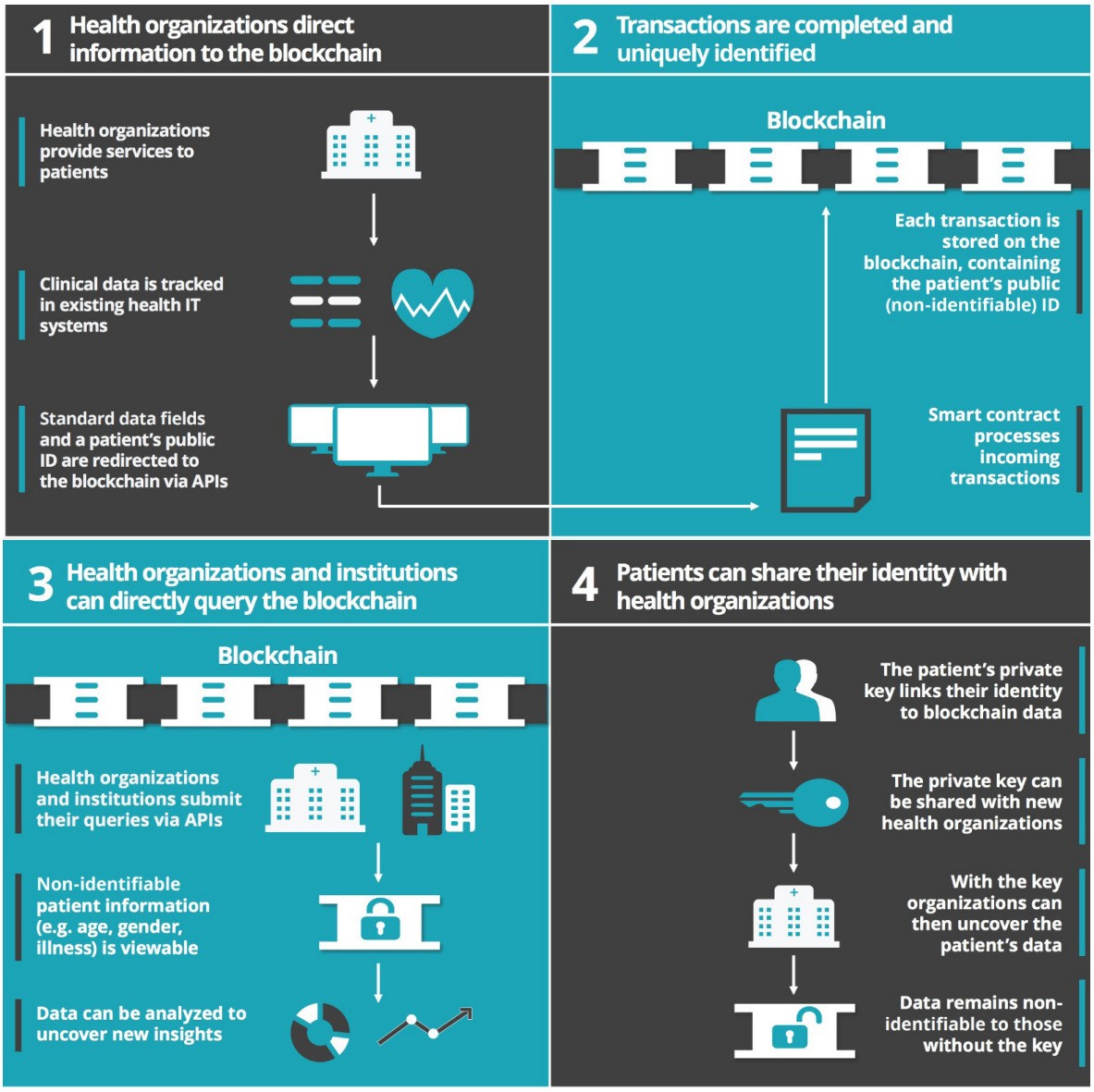
Blockchain technology is ideally suited to address EMR-specific issues – such as interoperability, trust, cost, security/privacy, access to population health data and patient agency because of its decentralized, immutable and privately trusted nature.

	HIE pain points	Blockchain opportunities
	**Establishing a trust network** depends on the HIE as an intermediary to establish point-to-point sharing and "book-keeping" of what data was exchanged.	**Disintermediation of trust** likely would not require an HIE operator because all participants would have access to the distributed ledger to maintain a secure exchange without complex brokered trust.
	**Cost per transaction**, given low transaction volumes, reduces the business case for central systems or new edge networks for participating groups.	**Reduced transaction costs** due to disintermediation, as well as near-real time processing, would make the system more efficient.
	**Master Patient Index** (MPI) challenges arise from the need to synchronize multiple patient identifiers between systems while securing patient privacy.	**Distributed framework for patient digital identities**, which uses private and public identifiers secured through cryptography, creates a singular, more secure method of protecting patient identity.
	**Varying data standards** reduce interoperability because records are not compatible between systems.	**Shared data** enables near real-time updates across the network to all parties.
	**Limited access to population health data**, as HIE is one of the few sources of integrated records.	**Distributed, secure access** to patient longitudinal health data across the distributed ledger.
	**Inconsistent rules and permissions** inhibit the right health organization from accessing the right patient data at the right time.	**Smart contracts** create a consistent, rule-based method for accessing patient data that can be permissioned to selected health organizations.

Source: Deloitte.

IBM, a reputable multinational technological organization, writes in their white paper that they believe blockchain can be applied to "resolve many of these challenges, including the fundamental issues of security, scalability, interoperability, and privacy", which could be extended to safeguard EMR data.[4]

In 2015, there were 112 million health care record data breaches due to hacking or technology failures, and this cost the U.S. healthcare industry an estimated $6.2 billion.[5] Blockchain could mitigate this problem due to its increased level of security through cryptographic signatures and key access, use of smart contracts to set permissions, information timestamps and audit trail, and vis-à-vis the distribution of data over multiple parties. Instead of patient information being updated and stored locally at one institution, health care organizations could direct a standardized set of information to a nationwide blockchain transaction layer, with only non-personally identifiable information available at the surface level. Information stored on the blockchain could be secured through cryptographic keys, allowing patients to determine who has access to their data, and for how long. This would enable patients to easily share their data between their various healthcare providers, as depicted in the figure below.



Source: Deloitte.

These datasets could be stored directly on the blockchain ("on-chain") or be linked to data that is stored externally ("off-chain"), such as in the hospitals' existing local system.

In addition, blockchains can become increasingly complex with the addition of "smart contracts," which can automatically apply set rules or permissions (e.g. determining if a stakeholder has the required approvals prior to accessing data) to further preserve data security. Finally, this can all be implemented in a frictionless process by leveraging an application program interface (API), which can feed the smart contract and allow the blockchain platform to seamlessly integrate with each organization's existing systems.

The Healthcare Industry's Perceptions of Blockchain

IBM conducted a survey of 200 healthcare executives, including payers and providers in 16 countries, and found that that the healthcare industry expects significant innovation related to blockchain in the near future.[3] According to the report, 16% of respondents expect to have a commercial blockchain solution at scale in 2017. By 2018, 9 out of 10 healthcare organizations plan to finance blockchain applications in each of the areas surveyed, with 94% investing in medical and health records.

These findings support the prediction that blockchain will may be a disruptive force in the healthcare industry within five years. This also provides evidence that innovation is required to solve the industry's current problems, and healthcare organizations are open to adopt blockchain technologies to address these challenges. Beyond this, healthcare organizations have indicated their intent to invest in a variety of blockchain applications, particularly in medical and health records, and they expect EMRs to be one of the top areas impacted by blockchain technology.

Market Analysis

There is a well-established need for more effective systems to improve the quality of healthcare and reduce the growingly behemoth costs. In 2015, U.S. healthcare spending increased to $3.2 trillion, equivalent to $9,990 per person.[6] The U.S. Medicaid program, for example, spends nearly $30 billion on administrative costs, including health information technology deployment and maintenance. Blockchain technologies have the potential to offer significant cost-savings by removing the need for third-party data managers and ongoing system maintenance of existing legacy IT systems.[7]

Premiere Healthcare Alliance's QUEST collaborative data-sharing initiative is an example of ongoing effort demonstrating efficient data sharing can save money and lives. Data-sharing among the 333 hospitals included in QUEST collaborative resulted in 92,000 lives and $9.1 billion dollars saved over 4.5 years. If these practices were replicated and transplanted in hospitals across the U.S. alone, it could save 950,000 lives and $93 billion over 5 years.[8] This data supports the argument that blockchain, which can contribute to efficient, secure and cost-effective data sharing, can have a significant impact on healthcare, and provides a sound business case to implement this technology.

Admittedly, it is often difficult for big and impactful industries like healthcare to challenge incumbent systems and overcome bureaucratic hurdles. As new technologies like blockchain propose better alternatives, balancing the potential costs and benefits will be critical.

About the Authors:

Alexandra is a recent graduate from the Master of Biotechnology program at the University of Toronto. Through the MBiotech program, she has developed a strong background in science and business, and gained hands-on experience through team projects and work experience in the biotechnology industry. She completed an internship in Medical Information, Medical Communications and Marketing at Amgen, a biopharmaceutical company, where she is currently working as a Marketing Associate. Her interest in health care has led her to pursue a career where she can make a difference for patients through innovative and accessible medicines.

Philip is a second year Sustainability Management student at UTM. His research interests include, but are not limited to, clean revenue regimes, corporate social/sustainability mechanisms, and environmental gentrification. Relevant projects in these areas from the past year allowed him to intern at Corporate Knights, a Toronto-based research, specialized media and financial information company over the summer. With prior experiences as a contributing editor for different school journals, coupled with his talent for writing and revising, Philip is excited to share the accessible, quasi-academic and student-led platform with students from all disciplines.

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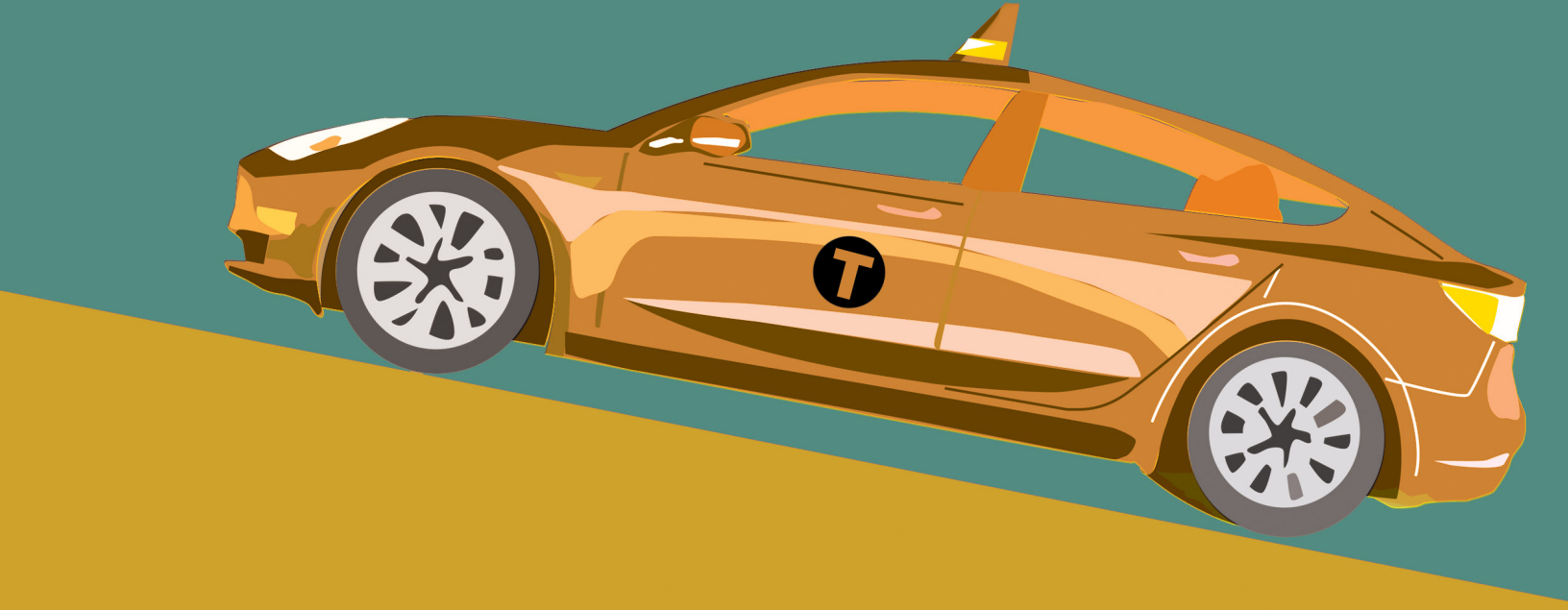
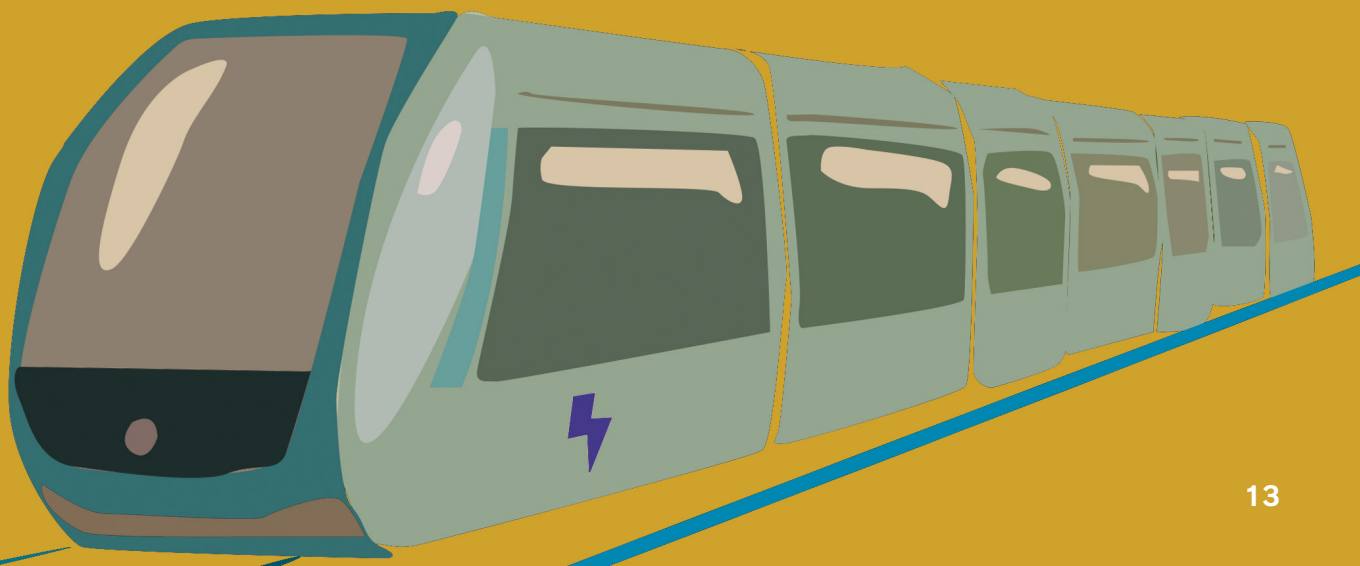


FUTURE OF MOBILITY:

SHARED, AUTONOMOUS AND ELECTRIC

BY MAY LIM



There are exciting changes coming to the auto industry. Even the word 'auto' already feels slightly out of touch – some trends will have a profound impact on our familiar ways of getting to and from places, hence the novel label, "Mobility-as-a-Service."

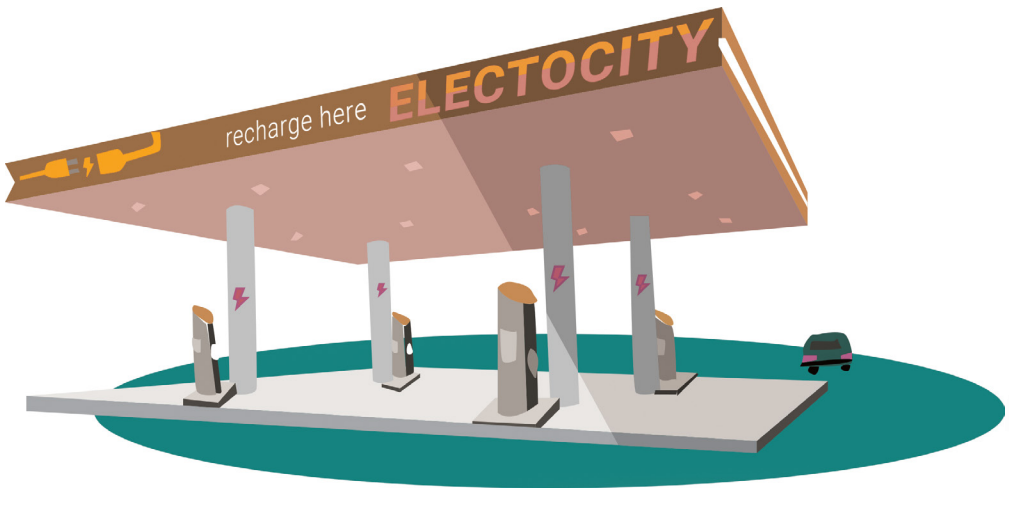
For decades, owning a car has been an indispensable part of adulthood; for many it is a milestone among others like finding a salaried job, buying a home, raising a family, etc. But this may no longer be true; babies born today may never have to take a driver's license exam, pay for car insurance and maintenance, or circle around city blocks looking for a space to park. Already, rushing to the nearest road and waving at passing cars to yell out "Taxi!" is more common to movies than on real streets. In 2017, more than half of people in the US have used ride-hailing apps, most of which allow you to schedule a pick up or share rides, follow a GPS route, see your ETA (estimated time of arrival), and provide feedback on the service.[1] On a day with a sudden downpour, you can easily spot hurdles of people waiting for their app-dispatched taxis in building lobbies, busily checking license plates of passing vehicles for their own. Recently, some people have turned to these services to travel to emergency rooms, because it would only cost a fraction of the price of an ambulance ride.[2]

This change of scene, driven by the offering of Mobility-as-a-Service (MaaS), has taken place in just over a couple of years. For example, Uber, one of the most used ride-hailing applications, didn't exist before June of 2010. Lyft, another popular and similar app, incorporated only six years ago. At least one ride-hailing service is available in over 600 cities around the world today;[3] the Chinese Uber-equivalent (to whom Uber actually sold its Chinese operations) Didi Chuxing, services 550 million active users each day.[4] Such "app-ization" of ride-hailing aims to optimize the transportation system we have had previously, raising its accessibility and convenience, all the while piggybacking on increasingly prevalent smartphones.

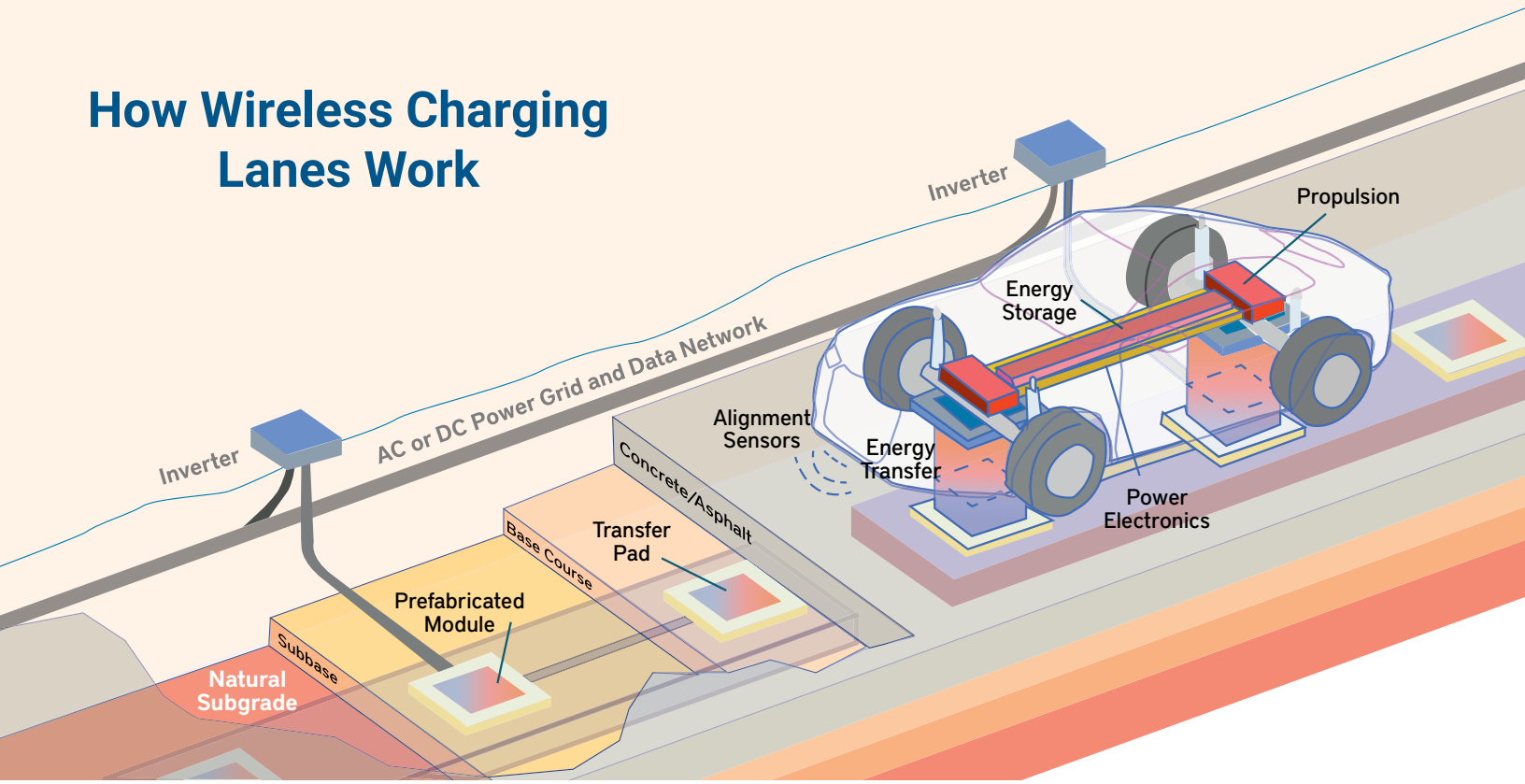
Status quo, however, is again ready to be disrupted. Autonomous Vehicles (AVs) are supposedly only a couple years away from being fully commercially available; Tony Seba, the founder of RethinkX Institute, believes almost every travel via personal auto today will be replaced by AV taxis by 2030.[5] Uber, Waymo, and Apple are just a few of many companies developing machine learning capabilities and conducting real road tests. By removing one of the biggest costs to operating a ride-hailing service – paying the driver – each ride could be offered more competitively against other mobility options, including public transit. And if there are enough AVs on the roads, it means they can "talk" to each other en route, collaborate on letting an emergency vehicle pass through, reduce human-induced accidents or traffic, and allow sharing of rides with shorter wait times and less detours.

Another thriving mobility trend is electric vehicles (EVs), although the invention itself is not a product of this century. (The first EV was developed around 1832.[6]) There are three types of EVs: Battery Electric Vehicle (BEV), Plugin Hybrid Electric Vehicle (PHEV) and Hybrid Electric Vehicle (HEV). Most common are BEVs and PHEVs: a BEV like Tesla Model S or Nissan Leaf runs entirely using an electric motor and battery, without the support of a traditional internal combustion engine. GM Chevy Volt or Toyota Prius are PHEVs that use both an electric battery and an internal combustion engine which replaces the electric motor when the charge is low. Many governments recognize the co-benefits of transitioning into electric mobility; Toronto, for example, wants all of Toronto's new vehicle sales to be electric by 2030 as part of the city's low-carbon plan.[7]

"Toronto, for example, wants all of **Toronto's new vehicle sales to be electric by 2030** as part of the city's low-carbon plan."



How Wireless Charging Lanes Work



An even bigger potential for EVs lies outside of their mobility functions. Through grid integration, an electric vehicle could be fully exploited through grid-edge compatibilities, meaning a car could store and provide power in times of need like peak hours, blackout and natural disasters, or communicate with smart buildings with EV chargers to avoid crowding the energy load. Incredible innovations are developed daily to allow faster and more convenient charging, such as wireless charging roads that could ultimately render pulling into a gas station or a charge point obsolete. Such opportunity charging is extremely advantageous for autonomous cars that do not have drivers: imagine pick-up and drop-off zones with road-embedded chargers that wirelessly and autonomously fill up the vehicle. If it sounds too futuristic, look at Torino, Italy, where electric buses have been charging wirelessly since 2003.[8]

These three major forces influencing the future of mobility are not, and should not be, exclusive of one another. The benefits of accessibility, safety and clean electrification can be achieved in consortium and incur a significant collective benefit to the society. Policy needs to proactively understand and acknowledge that different cars will be on streets soon (if not already in some cities[9]).The next step is to begin addressing the anticipated impacts on other public systems and private citizens, not to mention thousands of soon-to-be displaced drivers who have recently come to depend on Uber and Lyft income.[10] Behind the veil of excitement over new technology, there are many problems that are not in the best interests of industry players to proactively discuss with the public. For example, if everyone privately owns an AV that they take to work each day, and these AVs are sent back home empty, just as many extra cars will add to traffic on roads and cost taxes. If the price of an AV ride drops to lower than that of a transit fare, there may not be enough users of public transit to expand or maintain current services. Are robots better than humans at navigating, enabling narrower roads and more space for activities? Where and how will all these electric AVs charge and how will they affect the grid? Will the promise of comfort and convenience of AVs encourage people to move out of expensive cities into suburbs, compounding urban sprawl?

Among these uncertainties, the biggest certainty is in the need for policy to start shaping and regulating these changes as soon as possible. Insurance policy and civic law will have to adapt to these new "drivers" and new mistakes to be made. Traffic services may have to work with private companies to facilitate travel. Less obvious things like compensating for lost revenue streams from speeding tickets have to be thought about and planned for in advance.[11] Policy will be instrumental in consolidating the future of this industry, to ensure the changes work in tandem with other policy objectives like emission targets, less congestion and urban sprawl, and safer roads.

In all, the future of mobility may be unpredictable but it must not be unmanageable.

About the Author

May is in her second year of the Master of Science in Sustainability Management at University of Toronto. Her undergraduate studies in economics and public policy have been instrumental in growing her passion for enabling policy to enable technological development. She believes at its foundation is sharing of perspectives and dialogue, which helps technology develop for the right needs in a transparent and accessible way. May's current interests are sustainable urban systems, behaviour changes, and Mars (the planet).

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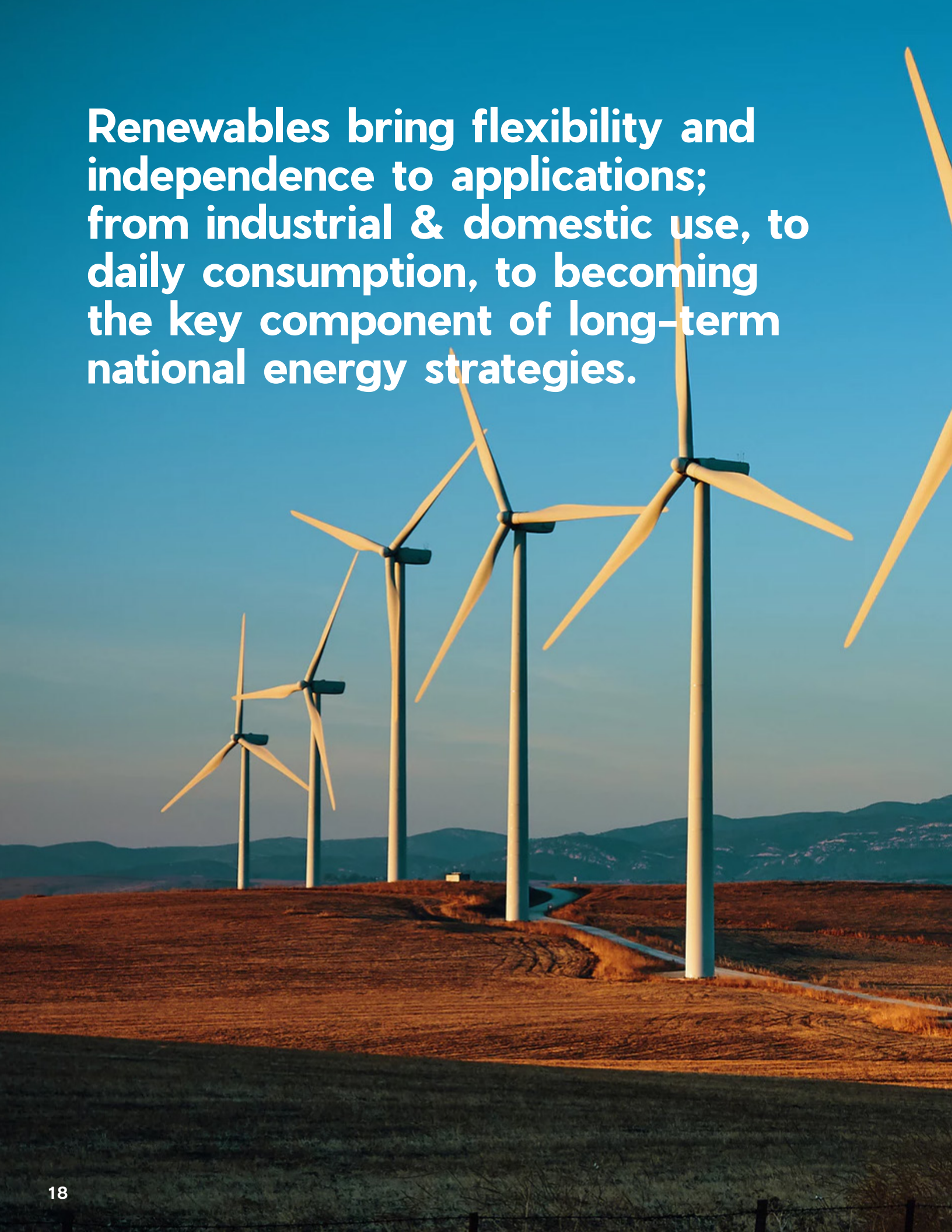
Fossil Fuels Are Going Extinct

Challenges and Opportunities in Green Energy

By
Jesse Hudecki
& Rabeet Khan

Electrical grids and energy distribution networks are complex systems, and adding renewable energy sources to that mix is even more complicated. With that being said, significant investment is happening, and grids are becoming more renewable (namely through investments in solar and wind energy) – 2017 was a record year for both solar and wind installation and investment. In China alone, installed solar capacity has increased by 53 GW over the last year, with $86.5 billion invested in 2017, and the momentum continuing in 2018 with over 1000 GW installed to date.[1] Even some fossil fuel producers understand the shift is imminent to renewables, with Suncor (a Canadian oil and gas producer) increasing their commitment to a renewable portfolio in 2018.[2] Despite these advancements, renewable energy still only contributes 24.5% of global electricity production, and only 18.4% of total consumption. However, according to a recent study by the International Energy Agency, this number should grow to 33% by 2022.[3] Without political interference, the state of renewables becomes a matter of economics and innovation. Despite the positive momentum presenting significant opportunities in the field, there are an equal amount of challenges (technical and non-technical) to overcome moving forward.

The two leading sources of renewable energy are Solar Photovoltaic (PV) and Wind energy. Growing price competitiveness in renewable energy generation has been attributed to two main areas; material costs have significantly dropped thereby generating a greater ROI due to increased efficiencies, and the spread of competitive auctions has facilitated their adoption into long term energy plans across the world.[4] Although demand for clean energy sources has exploded in recent years, the fundamental issue of intermittency has yet to be answered convincingly. It is not always a sunny day (especially in climates similar to ours in Canada, with our harsh, dark, and long winters) and the wind is not always blowing. Clearly, this shows that relying on solar or wind energy for the bulk of electricity generation is not feasible, as there would be times of excess generation and far more times of under-supply. Some of the issues can be addressed by emerging technologies such as machine learning algorithms, for example (a form of Artificial Intelligence).



Renewables bring flexibility and independence to applications; from industrial & domestic use, to daily consumption, to becoming the key component of long-term national energy strategies.

Weather patterns can be forecast with greater accuracy thereby enhancing efficiencies by calibrating dynamic wind and PV systems. AI can also be implemented through smart metering and building design to efficiently reduce demand during peak consumption hours, when natural gas fired 'peaker-plants' or other fossil fuels would make up for the energy shortage on the grid. Nonetheless, issues with an oversupply during off-peak demand hours and an undersupply during peak demand hours will persist until energy storage catches up.

Lastly, the materials used to create wind turbine generators and solar PV cells have an enormous environmental footprint. 90% of these rare earth metals (neodymium and dysprosium for example) that make up the magnets used in turbines, or lanthanum used for layering in solar panels, are mined in China and Mongolia.[5] A simple Google search of the Baotou region should paint an adequate picture of the environmental toll the mining process can have. Extraction and refinement generate significant sewage waste and air emissions as a by-product, which, complemented by weak enforcement of environmental regulations, has created an environmental disaster. These rare earth metals are essential components for most forms of our modern technology, and will need to be developed in a more sustainable way moving forward – including with their end-of-life disposal.

Can you actually store electricity?

Energy storage is one of the most promising developments to address intermittency in renewable energy systems. It is not a new concept by any means, with hydro storage being used to grind grain over 2000 years ago.[6] It should be noted that you cannot simply 'store' electricity – these options presented are forms of converting electricity into alternative states (ex. chemical). These days much of the excitement in energy storage surrounds batteries. Tesla's 'Powerwall' is a perfect example of this type of storage, using rechargeable lithium-ion battery cells. For industrial scale solutions, there have been major strides in lithium ion battery storage; however, fundamentally batteries are not the solution as they are plagued by a limited battery life and high prices.[7] Meanwhile, other storage technologies are also entering the foray. Compressed air energy storage is one possible solution that does not have a significant footprint. This technology works by filling vast storage reservoirs with compressed air when renewables are generating energy, and releasing that air to turn generators and create electricity during periods of low renewable generation. This type of storage is limited by geographical space constraints, and generally unable to be located close enough to large urban areas. Hydrostorage (essentially compressed air energy storage underwater) is very promising, despite the technology in its infancy.[8] Hydrogen fuel cells are an equally attractive alternative option, especially when it comes to large scale energy storage solutions. Hydrogen is one of the most abundant resource in the universe (much more common than lithium found in lithium-ion batteries) and the end products of its energy generating process (burning) are heat and water. To generate hydrogen energy, relatively complex chemical processes are required (electrolysis being one of them), which splits water molecules into hydrogen and oxygen. The problem with this process is the high capital intensiveness of the product and process requirements.

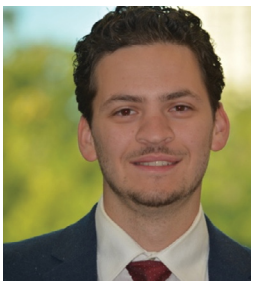
When it comes to fossil fuel alternatives, renewables are pitted against nuclear and natural gas energy production. In terms of global energy supply, nuclear currently accounts for 10% while natural gas provides 23%. [9] Nuclear fission is the main type of nuclear energy used throughout the world; however, there are quite a few researchers attempting to create stable nuclear fusion (the type of reaction that powers our sun) – if this is even remotely possible, it could mean a new era of nuclear energy in the world. Although nuclear is capable of taking a dominant role in the global energy supply, its progress is strained by public reputation, project expenses, and inadequate long-term waste disposal plans. In all, it does support renewables to generate low carbon energy, allowing for the technologies to integrate and improve with applicational experience in the meanwhile. Likewise, natural gas is the closest to renewables in both competition and support. It is a key fuel in the energy generation sector due to its versatility, fuel efficiency, and having lower emissions than coal or oil. It is projected to be a mainstay in future energy forecasts as it serves to bridge the world's transition from fossil fuel consumption to renewables, all the while meeting the colossal global energy demand.

With all that being said, renewables do have a promising future, and a growing list of countries and regions around the world now run predominantly on renewable energy. Whichever energy mix or transition option emerges as the most feasible option must be carefully curated, so that energy economics do not overshadow sustainability.

The cost of decarbonization must not be allowed to push to a point where the public can no longer afford zero carbon. Renewables bring flexibility and independence to applications; from industrial & domestic use, to daily consumption, to becoming the key component of long-term national energy strategies. The versatility, creativity, and innovation that renewables embody paint an exciting picture for the future of the energy renaissance era. We must remember that our energy demands and repercussions are not integral to life on this planet; they are only powering human activities.

Earth has always been sustainable and it is only in our best interests to ensure that our demands do not further and entirely cripple the planet. Education and awareness among the general public is imperative to ensuring informed political support and bolstering scientific community inclusivity. With the transparency and understanding that will follow, energy consumption itself may undergo a revolution, paving way for a cleaner, safer, and prosperous future for mankind and our world itself.

About the Authors



Jesse is a second year graduate student in the MScSM program, who recently completed his internship at a carbon finance consulting company. His research is focused on Artificial Intelligence and business strategy (with a sustainability lens) – with diverse interests from renewable energy and responsible investing to cooking the best ravioli known to mankind.

Rabeet is a second year MScSM graduate student, who studied Mechanical Engineering in his undergrad and is currently doing his internship at the UN Global Compact Network. His interests lie in elevating the human condition and ensuring a prosperous future (all the while taking a nicer photo) - while his research is focused on advancing sustainability through behavioural economics.

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Why Plant Plastic is Fantastic

By Caitlin Azzalini

Did you know that in 2015, the estimated weight of plastic polluting our oceans was 268,940 tons?[1] (That is equal to 200,000 Honda Civics![2])

The reason behind this unfortunate fact is simple: plastic is an overproduced commodity with a poor waste management system. But if we took away plastic, many life-saving healthcare equipment would disappear, food waste would increase, transportation and construction would become less efficient, and many commodities of our everyday lives would become non-existent. For many years now, plastic recycling has offered opportunities for plastic repurposing and energy generation through conventional waste management processes. But it has not been nearly enough to make a dent in the plastic waste we have produced around the world. Landfills and great garbage patches found in the oceans are proof of the gaps in the current plastic disposal system. Not only will these piles of waste take centuries to degrade, they will also leak pollutants into the soil and water over time[1]. Thankfully, there are emerging strategies to help mitigate this waste.

One promising strategy is to replace current plastics with bioplastics. These new plastics are produced from plant polymers, which make them independent from petroleum – the non-renewable oil that causes typical plastics to degrade slowly.[3] In this article, we will see how this new generation of polymers confers a variety of environmental benefits. The weaknesses of bioplastics will also be discussed, as they must be resolved in order for bioplastics to successfully disrupt the preferred status of petroleum-based plastics. Finally, we will discuss how nanotechnology, specifically nanocomposites, may provide a solution for these weaknesses by improving the physical and chemical properties of bioplastics.

In the last few years, biodegradable polymers, like polyhydroxyalkanoates (PHA), have been produced from plant-based renewable sources like starch, polylactic acid (PLA), soy,

From Plant, To Plastic, To Plant

and cellulose, and generated via bacterial fermentation. We call these renewable plastics because the raw material composing the plastic (referred to as polymer) is returned to the soil after its use. More specifically, the polymers are decomposed in a special compost environment via microorganisms.[3,5] Because of this fact, bioplastics participate in the circular economy where products are part of a bio-cycle, unlike existing plastics that follow a linear life cycle.[7] The challenge, however, is to produce competitive biodegradable plastics that are thermostable, thermally and mechanically flexible, light, and cheap.[8]

So far, Ingeo has been the most successful biodegradable plastic to reach the market. Ingeo is produced by NatureWorks, a leading company in renewable materials and sustainable technology.[9] Consumers will see Ingeo in products such as Danone yogurts, Taco Time cups, take-out containers, and blankets.[5] The greatest advantage of Ingeo is its starch-derived polymer, polylactic acid, extracted from corn. Its production uses 43% less fossil resources than petroleum-based plastics, and does not require any additives, making Ingeo an environmentally friendly product.[9] To some, Ingeo may sound like a dream product that will replace all plastic and solve our waste disposal problem. However, despite it being a major improvement over non-biodegradable polymer, it is not quite perfect. Ingeo plastics tend to be brittle at room temperature, which limits their applications. Also, Ingeo must be disposed of in commercial facilities before going back to the soil, further complicating the already complex plastic recycling process. Any contamination in the recycling of Ingeo products will negatively impact its decomposition, leading to greater costs, and decreased recycling efficiencies.[9] Therefore, for bioplastics like Ingeo to fully disrupt the plastic industry, improvements are still required. Nanotechnology may have something to offer.[3,4,5,6]

Nanotechnology, a common buzzword in science and technology, is the manipulation of materials at the nanoscale (1-100 nanometres). As the surface-to-volume ratio of materials is much greater at the nanoscale, the chemical and physical properties of these materials are much different than those at the macroscale.[3,4] These unique properties of nanotechnology have equipped scientists with powerful new tools to drive bioplastic innovation. One current interest focuses on bio-nanocomposites, where biopolymers like PLA are doped with nano-sized fillers to improve the material's mechanical strength, flexibility, biodegradability, and other properties.[4,5,6,10]

The most promising filler is montmorillonite (MMT) – a hydrated alumina-silicate clay. The nano-sized particle of MMT is structured in layers – sheets of MMT bound to one another via Van der Walls interactions. Because Van der Walls interactions are only electrostatic, sheets can easily be disrupted by polymer diffusion (for example, by using PLA), producing an expanded matrix with greater mechanical strength. This new tortuous environment will also increase the shelf-life of products, because it will be harder for external gases like oxygen to reach the packaged food.[4] Ingeo could potentially find a solution to

its brittleness in clay nanocomposites, while at the same time increasing the shelf-life of its packaged foods. Other properties observed so far with nanocomposites are greater elasticity, antimicrobial properties, oxygen sensors, and faster degradation time.[3,4,5] The degradation of biopolymers is still under experimentation, but researchers are trying to get PLA biopolymers to degrade in backyard composts, so that one day we can avoid commercial facilities and simplify the waste management process of bioplastics.[5]

In summary, we have seen that bioplastics are a sustainable replacement to petroleum-based plastics, because they are circular products that can biodegrade and do not depend on non-renewable fuels.[7] Furthermore, nanocomposites are giving researchers new opportunities to change the state of current bioplastics, like PLA-based bioplastics, by improving their mechanical strength, flexibility, and even biodegradability.[3,4,5] And fortunately, there is more to come. Other applications, such as food-packaging products with antimicrobial properties, moisture control, and oxygen and ethylene sensors, are also being investigated.[5] These are properties that current plastics do not have, and if implemented successfully, nanocomposites will give bioplastics a competitive advantage over petroleum-based plastics. Companies like NatureWorks should build consumer awareness in order to generate a large demand for these improved products when they are ready to reach the market. Once the benefits of biodegradable plastics outweigh the use of current plastics, we will see a disruption in the market. Until then, we must keep an eye open for bio-nanocomposites and their growing potential in this industry.

About the Author

Currently in her second year in MBiotech, **Caitlin** is working at AstraZeneca as a Study Delivery Associate where she participates in the management of clinical trials for Canada. She enjoys being part of the Biotechnology industry, because it is diverse and constantly evolving. She hopes to pursue her career in the pharmaceutical/biotechnology industry here and around the world.

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Food For Thought: The Changing Culture of Meat

By Olivia Lahaie

“Canada is home to over 3.1 million vegetarians and vegans - over 50% of them are under the age of 35.[1]”

The landscape of Canadians is changing. A recent study out of Dalhousie University estimates Canada is home to over 3.1 million vegetarians and vegans; and that over 50% of them are under the age of 35.[1] The changing demographic might spell trouble for meat producers and manufacturers, but may create opportunity for those looking to diversify. A Nielsen poll found that nearly 40% of Americans were actively trying to incorporate more plant-based products into their diet.[2] Research firm HealthFocus International believes consumer research is currently underestimating the trend away from meat consumption, citing their own study that reveals consumers in the United States are cutting back by 60%.[3] Whatever the proportion, the evidence is mounting that people’s relationship with meat is changing.

The rise of the “conscious carnivore,” or “flexitarian”, can be attributed to a number of issues that continue to increase in public consciousness, including robust evidence of the health and environmental costs of conventional industrial meat production and consumption which seem to be driving the charge to reduce meat intake. This evidence, along with other personal criteria including animal welfare has contributed to the dramatic rise in the flexitarian lifestyle and the demand for meat alternatives.

The health risks and benefits of reduced meat intake are well documented. The World Health Organization concluded in 2014, based on a review of published data that there is evidence that processed and red meats are linked to the development of cancer.[4] Plant-based diets have also been shown to reduce the risk of cardiovascular disease. This makes diet especially critical to those who are already at risk for developing these diseases.[5]

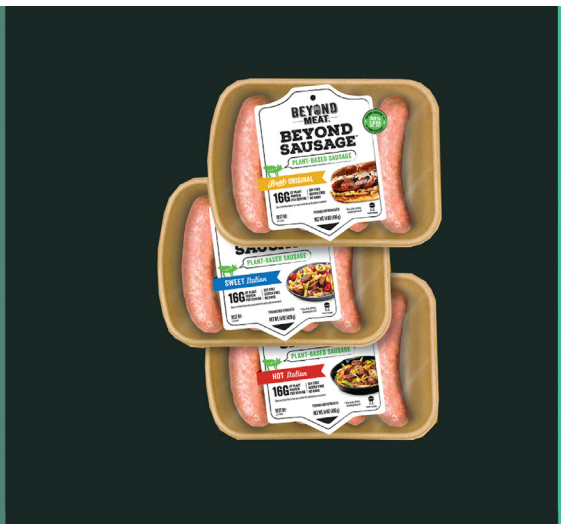
The comparatively enormous amount of emissions released and resources needed to produce beef, even compared to other livestock or crops, has also been well studied.[6] Calories are lost the higher up the food chain you go, as energy is lost for growth and development of livestock - in turn rendering livestock (and particularly ruminants like cows) inherently less sustainable as a food source. Scientific models propose that less than half of current production could be met if all beef was produced “sustainably” using only arid pasture land.[7]

However, people often do have emotional attachments to the food they eat, including meat, and may be reluctant to remove it from their diet. This has led to an explosion of research and innovation into ways to sustainably “meat” demand. This diversification in consumer demand is leading to big changes at the retail level. A Bloomberg article puts American sales of plant-based foods up 20% in the past year, with plant-based meats up 24%, totalling USD 670 million in sales. As the article’s author states, “almond milk and veggie burgers aren’t just for hippies anymore” - these products are mainstream.[8]

Leading food and meat manufacturers are responding to these new consumer demands. American meat giant Tyson Foods was the first major company to invest in alternatives to conventional meat, acquiring stakes in Beyond Meat, Memphis Meats, and most recently, Future Meat Technologies[9]. Earlier this year, Canadian Maple Leaf Foods acquired Field Roast Grain Meat Co., which along with the acquisition of Lightlife Foods, gives Maple Leaf the lion’s share of the American plant-based proteins market.

The plant-based meats have been making the largest splash in the field of meat-alternative, advertised as having the taste and texture of meat, while being entirely meat-free, and already commercially available. The Beyond Meat burger has even made its way into the Canadian fast food industry, as A&W Canada adds it to the menu at over 1000 locations for $6.99. The Impossible Burger, known for its signature “bleeding,” just received FDA approval for its key ingredient, an engineered soy ingredient that gives the burger its “bloody” taste and appearance.[10]

Cultured meat is also an industry attempting to provide consumers with the meat they enjoy without the use of conventional livestock. This “in-vitro meat” is real animal tissue, humanly taken from live animals, cultured and grown in a lab to create what many refer to as “clean meat”.



The primary challenge with these technologies is the serum used to culture the cells to grow. Often animal blood serums are used because they effectively replicate the growth factors needed to simulate the signals and nutrients in a living animal. However these serums can also greatly increase the cost of cultured meat, and finding cost effective replacements that replicate the medium requirements seem to be one of the main hurdles to commercialization.

However that might be changing. In a recent ABC News interview, Mark Post, the inventor of the lab-grown burger, which cost US $325 000 in 2013, announced that price was down to US $11 a burger.[11] Future Meat Technologies, with its investment from Tyson Ventures, says it hopes to have its first products on the shelves by the end of 2018, and believes it can have costs down to US $2.30 to $4.50 a pound by 2020.

Proponents of these technologies promote cultured meat as the future solution to sustainably meeting meat demand, but an article in Wired highlights the conflicting and lacking research on whether the industrial energy use needed to create these products leads to higher environmental costs than conventional farming when production is compared using a life cycle analysis - reiterating the need for further investigation.[12] However, there are several undisputed benefits to cultured meat, including the ability to produce meat that is hormone and steroid free, or fish that is free of mercury and plastic.

Costs are just one hurdle for these meat alternatives to overcome. The FDA recently announced that it will hold public meetings on cultured meat products, and begin the process of examining the new challenges that accompany them.[13]

Even then, if they receive FDA approval, cultured meats and plant-based meats must overcome the consumer mindset that these products are "unnatural," and genetically modified.

This conflict over what is "natural" is highlighted in the growing battle over naming rights between conventional producers of animal products, and these new innovative alternatives. New meat alternative products are being marketed as "clean meat," "meat 2.0" and "pure meat" – with "green meat" being dumped early in the naming process. The cattle industry is fighting back to protect the nomenclature of "meat" and "beef" to only represent animals "born, raised and harvested in a traditional manner." The industry is pushing for terms like "fake meat," "synthetic meat" or "meat by-product," in an attempt to provoke the fear of "franken-food." Similar battles have been waged by the dairy industry against almond and soy milk producers.

As businesses race to deliver products for the emerging flexitarian market and consumers desperately searching for alternatives to a conventional meat-based diet, the question arises, what do consumers want instead? And will they be able to look past the conventional, and accept these new innovative products as they enter the market?

About the Author

Olivia is a flexitarian who enjoys a balanced diet full of vegetables, grains, and the occasional ribeye. She recently completed an internship at Food & Consumer Products of Canada, and is expected to graduate from the MSc. Sustainability Management program in spring 2019. Olivia's research has focused of meat production and policy in Canada, and recently started work on a study of behavioral decisions relating to diet and sustainability. Her professional interests are in the operationalization of sustainability in governance and policy development for the food processing sector.

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CLEAN AND GREEN: A VISION FOR SUSTAINABLE CANNABIS IN CANADA

BY
SPENCER KARABELAS-PITTMAN &
STEPHEN SECCARECCIA

Canada's upcoming federal legalization of cannabis, a first among OECD nations, has generated a lot of excitement from cannabis users, entrepreneurs, and investors alike. Estimates of cannabis industry growth remain explosive, with conservative estimates placing the market size at $5 billion CAD per year and growing.[1] The regulation of this industry, both in the production and sale of cannabis flowers alongside cannabis infused consumer goods, remains the biggest variable of industry growth potential. There are few nations with better potential than Canada in the availability of expertise in industrial agriculture and technologies for agriculture and energy efficiency, and growing vision of strategic investment in clean growth ventures. As such, the legalization of cannabis in Canada holds the potential to not only grow domestic agriculture, drive product innovation, and increase tourism, but also to be Canada's most sustainable industry.

Estimates of cannabis industry growth remain explosive, with conservative estimates placing the market size at $5 billion CAD per year and growing.[1]

Cannabis can be produced outdoors similarly to any agricultural crop but bigger producers prefer indoor greenhouse productions.[2] There are many variables of plant growth that can be controlled using technology in indoor cultivation systems, which enhances the quality of the end crop. The most complex indoor cultivation systems use hydroponics that cycle nutrients through enclosed water systems, use artificial lights with varying energy efficiencies, and have HVAC systems to circulate air and control temperature and humidity. Installation of energy, water, temperature, and humidity sensors can help control resource usage, while providing valuable data towards process optimization.

As the Government of Canada proceeds with legalization, maintaining a market price for cannabis that ensures elimination of black market competition is a high priority. With a regulated market price, increasing energy costs, carbon pricing, and consumer demands for more sustainable products, cannabis production companies must focus on reducing costs to maintain competitive advantage alongside organizational sustainability. Government subsidies towards energy efficiency projects have already shown to be effective in reducing energy consumption across various industries. With the highest costs of cannabis production coming from energy usage, it is mutually beneficial for all stakeholders to harmonize actions towards energy reductions.

Incorporation of energy reduction systems into Canada's fastest growing market can help maximize profitability alongside reduction of environmental impacts. The unique opportunity to set the standard of federal cannabis legislation on the world stage means Canada must act swiftly and rigorously to promote enhanced wellbeing and minimized impacts of this industry as it develops.

Clean and Green might also mean… Vertical Farming

As more cannabis producers are taking to indoor cultivation, it is becoming evident that vertical farming has many benefits, especially in urban applications, such as cost effectiveness and space optimization. In light of the fact that growing space can be costly and limited by an approved Government of Canada license to cultivate, vertical farming is an innovative way to take advantage of limited square footage.

So what is vertical farming?

Vertical farming can be defined as the practice of producing food or vegetation vertically in stacked layers, vertically inclined surfaces and/or integrated into buildings. Modern vertical farms use CEA technology, which stands for Controlled Environment Agriculture and involves the control of humidity, temperature and gases, as well as fertigation, the injection of fertilizers, soil amendments, and other water soluble products into an irrigation system. Finally, CEA involves the utilization of artificial light to create photosynthesis.

A typical vertical farming space has trays of plants stacked from floor to ceiling. To give some perspective, Keystone Technologies, a Japanese vertical farming firm, can fit as many as 218 plants on a 6ft x 1.5ft shelf. With units that stack five shelves high, the company can grow 1090+ plants in an area that is 6ft long by 7ft high.

Why vertical farming?

The answer seems fairly intuitive; however, the statistics supporting the business and social case for vertical farming are intriguing. First, for some background context, the United Nations reports that the urbanized world accounts for more than 50% of the world's 7.6 billion people, which is predicted to rise to 86% by the year 2050.[3] With the staggering proportion of people that rest in urban centres and its rapid increase come significant sustainability issues. Cities account for 80% of global energy consumption and GHG emissions -- a percentage that will inevitably increase as population sizes in urban centres increase.

The great migration of individuals from rural settings to urban centres is putting significant strain on water and energy supply, food demand, waste management, sewage systems, transport networks and land appreciation. Vertical farming touches on and relieves the strain of several of these factors. Keystone Technologies (the Japanese firm mentioned above) has systems that use 1/25th of the water required for traditional farming. They can be energy efficient, vertical farms can make use of natural light or use energy efficient LED bulbs to create photosynthesis. The urban setting of vertical farms significantly reduces food transport miles; for example, Sky Vegetables, a New York city urban farming company, states that its farm reduces the distance travelled from thousands of miles to under fifty. Therefore, the energy and CO2 output required to transport vegetables is significantly reduced, the spoilage is reduced and the shelf-life of the product is drastically increased. Chemical use is reduced, hydroponic growing is free of pesticides, resulting in zero chemical runoff like phosphorus and nitrogen that can wreak havoc in our water systems. Last but not least, hydroponics offer superb yield rates; more than 20,000 heads of lettuce are cultivated every day in one 3000 square metre facility in Japan.[4]

So what does the height of innovation in vertical farming look like?

It looks like year-round vegetables, minimal resources, climate resiliency and one-tonne of vegetables produced every other day. Singapore-based Sky Greens is another innovate vertical farming company, touted as the world's first low-carbon hydraulic driven vertical farm. It system uses a water-pulley method that rotates the company's 38 troughs throughout the day, to gain maximum sun exposure -- eliminating the need for artificial light. The whole operation is run on rainwater and the same water that acts as a hydraulic is also used to nourish the plants. Vegetables grown at Sky Garden can be shelved at local grocers within 4 hours, compared to 3 days to 3 weeks for imported vegetables to reach the same shelves in Singapore. The reduction in water and energy use, the increased yield and the astounding reduction in travel time exemplify the key components of vertical farming's business case.

How does this all tie into marijuana?

As mentioned previously, there is a limited amount of cannabis growing space that is licensed to producers by the government. Maximizing the allocated space not only results in decreased resource and energy use, increased yield rates and production it also creates greater profits. In the Canadian market where the demand for recreational cannabis is projected to outstrip supply, there is a clear business case for vertical farming.

The business case and relevant examples will be analyzed further, but what about the social case for vertically grown cannabis? Medical benefits aside, marijuana clearly lacks the nutritional value or utility of growing vegetables (traditionally or vertically). However, it can be argued that maximizing the vertical space to grow cannabis saves as much land as possible for traditional farmers.In lieu of greenhouses dedicated to marijuana cultivation that sprawl thousands of square feet, the land can be returned to its original farming uses. Furthermore, as noted previously, water consumption dedicated to growing is drastically reduced as well.

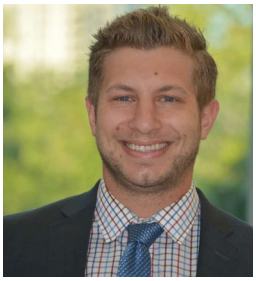
Vertical farming was exactly what Jeremy Heidl, owner of Pen Vape, was thinking when he moved to Denver to start his own company. We were fortunate enough to speak directly with Spacesaver Corporation, the company that set-up Pen Vape's vertical farming operation and shared some fascinating statistics. With the price per square foot of warehouse space doubling in Denver, Pen Vape needed to innovate to survive. Jeremy, owner of Pen Vape, envisioned a setting akin to a doctor's office using file cabinets that slid in and out with one-another to maximize space. He wondered if the same concept could be applied to producing cannabis, which led him to discover Spacesaver. Along with Spacesaver, Pen Vape was able to convert 320 square feet of canopy into over 1600 square feet - a 500% increase in production. The resultant increase in both yield and efficiency provided Pen Vape with a 30% return on investment after 10 years.

Another US-based company, Ideal Harvest specializes in vertical farming retrofits also shared the outcomes of a 12-month case study they conducted in January of 2016. The company ran a side-by-side test of vertical and horizontal growing operations. Both grow rooms were 600 square feet; the vertical operation, however, utilized all the space in the room and had a canopy of 2,237 square feet, whereas the horizontal operation had a mere 768 square feet. The vertical grow room was able to house 960 plants to the horizontal grow rooms 288. Quite impressively, the vertical grow room produced 317,000 grams of cannabis over a 12-month period compared to the horizontal room's 109,000 grams. Based on Colorado's average price per gram at the time of publication, $4.46 USD, the vertical farms annual production earned revenues of $1.4 million USD as opposed to the horizontal rooms $485,000 USD in revenue. These numbers meant the price per gram of the vertical farm was 50 cents compared to 86 cents per gram in the horizontal installation.

As the market for cannabis grows, and regulations start shaping the industry and fostering deeper discussions, the cannabis industry can be expected to expand and become competitive. Deloitte predicted the Canadian pot industry would total over $22 billion a year soon, which would exceed the total annual retail sale of beer, wine and spirits combined.[5] In order to meet such demand, and in the most sustainable way without robbing resources from other valuable uses, constant innovation such as different applications of vertical farming will be critical.

About the Authors

Spencer is an empathetic, curious, and industrious student and practitioner of sustainability management. He is recently finished his internship with McCain Foods Canada, where he gained experience in corporate and agricultural sustainability management, farm assurance, and legislation analysis. He also worked in environmental conservation with Parks Canada, during their 150th year celebration. Spencer hopes to continue his work in corporate and agricultural sustainability, while branching out into sustainable development of rural Canadian communities.



Stephen is an urban agriculture enthusiast and a lover of green building design. As a student in the MSc Sustainability Management program, Stephen has found an environment where he can research, explore and articulate his interest in the built environment. In Stephen's spare time he enjoys being active in nature, playing sports and cooking for friends and family. Stephen is eager to continue sharing his knowledge about innovation and sustainability.

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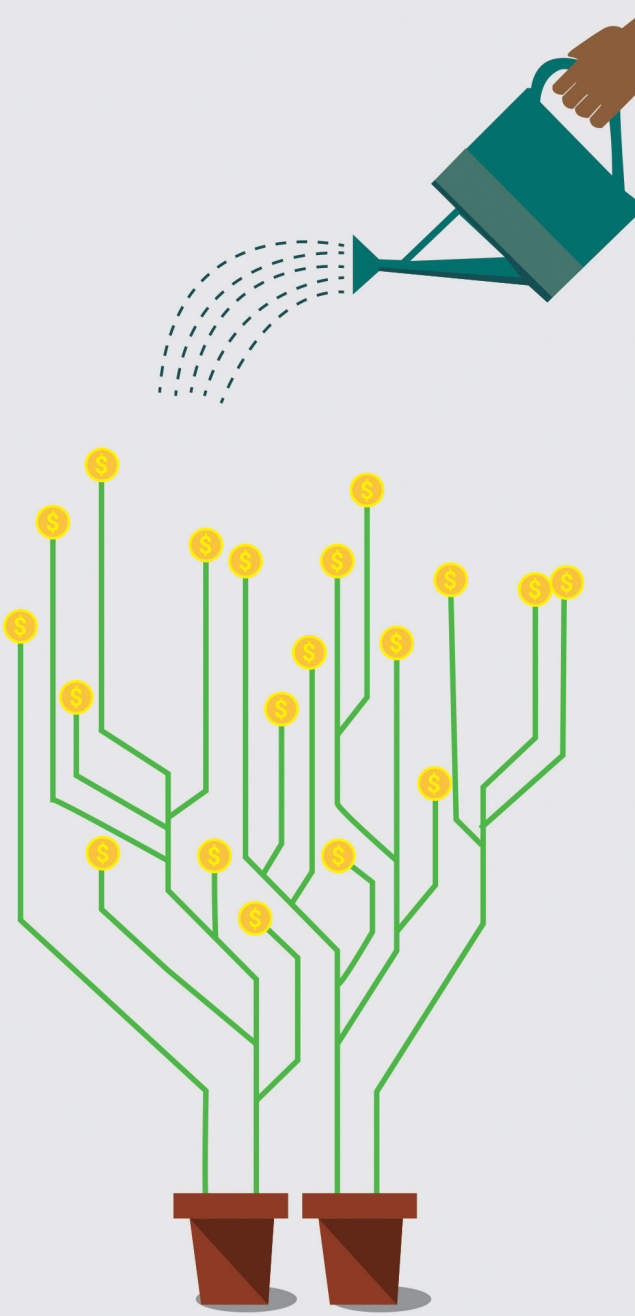
THE INDUSTRY VENTURE CAPITALISTS HAVE THEIR EYES ON: SOFTWARE-AS-A-SERVICE



By Paramroup Thind

If you have a smartphone, it probably has a dozen apps you've downloaded to meet your unique needs -- like communication channels, file-sharing, photo-editing, etc. Some of these apps you may be subscribed to and you are billed every month or year. Mobile apps are one of the poplar arms of what is called "Software as a Service", a fast growing industry that is attracting millions of dollars of venture capital. More formally, Software as a Service, or SaaS, is defined as a model for licensing and distributing software through cloud or internet services hosted by the provider. SaaS solutions come in many different forms, targeting individuals, Small-Medium Businesses (SMBs) and large enterprises. Other famous examples include Netflix, Linkedin Prime, Slack, Salesforce, Box, Amazon Web Services, Shopify, EventBrite, SurveyMonkey, etc.

SaaS is NOT a new sales model

Nor is it a new BUYING model

SaaS is a new DELIVERY model

As SaaS is a relatively nascent industry, many of today's leading companies or SaaS branches didn't exist 15 years go.[1] Software was traditionally sold as a product solution, commonly known as enterprise software. In this model, users purchased and installed a license on their own personal device. There was no technical support and users would have to manually update to the latest version. In contrast, today the user rents the software. The most common model is where software is located on a cloud platform and user pays an ongoing subscription fee to maintain access. This new model has many benefits for the customer, such as enabling the software to be always up-to-date and interoperable with plug-ins.

How are these million-, billion-dollar SaaS companies making money? Subscription-based transactions are one of the most common business models today. To present a stable, recurring revenue stream, the industry has shifted from one-time transactions or upfront fees to incur smaller, subscription-based payments made each month or year. For companies, costs per customer decrease as the business scales. In addition, the little overhead they have is dispersed over a large number of customers. Worth noting is that many of the biggest SaaS companies get the majority of their revenues from large enterprise clients. Companies such as Salesforce and Hootsuite have provided a unique value proposition for these large Fortune 500 companies for which they pay over hundreds of thousands of dollars each year.

Venture capitals see many SaaS start-ups; In the past year alone, $1.02 Billion was invested in Canadian SaaS companies.[2] SaaS solutions are increasingly prevalent in healthcare, Customer relationship management (CRM), sales, accounting, finance, media; the list is constantly growing. The advantage in their ability to penetrate multiple markets is that it allows for a slower saturation. Many of the new entrants today owe it to big pioneers that first challenged incumbent systems; Slack, for example, has a valuation over 8M, the company has experienced extreme growth with over 8M daily active users and 3M paying users, and is said to potentially replace email as well as popular video-conferencing platforms such as Skype.[3] Slack's bottom-up distribution strategy and messaging-first approach gives them an edge against larger companies such as Microsoft and Facebook who are launching similar products.[3]

Venture capitals love investing in scalable, repeatable business models. Successful SaaS companies share a number of characteristics: they typically have a predictable and fast-growing revenue growth owing to the subscription-based model where customers renew their contract on a monthly or yearly basis. The recurring nature is an easy way for investors to forecast a company's future cash flows and budget as well as predict growth. Venture capitalist often put a lot of effort into understanding the financials and key performance indicators (KPIs) of a potential company. Typical SaaS KPIs include scalability, monthly active customers, cash burn, runway, average revenue per user. KPIs give investors a snapshot into the state of the company and serves as a 'measurement of outcomes'.[4] KPIs are used almost like a standardization tool, stripping the color and noise, and allowing investors to compare outcomes to other companies. Often for early stage SaaS companies, the KPIs themselves are not that important but understanding the mechanics behind them and what activities drive KPIs is key.[4] What is driving this KPI? Is it a result of the core business? Will this KPI improve with time and as the company grows? Every investor looks for potential and these KPI are an important tool to inform their analysis and decision process. In the SaaS industry, there are two key metrics: Customer Acquisition Cost (CAC) and Lifetime Value (LTV). CAC refer to how much money it costs to acquire one customer. As the company matures, the CAC should get lower. Meanwhile the LTV represents the amount of revenue a customer generates for the business during his or her total lifetime. This number typically increases over time.

VC are investing in companies for them to grow and scale. Plaza Ventures Partner Matthew Leibowitz explains, "The comparable standards are not new in the SaaS space but if you can build a company that hits or exceeds the KPIs that other SaaS companies are achieving, then it's a great time to build your SaaS company. With these benchmarks comes attraction from investors, buyers, customers, talent and more."

Many investors make their money back when the company goes through some type of a liquidity event. An 'exit' occurs when an investors decides to get rid of their stake or shares in a company. In the VC industry, a successful exit usually comes in the form of 2 liquidity events emerge from Mergers and Acquisitions (M&A) events and Initial Public Offerings (IPO). For instance, if a VC firm invested in a company valued at $40M and the startup is acquired by another company for $1B. The VC firm would be paid by the acquiring company for their stake and would receive 3200% return on their investment. On the other hand, if the startup decides to go public (IPO), the VC firm can sell their sales on the open market. The risk that VC take in that in both situations, it is a common occurrence that the firm could lose money, i.e. if the shares are bought at a lower amount or if the company runs out of cash before it reaches a liquidity event. In the last 4 years, there has been approximately 90 exits of Canadian Saas Companies. Shopify and Kinaxis were the only two to have had an IPO.[2] Microsoft, Intel, Box, Hootsuite, GE Electric, and Ticketmaster are some of the biggest purchasers of Canadian SaaS companies .

As more and more SaaS companies enter the market, it has become more competitive and there is more pressure to differentiate. The barriers to entry for SaaS companies are quite low and virtually non-existent. Because SaaS companies are tethered to the cloud, the overhead and operation costs associated with hardware, production, manufacturing, distribution observed in other industries are almost zero. Furthermore, once the technology is developed (which is one of the more capital-intensive stages), a typical SaaS company needs a lot less investment to develop. The difficulty lies in taking market shares, especially in already saturated markets. It presents a double edged sword: entrepreneurs can enter easily and but newcomers can disrupt the industry quite easily, too. Saas companies have to constantly improve their technology, offerings and marketing to stay on top of this competitive market. This has actually been a great driver for the industry as a whole, because companies are constantly innovating, building out new tech and finding niche markets and needs to service.

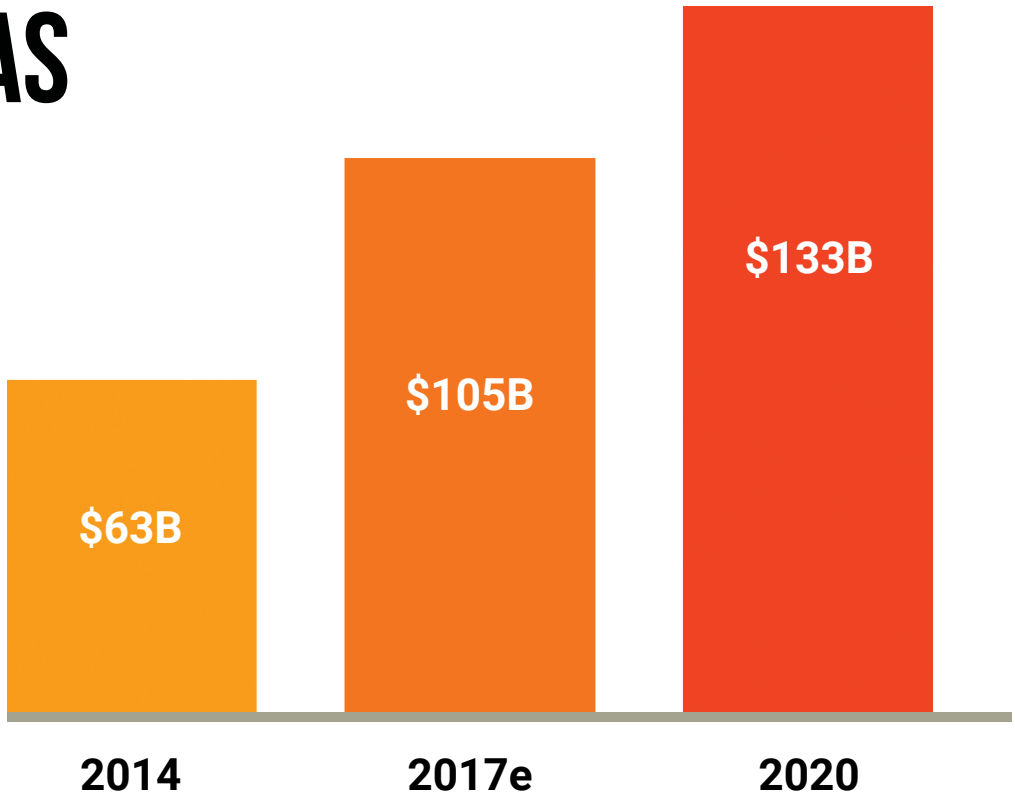
Here, one advice to SaaS company is to solve a problem and fill a need. The value of a SaaS company is largely attributed to the value of the solution it provides. Companies and founders can easily become engrossed in building out the technology or populating their data foundation. There also needs to be a delicate balance between perfecting the technology and taking it to the market. A company can tweak, improve and change their technology as they grow; a common misconception is that they have to be perfect to enter the market. Of course, other avenues such as revenue generation, marketing and customer success are important parts of the business and should not be dismissed until later.

Last year, VC-backed Canadian technology companies raised $2.7B distributed across 333 deals. With the average deal size increasing 31%, from $8.3M in 2016 to 10.9M in 2017.[5] Toronto, Montreal and Vancouver continue to lead the way in terms of deal activity and capital raised.[5] Traditionally Canada's technology ecosystem has struggled with shortages in capital, but as Canadian companies and talent continue to improve, only further growth and expansion can be expected[5]. The PwC and CBI report on key private companies shares some of the up and coming SaaS businesses to be on the lookout for: some of these may be recognizable as a household name in the Canadian tech industry: Wealth Simple, Hootsuite, Hopper, Lightspeed POS, FreshBooks, SportLOGIQ, etc.[6] Some of the upcoming start-ups to keep an eye out for include Drop Technologies, UberFlip, Q4, and Ecobee.[6]

The biggest advantage of the SaaS industry is its flexibility to continue reinventing and adding value to its services. In the foreseeable future, SaaS-based companies will continue to attract funding and grow. The next step for any up and coming start-ups is to improve the way they tackle integration. Especially with so many different technological solutions at play, the company that creates a seamless experience for users will be able to best position itself in this fast growing industry.

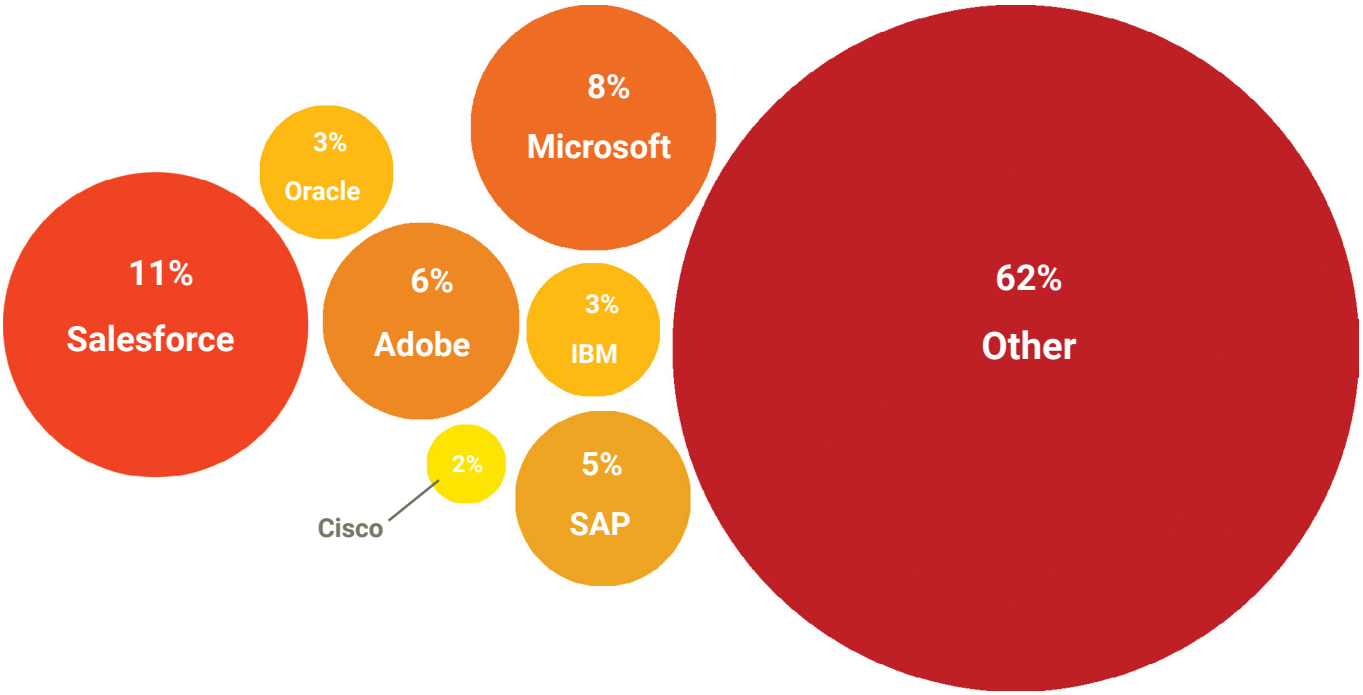
GLOBAL SAAS MARKET

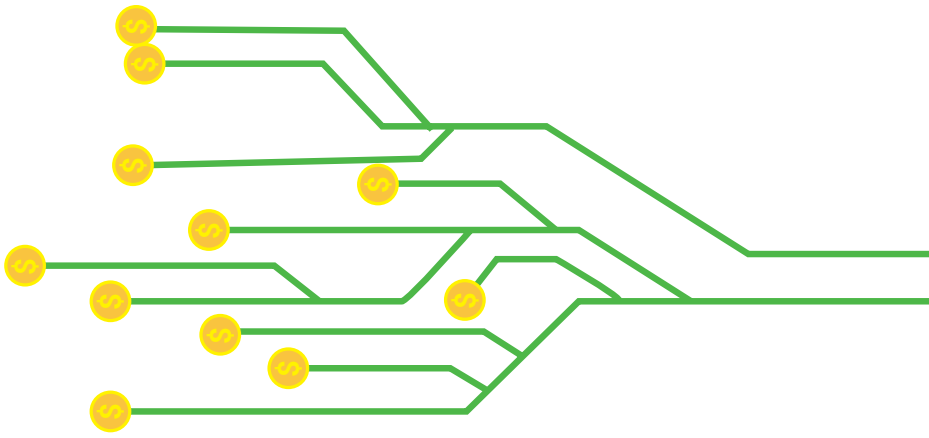
SOURCE: VISUAL CAPITALIST



MARKET SHARE IN 2015

SOURCE: VISUAL CAPITALIST





VC DEVELOPMENT STAGES

SOURCE: CANADIAN VENTURE CAPITAL ASSOCIATION

VC DEVELOPMENT STAGES	
SEED STAGE	Company has a concept or product under development, but is probably not fully operational
EARLY STAGE	Company has a product or service in testing or pilot production. In some cases, the product may be commerically available
LATER STAGE	Product or service in production and commercially available company is generating on-going revenue, but not necessarily profitable

Different types of Key Performance Indicators (KPIs)

Run Rate

Run rate refers to the financial performance of a company based on the current financials as a predictor of future performance.[11] The revenue run rate indicates how sales are developing over time. Investors can extrapolate how likely a company will hit their forecasts, and indicates potential problems with pricing.

Lifetime Value (LTV)

LTV is the projected net value that a customer will generate during their lifetime. It is essentially the average amount of money made over the lifespan of an average customer, discounted by future flows.[10] Understanding LTV, in its relation to type of customer and CAC, is critical to building a sustainable company.

Customer Acquisition Cost (CAC)

CAC is the average cost of convincing one potential customer to buy a particular product or service.[8] This includes the total sales and marketing costs required to attract customers and convert customers. Companies can improve their CAC by working on their conversion metrics, enhancing user value and implementing CRM techniques.

The LTV to CAC Ratio

The LTV to CAC Ratio measures the relationship between the lifetime value of a customer and the cost of acquiring that customer. Helps determine how much a company should be spending to acquire a customer. Generally, the LTV should be greater than CAC (industry average is 3:1).

Burn Rate

Burn rate is a measure of negative cash flow and used to track the amount of money that a company spends.[12]

Churn Rate

Churn rate is an indication of how well a company holds onto their customers. The churn rate is the percentage of subscribers who discontinue or stop buying the service within a given time period.[1] Ideally, a company should be gaining more customers than it is churning (i.e. growing). For SaaS companies, it is informative to also look at the churn rate over time, understanding the reason for any spikes or falls can help indicate reason why customers stop buying or started.[9]

Monthly Active Customers (MAU)

It is the number of unique users for a 30-day period. The MAU helps investors understand how well a company is monetizing and the revenue potential of a company.[9] MAU is particularly important for web-based companies.

About the Author

Parm is an analyst with Plaza Ventures, a venture capital firm in Toronto, Canada. She completed her Bachelor of Science Degree at McGill University and is in the Masters of Management of Innovation Program at the University of Toronto.

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WHAT'S WEIGHING DOWN INNOVATION IN NON-FOR-PROFITS?

A FAIR GAME? INNOVATION IN NON-FOR-PROFITS

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Each year, thousands of organizations around the world get recognized for their performance, service, and impact. For example, Fast Company's ranking of the top 50 most innovative companies in 2017 includes familiar global for-profit companies such as Google, Amazon, Netflix and Apple. There is only one not-for-profit organization on the list: Pledge 1, an organization that provides seeding for early stage philanthropy, is ranked 42nd. No not-for-profit organizations made it onto the Forbes' top 100 most innovative companies in 2017, another list that features many global tech, pharmaceutical, research labs and finance companies. This is largely due to the fact that Forbes bases their ranking system on a company's 12 month sales growth as a measure of innovation premium. The innovation premium is the proportion of a company's market capitalization that exceeds the net present value of the company's cash flows from its current products in its current markets. Not-for-profit organizations don't stand a chance at making a list that is based on sales and company's cash flows. While capital plays a crucial part in the success and impact of a not-for-profit, a better measure would be impact or quality of service.

Frequented measures of innovation include the number of patents, new products and processes, money spent on research and development, or looking at sales/adoption of new products compared to overall sales - as well as a subjective measurement such as innovative behaviour and organizational innovation. Many of these Key Performance Indicators (KPIs) make it nearly impossible for non-profit organizations to compete with for-profits on innovation. Take patents as an example, where both for-profit and not-for profit organizations are considered in a study (41% FP and 58% NFP) with the number of patent applications as the measure. For-profit companies made up 86% of total filed patent applications while non-profit organizations filed 15%. Non-profits tend to file patents based on market value to protect their invention from future issues while for-profits file patents to build market value and block competition.

However, just because not-for-profit organizations are not making these coveted lists, it does not mean that they are lacking in innovation. Innovation has been considered an emerging key factor for the success and survival of organizations, whether for or not for profit.

Social Non-Profits

Non-profits are dominant players in the social sector, and innovation is critical to delivering social goods and services most competitively. Therefore, non-profit organizations are an important vehicle for fostering social innovation, especially at the community level. Social innovation provides an opportunity to move away from thinking in silos about business and civic engagement, and brings light to the interconnectedness of various factors and stakeholders. Similar to innovation in general, a social innovation can be a product, production process, or technology, but it can also be a principle, an idea, a piece of legislation, a social movement, an intervention, or a combination of these elements.

Innovation has been linked to positive organizational performance. Understanding the relationship between innovation and mission of a non-profit organization is crucial in ensuring the subsequent results from increased operational efficiency and effectiveness are relevant. This becomes complicated when comparing different non-profit organizations as each organization require specific and varied measurements to understand the impact of the innovation, which does not allow for simple comparison of a single type of unit. Many non-profit organizations measure their impact through outreach and the number of lives they impact. Several researchers have indicated that innovation is the only way to improve service quality in non-profits and argued that innovation might be the only means to justify the existence of nonprofits.[4]

Effective leadership and adaptive work culture is also fundamental to the effectiveness of any efforts towards innovation. Non-profit organizations that consistently innovate have committed leaders at all levels who empower teams to push beyond the their limits to accomplish the mission of the organization. They distribute leadership within their organization and throughout their external networks to cultivate a strong second-in-command, build enduring teams with long tenure, and develop powerful boards that play a foundational role in supporting this type of work. An effective culture for innovation, therefore, embodies skilled leaders and managers who create conditions and support systems for the employees to collectively achieve big impacts.

Barriers to Innovation

Organizations in the non-profit sector face several challenges that may impede their ability to innovate, and maximize its contributions to society. Risk-taking has been deemed an important factor as it is based on how much failure an organization can tolerate, which is directly related to the number of groups to which it is responsible and reliance upon each group. Non-profits are usually equally responsible to multiple stakeholders, including funders, employees, volunteers and clients to whom it provides goods or services, whereas for-profits' primary responsibility is to its shareholders. Therefore, due to their dependence upon the results of their work rather than financial incentives, non-profits are risk-averse because failure in any area of the organization may destroy the organization itself.[7]

Similarly, access to funding is also a critical barrier for innovation in non profit organizations. Financial constraints can include the means of acquiring money as well as the means to use its capital to motivate all stakeholders.[7]

Every year, non-profits typically depend on unpredictable grants and donations. This is a fundamental business challenge because most non-profits do not support themselves through competition by selling differentiated services or products, they find grants, solicit donations, or they fundraise to keep their services running. There is an interesting paradox to consider here, the core services non-profits provide are often severely underfunded yet these organizations are forced to spend a considerable amount of time and effort chasing the limited financial resources available.[8]

In Canada for instance, the capacity of the non-profit sector has been undermined by the shift in government support towards shorter-term, targeted and project-based funding. This funding regime raises serious capacity issues such as recruiting and retaining staff and volunteers and assuring organizational infrastructure.

Additionally, project-based funding can result in a number of unfavourable consequences including restricted autonomy, reduced independence, and limited ability to engage in long term programming.[9] Thus, this funding paradigm undermines one of the very strengths of the sector; its creativity and ability to innovate, as there is now very little tolerance for risk taking.[9] While innovation is heavily encouraged, there is little evidence that government funders are willing to allow non profit organizations to try something that may not be successful.[9]

Nonetheless, the non-profit sector in Canada is a growing social and economic force and a key element in enhancing employment opportunities and social policies. In Ontario, approximately one million people are employed in non-profit organizations, which represents about 8% of all paid employees in Canada.[9] The nonprofit sector is also supported by millions of volunteers who contribute 1 billion hours of time each year. It has also been reported that Canada's Charitable Nonprofit Sector will account for more than $200 billion in revenue and roughly 700,000 jobs by 2026. It is evident that nonprofit organizations are not only contributing to the mobilization of people, but also providing the impetus for social equality and economic growth.

The conversation surrounding innovation must start with an understanding of the unique challenges and constraints a non-profit organization faces. They may not be in spotlight as often as megamillion, billion, dollar for-profit companies, but each of them drive impact in their community that has no price tag. "A good question beats a good answer." All non-profits started by posing a question to the status quo. By applying the same thinking and building on collaboration and trust, non-profits can also harness the power of innovation to their advantage.

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