BuildFIT

An Interactive Energy Management Software

19-684 E&TIM Seminar: Capstone Project

Kelsey Scott	Pritham Aravind	Apratim Vidyarthi	Rochelle Samuel
kescott@andrew.cmu.edu	pvaravin@andrew.cmu.edu	apratimv@cmu.edu	rsamuel@andrew.cmu.edu

Special thanks to Jimmy Williams Jr., Thomas Hajduk, Daniel Armanios, Folke Kafka, Azizan Aziz, Mark DeSantis, and Reed McManigle

Contents

Executive Summary

Almost 30% of energy usage in commercial buildings is wasteful and can be reduced without major behavioral changes.[1] A streamlined data pipeline that can convey to the chief financial officer (CFO) the potential cost savings, help building management reduce energy consumption, and encourage end-users to change their behavior to improve efficiency would provide immense environmental and financial benefit to a company. BuildFIT caters to all three stakeholders, transmitting data taken from hardware installed in buildings, analyzing it, and providing natural language processed recommendations that are actionable. This report details the commercialization strategy, technology strategy, and business model for BuildFIT.

BuildFIT is currently in beta-testing, with ten major clients, including the cities of Pittsburgh and Washington, D.C., using its software. While some technical development is required, including ensuring hardware compatibility with major submetering vendors and enhancing the accountable and actionable recommendations, the concept is highly marketable. Competition in the market already exists, with Lucid's BuildingOS being the major competitor. BuildFIT's competitive advantage is in the combination of analytics and recommendations that meets the needs of different actors, thus enhancing action and accountability. And while aligning the incentives for private actors, this can reduce negative externalities, including 3.6% of national greenhouse gas emissions that are reducible.[2]

The strategy we recommend is in three phases: in the short term, marketing to clients with large building portfolios; in the medium-term expanding towards energy-intensive industries like the service industry, manufacturing companies, and companies with server farms; and finally, in the long-term enhancing data mining capabilities, engaging in a shaping strategy, and aiming for expensive but highly lucrative federal agency contracts. This strategy should be enacted along with a $30/60/90 per-building per-month subscription fee, and applications to Innovation Works and a federal SBIR grant for commercialization funding. Hiring interns and using this funding will help manage labor costs, which are the major cost driver for such a technical innovation.

Ultimately, this technology promises great improvements in environmental sustainability, economic efficiency, and a data-oriented economy. This makes it commercially viable, and provides strong opportunities for market growth.

[1] Stauffer, Nancy. 2013. "Reducing Wasted Energy in Commercial Buildings". *MIT News*. http://news.mit.edu/2013/reducing-wasted-energy-in-commercial-buildings.
[2] Ibid.

The Innovation Idea: A Description

The Concept

BuildFIT is an intelligent energy monitoring software for building portfolio management that facilitates communication between energy buyers, users, and facilities managers. The software displays energy consumption in buildings on a granular and high-level depending on the user, and provides recommendations to various different user groups.

The software is currently an internet-based platform that utilizes big data and specialized algorithms to interpret energy consumption at a granular level within an organization's buildings, across different geographies. The conglomeration of data and visualization provides the facilities managers the ability to monitor their buildings remotely to ensure compliance with their performance, operations, and sustainability goals. Additionally, the algorithms produce natural language recommendations that offer energy and cost savings. From a technical standpoint, the combination of big data, natural language processing (NLP), energy management, and cloud computing package well-known technologies to help building managers, residents, and financial departments.

These natural language recommendations provide the biggest source of differentiation for BuildFIT with respect to its competitors, since this feature addresses a major problem many large companies face: how can people with different powers, positions, or authorities communicate in a mutually shared language? Many other companies provide energy monitoring dashboards, however no other dashboard is able to make granular recommendations that are consumable for both a Chief Financial Officer with buying power, and a Facilities Manager with an intimate knowledge of facility needs. The BuildFIT system can save large companies hundreds of thousands of dollars and significantly reduce energy waste, which could reduce a building portfolio's carbon footprint to help meet EPA, state, or local program goals.

Sources of funding

Innovation Works

Innovation Works (IW), a Pittsburgh based investment organization focused on "supporting innovative startups and technology that could create regional economic impact", is the ideal first investor[3]. IW has a strong history of transitioning innovative tech solutions into commercially ready products, having invested $69.2 million in more than 300 technology startups and promoting these organizations to gain follow-up funding to more than $1.7 billion since IW began seed funding in 1999.[4] Additionally, IW has a strong working relationship with the Carnegie Mellon University (CMU) community.

The BuildFIT product is an ideal technology for IW to invest in. Currently, IW has an energy programs initiative, claiming that "With IW's expertise in technology commercialization, IW helps [Southwestern PA] play a leading role in energy technology development and commercialization."[5] The algorithms and technology potential that BuildFIT offers complement the innovative and technical principles that IW promotes, and the focus on energy and

[3] Innovation Works, 2008. *Community Report: Fostering Entrepreneurial Growth*. Pittsburgh: Innovation Works. https://www.innovationworks.org/Portals/1/documents/INW%20Community%20Report.pdf.
[4] Ibid.
[5] Ibid.

sustainability align with their vision of shaping the Pittsburgh landscape. With the City of Pittsburgh and other Pittsburgh-based organization as current beta-testers, BuildFIT has demonstrated the ability to positively affect the region and beyond. Thus, IW is an ideal first source of external funding.

Small Business Innovation Research

Another possible funding source is a Small Business Innovation Research (SBIR) Grant through the United States' Small Business Administration and the Department of Energy (DoE) or Department of Defense (DoD). SBIR grants are provided to support research and development efforts at small companies in order to support federal missions and promote technology commercialization.[6] Phase I grants provide up to $150,000 to aid in feasibility research and Phase II grants provide up to $1 million for further development.[7] Due to the federal sponsorship, SBIR projects help build credibility that easily converts into a network of customers pending success of the SBIR supported project.

BuildFIT algorithms have the ability to provide immense savings to secured facilities, including military bases and government buildings. However, there are additional security requirements in order to satisfy these customers' needs. Due to these additional development demands, particularly on the technical and hardware fronts, applying for an SBIR grant would provide the additional funding necessary to meet the higher technical demands to serve secure facilities. Thus BuildFIT should apply for an SBIR grant from the DoE or DoD to: in Phase I prove the feasibility of applying the algorithms within secure internal networks, and in Phase II prepare the technology for commercialization and deployment within secure facilities like military bases and secure federal buildings.

Technology

What is BuildFIT?

BuildFIT is being developed as a software solution to stop buildings from wasting energy and money. BuildFIT's idea is elegant in its simplicity: essentially, BuildFIT is a data aggregation dashboard that tracks and displays how much energy a building is consuming, and also produces natural language recommendations based on a given user's priorities and goals. It works by channeling data from utility bills, building automation systems, on-site generation systems data, smart meter data, submetering data, and sensor data into digestible information that users at different levels – from building

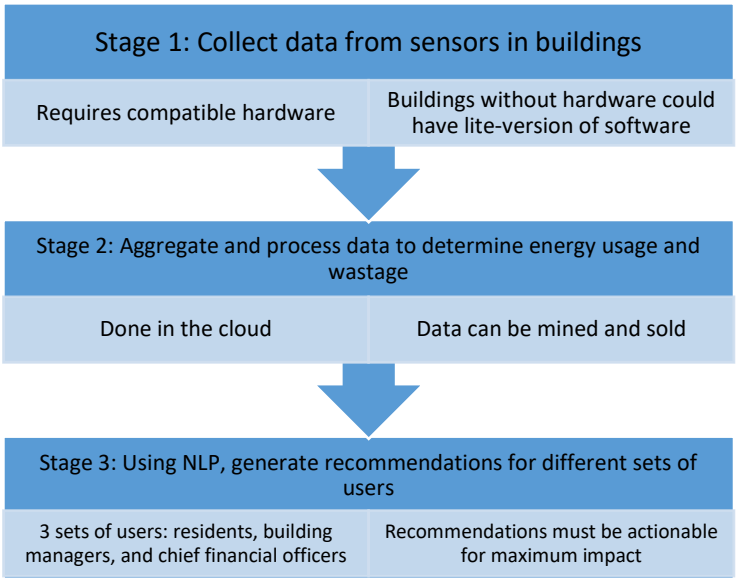


Figure 1: BuildFIT: The Concept

[6] "About SBIR | SBIR.Gov". 2016. *Sbir.Gov*. https://www.sbir.gov/about/about-sbir.

[7] Ibid.

occupants, to facilities managers, to financial heads and managers – can use to optimize different aspects of performance. The data BuildFIT uses is sourced from a variety of sensors, thus can use data about a building's energy consumption, ambient temperature within and outside the building, and whether doors and windows are accidentally left open. BuildFIT at its core is a software that enables and enhances installed sensors and hardware.

Currently, BuildFIT is in the beta-testing phase one. Their beta one version is currently being used by a variety of local and early adopter customers, including The City of Pittsburgh, the University of Pittsburgh Medical Center (UPMC), and the U.S. General Services Administration (GSA). After this beta version, the next released version of BuildFIT will be the commercialized version, which can be sold to companies with different building portfolios. BuildFIT was designed as a research project within the Carnegie Mellon School of Architecture with Azizan Aziz and Bertrand Lasternas as the primary investigators. These key players will share the company ownership post-commercialization.

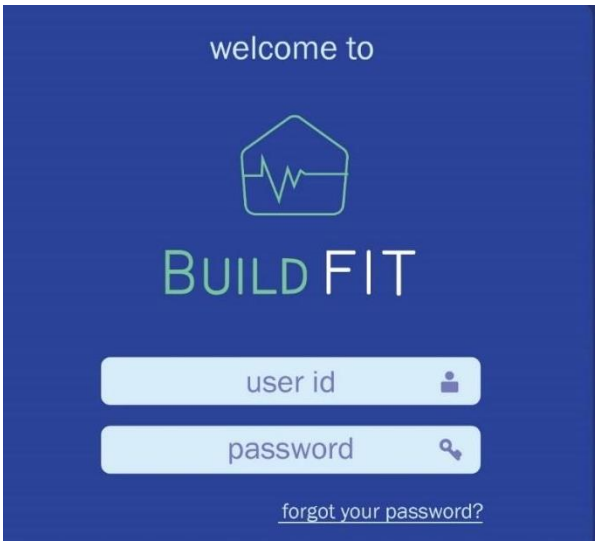


Figure 2: The login page for BuildFIT

No patent on the natural language algorithms or the overall innovation currently exists, since the innovation is a combination of existing computing and data concepts. It may be possible to get a patent for some of the algorithms and for the overall software in the future. Nonetheless, there are some competitors with similar technologies: Lucid BuildingOS, Schneider Ion, and SkySpark. Each of these competitors has its own software at various stages of design maturity. Lucid BuildingOS, which has an established customer base, is the only commercialized product with advanced functionalities and multi sensor data aggregation that compare to the advanced technology that BuildFIT will offer. This will be discussed further in the market section.

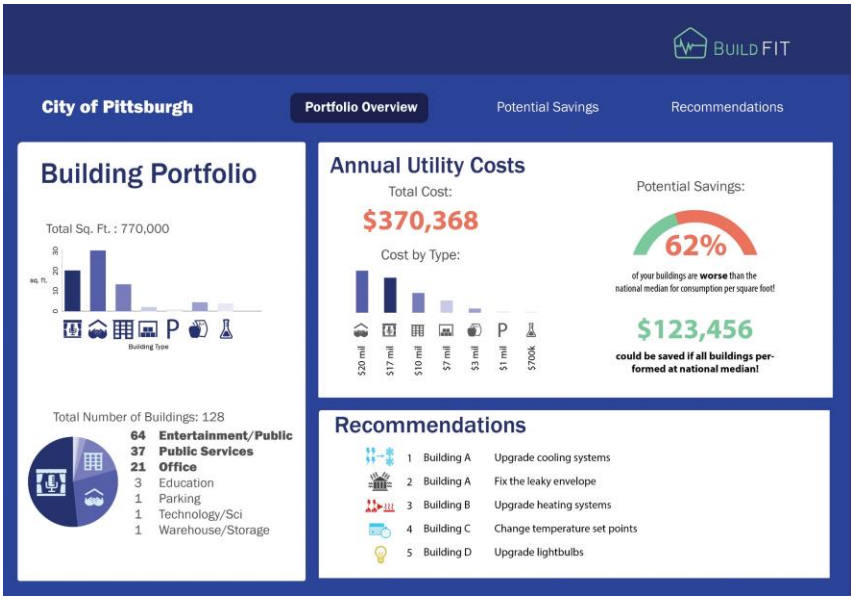


Figure 3: The BuildFIT dashboard

Technical Uncertainties

The software has minimal technological uncertainties due to the technology being well-established academically; however, what BuildFIT does with the data can be developed even after the software is officially launched. For example, BuildFIT could aggregate the data being gathered by the company (from non-federal or highly sensitive customers). Additionally, the software could be optimized to reveal when energy consumption is abnormal (essentially requiring some basic statistical comparisons and regression or modeling) and thus be used for security purposes at server farms and other computing facilities.

The true technological uncertainty lies in the hardware. Compatibility issues between BuildFIT and different sensors could be an issue in implementation, so BuildFIT will need to partner with prominent sensor producers. A strategic partnership will create a synchronized software/hardware ecosystem that potential customers could install as a package, to get the benefits of BuildFIT quickly and easily.

Other technical uncertainties are not specific to BuildFIT. De-bugging the software and ensuring easy implementation for different customers, for example, are technical requirements and uncertainties for all embryonic software packages. These uncertainties are less important since any agile or waterfall software development method will manage and mitigate these uncertainties.

Technical Objectives

There are two categories of technical objectives: generic software-related objectives, and energy-specific objectives.

Generic objectives:

- The software must be functional 24/7, and BuildFIT must provide customer support that deals with any irregularities and meets the customer's needs.
- The software must function fully right out of the box, to provide customers with low implementation cost and reduce stress.
- The software must be entirely compatible with a large set of hardware providers.
- The software must have a very user friendly design and interface.
- The software must be is computationally inexpensive, so that it can be run on any computer and easily scale to maximize the potential customer base.
- The software must be secure, protect the customer's data, and ensure that the data is only shared when the customer agrees for the data to be shared.

Energy-specific objectives:

- The software must provide recommendations that are user-friendly and understandable, to each category of user (building occupant, facilities manager, financial manager).
- The software must provide recommendations that are realistic, actionable and trackable, to ensure that the users actually take action.
- The software must have accurate recommendations and data visualizations.

R&D Strategy and Plan

Since the first phase of beta testing is currently in process, most of the software development activities have to do with usability and accuracy. For the most part, the software itself functions as

designed; the largest development need is fine-tuning it for ease-of use. The beta test is producing user-data, so the sequence and milestones of the R&D plan can be seen below.

Table 1: R&D Goals

Sequence of Activities	Goals	Metrics	Anticipated Results
Analyze beta-test data	Complete analysis	Accuracy and correlation with other data	Production of actionable tasks regarding changing the software
Debug software	Software robustness – running software under different conditions	Success rate/failure rate and tolerance for heavy computations and errors	Many bugs, and bug fixes
Secure software	Performance of software under different attacks	Success rate/failure rate and tolerance for different attacks	Improving the security of the software
Implement usability recommendations	User-testing – probably through surveys – to determine whether each iteration is usable	Usability ratings for each category of user	Improving the effectiveness of the recommendations, and the usability of the overall software
Implement modifications to natural language processor and recommendations	Determine how actionable and effective the recommendations are. Determine how often user act on the recommendations	Success rate for each of the milestones	Improvements in the NLP, the recommendation algorithm, and the nature of the recommendations

Market

Market Opportunity

Market Segmentation

The markets that BuildFIT will target can be segmented according to two criteria: building portfolio size, and ownership (private or public). Based on this criteria, the market can be divided into six market segments as follows:

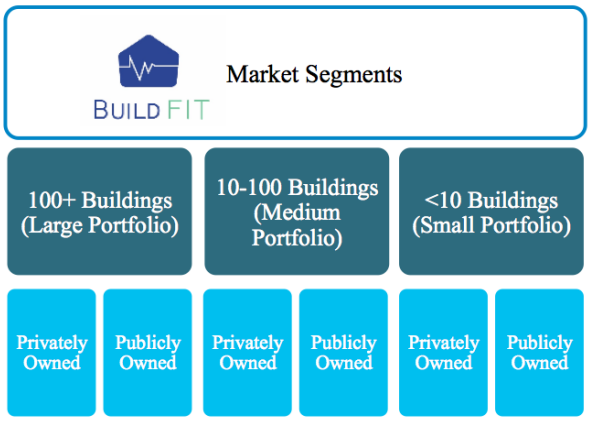


Figure 4: Market Segmentation

Current customers of BuildFIT's beta-version (PNC, District of Columbia, City of Pittsburgh and The US Air Force) are a mix of public institutions and private companies with large portfolios. However, the cost of implementation to federal agencies is higher given the security requirements – which prevent the usage of cloud computing, and require on-site installation of sensors and other network hardware by the company. This means that in the short-term, when BuildFIT has low revenue and is establishing itself, federal clients will be difficult to service. Thus, the first major target market should be private companies with large portfolios of buildings. An advantage of targeting customers with large building portfolios is that they will usually have buildings with wide-ranging functions (warehouses, office buildings, etc.) and wide-ranging geographical locations which is exactly what BuildFIT is designed to serve.

Fulfilling Critical Needs

The critical need that BuildFIT aims to solve is the disconnect between upper management (c-suite executives, specifically the Chief Financial Officer) and the facilities management services (FMS). It also aims to build more accountability and transparency since the software is built to provide specific recommendations for various individual employees to perform. The ability to quantify these recommendations into estimated dollar savings provides direct incentive for both the CFO and FMS to take immediate action, thus allowing BuildFIT to play an *active* role in cost savings.

Barriers to Adoption and Entry

The initial target markets we are looking at will have certain barriers to adoption. As previously mentioned, federally owned buildings require high data privacy requiring the installation of physical internet cables underground for the sensors, increasing costs. It will also be difficult to install this software in older buildings that lack sufficient infrastructure like sensors, limiting the customer base that can be initially targeted. Once a strategic partnership with a sensor installation company is developed, however, this barrier will become much less problematic.

Beyond barriers to adoption, certain barriers of entry to the market also exist. There are multiple comparable products currently circulating in the market. Since the software is fairly replicable, expediting the official release of BuildFIT is crucial in gaining a first mover advantage. Although BuildFIT is currently installed in about 200 buildings; BuildFIT's current client base (PNC, City of Pittsburgh, District of Columbia and US Air Force) consists of more than 7,000 buildings. Tapping into the extended building portfolio of existing clients is feasible and will ensure BuildFIT's continued profitability.

The total market potential is immense, seeing as there are more than 900,000 buildings *just* owned by federal and state governments, and the government would definitely benefit from a software such as BuildFIT.[8] There are also millions of private buildings that are compatible with BuildFIT's software. Besides, with the improvement in building energy management market, the sale of such software is said to double in size to $22.4 billion by 2020, according to leading energy consultants.[9] These forecasts make BuildFIT a very optimistic venture with a clear path forward. Nevertheless, a major uncertainty is the impact of competition in this growing market, which is discussed in the following section.

[8] "Excess Federal Properties Map - October, 2011". 2016. The White House. https://www.whitehouse.gov/issues/fiscal/excess-property-map.

[9] "Energy Management Market 'To Almost Double' By 2020". 2016. Envantage. http://www.envantage.co.uk/energy-management-market-to-almost-double-by-2020.html.

Competitive Landscape

There are currently numerous building energy management software circulating in the market, but we have identified four direct competitors to BuildFIT:

- **Lucid BuildingOS.** Lucid BuildingOS was formed in 2004 and is a more mature company with a diverse client portfolio including Universities (Stanford, Cornell, University of California), Private companies (Google, Hyatt, Autodesk) and public institutions (NASA). They have a robust pricing strategy ranging from $20-$95 per building per month and allows for individual building owners to purchase this capability as well.[10]
- **BuidingIQ.** This is a fairly mature company that provides basic dashboard type software integrating "Internet of Things" or IoT into their data collection. BuildingIQ is focused only on industrial clients, and does not provide specific recommendations which increase accountability. Information on their current client base is unknown, but they have formed partnerships with numerous asset advisors, energy companies and sensor companies to expand their knowledge base.[11]
- **Skyspark.** Skyspark by SkyFoundry is a relatively new company and is still very primitive in its design. The software still relies on data from the utility providers for primary information and have only recently started installing sensors and collecting their own data. They still have no pricing models and no clients.[12]
- **Schneider Ion.** Schneider Ion is also extremely primitive in design and is yet to be launched as a full-fledged Schneider product. Given Schneider's expertise in both software and hardware in the energy industry, they could pose a large threat if their technology reaches the same technical level.[13]

Amongst these four competitors, Lucid BuildingOS provides the most eminent and credible threat due to its mature presence in the market and its diverse customer base. Comparatively, BuildFIT has the potential to outperform BuildingOS with its meaningful recommendations to improve building efficiency and estimate the potential dollar. Also, the superior data collection (multiple and varied data sources) and data management provides sufficient technical competitiveness in the building energy management market. Finally, the potential commercialization of collected data, alongside the implementation of data mining techniques in the aggregated data, could provide additional revenue streams.

To ensure that sufficient market share is captured successfully, BuildFIT's competitive strategy should comprise of the following steps:

[10] "Lucid Technologies". 2016. https://lucidconnects.com/.
[11] "Buildingiq". 2016. *Buildingiq.Com*. https://buildingiq.com/.
[12] "Skyspark". 2016. *Skyspark by Skyfoundry*. https://skyfoundry.com/skyspark/.
[13] "ION Setup 3.0 - Schneider Electric". 2016. *Schneider-Electric.Com*. http://www.schneider-electric.com/en/product-range/61461-ion-setup-3-0/.

Figure 5: Commercialization strategy

Product and Value Proposition, and Intellectual Property

BuildFIT's product concept fundamentally involves collecting energy usage data within buildings, assessing the efficiency of the energy usage, and providing intelligent recommendations to fix infrastructure issues and improve buildings overall energy efficiency. This will help bridge the communication gap between the CFO and FMS and provide tangible monetary savings by reducing utility costs and unrequired repair costs. This is the key value proposition that BuildFIT provides, which also provides its competitive edge.

The product would be delivered as a computer application with a dashboard style view of the energy usage for their portfolio of buildings for use by the CFO and FMS managers. It will also be provided as a mobile app so that the generated recommendations can be targeted to specific building occupants or managers who will bear responsibility to implement these recommendations. BuildFIT could possibly expand their software offerings further and introduce an app for a wearable device to increase the connectivity and quicken the implementation process, thus increasing overall savings.

Currently BuildFIT does not have any intellectual property, given the high costs of establishing and defending intellectual property. The product itself doesn't have novel algorithms that provide a strong competitive advantage, though some aspects of it could be patentable. Additionally, most of BuildFIT's methods have been published, which would make it difficult to patent. According to Reed McManigle, an IP management professional, "it may be possible that there are nuggets of novelty, but they are on aspects of the overall system that are so narrow that others could have a competing product without that narrow aspect and still get market acceptance."[14] Thus, unless BuildFIT is going to make significant changes to the product, intellectual property does not seem valuable.

Finally, by looking at the competition, we anticipate that customers will be willing to pay around $20-$100 per building per month for this service, depending on the extent of technical and design capabilities. This pricing strategy will likely vary between private companies and government agencies, however, depending on the willingness to pay of the public organizations. BuildFIT must also be cognizant of the market dynamics and be flexible in adapting their pricing to keep a competitive edge.

[14] Correspondence with Reed McManigle. 2016 Reed McManigle, Interview by Apratim Vidyarthi. In person. Pittsburgh, PA.

Commercialization

The initial target market will primarily target private companies with large building portfolios, and must eventually expand to companies with smaller building portfolios and eventually owners of individual commercial buildings. Simultaneously, existing public sector clients should be kept and this base can help expand into the public sector market. This path to the customers will ensure that BuildFIT builds a strong reputation and improves its data processing methods with large amounts of data, before expanding to relatively lower return market segments.

The market entry strategy should be different for the private and public sectors. For the public sector, the service must be priced cheaper; but BuildFIT must also be aware that most federal buildings (especially military buildings) don't allow external network connections. This will require the construction of internal networks. Nevertheless, this extra initial cost will be valuable since it will facilitate a strong relationship between BuildFIT and potential federal contract providers, which could push forward and partially fund BuildFIT's research and development. For the private sector, BuildFIT must work on refining the algorithm to the extent that most recommendations can be generated instantaneously and can be integrated seamlessly to any existing data collection capabilities that the buildings may have. Another advantage in the private sector, is that they can be held responsible for the purchase and installation of servers, networks and other peripherals; thus reducing BuildFIT's overall costs.

Referring to the institutional theory of market strategy, BuildFIT should see itself as a company that shapes its own market. BuildFIT is essentially a "hedger", developing analytical capabilities on top of a passive energy dashboard software. BuildFIT should also leverage its ability to make a diverse group of participants interact with each other and growing their market through word of mouth. Finally, BuildFIT can shape its own acts and assets by forming key partnerships with federal agencies such as FERC, EPA and DOE.

Since BuildFIT already has a lucrative set of existing customers, this must be the prime focus when designing a marketing strategy. If prospective customers understand that BuildFIT is a tested and proven technology, they will be more inclined to purchase it. Additionally, the aspect of providing recommendations must be stressed, since that is the key value proposition that the product offers.

For BuildFIT to successfully capture the target market, certain partnerships will need to be formed with the following organizations:

- **Construction companies:** This partnership will allow BuildFIT to ensure that its software is compatible with new buildings, and serve as a potential avenue for bundling. By providing BuildFIT as a bundled software with new buildings, a construction firm's projects would look more attractive and at the same time provide BuildFIT with new market share.
- **Real estate development companies:** This is an extension of partnerships with construction companies, though real-estate development companies focus more on the distribution of the software than the technical implementation. Some companies that focus on construction as well as real estate management are Clark Construction, Mortenson Construction and Skanska.
- **Sensor companies:** This type of partnership would mitigate the technological risk of having a software that is entirely inapplicable in older buildings. Technically speaking, if the data format and output from a sensor is not compatible with BuildFIT's software, then

the data is irrelevant. By partnering with sensor companies like Libelium and Episensor, BuildFIT guarantees that the software will work with a large portion of the sensor market, and guarantees that the sensor companies will have broader data-processing uses for their sensors.

Beyond helping develop a bigger customer base, forming these partnerships can help BuildFIT by doing the following:

- Creating a streamlined, established data pipeline:
  In the event that BuildFIT decides to move towards mining and selling the aggregated data it recovers from private companies' energy usage, building these partnerships will minimize the costs of cleaning, troubleshooting, and sourcing data.
- Technical development:
  BuildFIT can reduce the cost of technical development by leveraging strategic partnerships with organizations in complementary industries. Particularly with sensor companies, there is an immense value in knowing that both a software and hardware solution for energy management would be compatible, given that the two functioning in tandem is the only way to achieve state of the art energy monitoring and management.

Ultimately, these partnerships will ensure that the barriers to entering the market can be easily overcome and a considerable share of the market can be captured and maintained.

Business

Revenue Streams

Currently, the beta BuildFIT software is being offered to its clients free-of-charge. Clients include eight well-known organizations such as PNC, UPMC, the City of Pittsburgh, and Google, all of which have large and modern building portfolios. As discussed above, BuildFIT should first focus on tackling the private market, with companies that have large and modern portfolios since this is the most feasible segment. The first phase aims to include previous beta clients and universities, leveraging BuildFIT's relationship with Carnegie Mellon University. Expansion to include more diverse clients, such as manufacturing, technology, customer service, and eventually the federal government, can be actualized after these preliminary markets have been captured.

With this in mind, the initial revenue streams will stem from these private, large portfolio customers, and the following pricing strategy will delineate how revenue will be generated.

General Pricing Strategy

BuildFIT will be priced as a subscription service, with customers signing a two to five-year contract to use the software. Lucid Building OS, one of BuildFIT's major competitors, uses a tiered pricing system that offers increasing levels of service to clients on a per building per month basis.[15] Figure A shows how Lucid Building OS's pricing strategy is delineated.

[15] "Lucid Technologies". 2016. https://lucidconnects.com/.

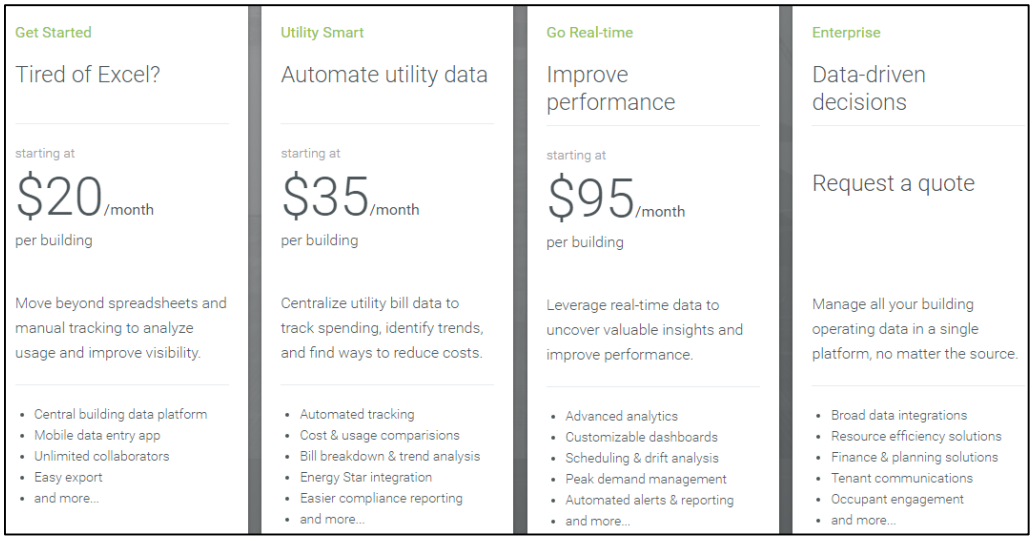


Figure 6. Lucid Building OS Pricing Scheme[16]

Since Lucid Building OS is a key competitor, our team recommends that BuildFIT adopt a similar tiered pricing strategy that competes with them for price leadership coupled with their competitive advantage (the full BuildFIT service) in order to capture the market. As shown in Figure 1, Lucid Building OS has a $20-$35-$95 tiered monthly subscription costs, with a separate enterprise tier for clients with large building portfolios charged at an unknown price premium. Since clients with large portfolios are the target market, BuildFIT can capitalize on its main differentiation of personalized recommendations and price the tiers for these larger clients the same as smaller clients. With this strategy, we recommend a $30-$60-$90 monthly subscription pricing scheme per building, with similar offerings as described below:

- **Track.** This bare minimum service is intended for new customers or customers that do not have large and/or modern building portfolios. It targets those that just want a central platform to track their energy usage in real-time. This data can be exported to internal data management programs (such as Microsoft Excel) for building managers to manually compute trends and make recommendations, or however they decide to use the data.
- **Trend.** This service goes a step further than the tracking in tier 1. Not only does it track energy consumption, but it also analyzes the consumption data to identify trends. It incorporates utility bills to consider spending. It builds on the real-time data with its own built-in analyzing capabilities that can generate cost comparisons and other energy usage breakdowns.
- **BuildFIT.** This is the full BuildFIT service that represents the major customer value proposition. It includes all the above and the personalized recommendations based on balancing costs, sustainability, and performance, and client goals.

[16] Ibid.

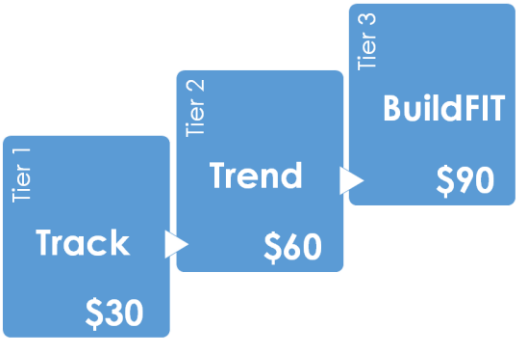


Figure 7. Recommended BuildFIT Pricing Strategy

Prominent clients with large and modern or sensor-outfitted building portfolios, in particular those that participated in the beta testing, are likely to be the first customers to invest in the third tier pricing – and because of their early engagement in the software, could potentially be lured to this tier via discounts and other promotions. These companies understand the value in having BuildFIT-level recommendations and will have contributed to the pricing levels based on their willingness to pay (that BuildFIT will determine via exit surveys after Beta testing has completed). Also, large and modern building portfolios can receive the most value from this service, since energy is a major cost for them and data points (i.e. sensors) are usually already installed.

The first tier allows for newer clients to explore the BuildFIT platform and hopefully move up to the second and third tier over time. These may be companies with smaller portfolios that do not yet see the value of the recommendations or companies that do not have the necessary sensor infrastructure. With these expectations, our team anticipates that given the current clients and connections, BuildFIT will garner its first revenue streams through the third tiered program (since the software is already installed).

Other Potential Revenue Streams

As new clients are accepted revenue can be generated from potential contract initiation fees and eventually a balance for the first and second tiers once other markets are realized, such as smaller or less modern building portfolios. Besides clients purchasing and installing the BuildFIT software, other revenue streams include partnerships with submetering[17] companies and those companies selling aggregated energy consumption data. For those clients with less modern buildings that do not have sensors and submeters installed in their buildings, our team looked at BuildFIT offering an installation service to persuade these customers. Instead however, BuildFIT is currently speaking with submetering companies to talk about potential partnerships so they can offer clients a cheaper, packaged deal for the installation and software if they decide to use BuildFIT. This deal can help to move customers up to the second and third tiers by seeing the value in the discount for getting submeters and sensors.

[17] Submetering is the implementation of a system that allows a landlord or a homeowner's association to measure and bill tenants for their individual utility usage.

Cost Model

Key Cost Drivers

BuildFIT is a software, so costs to the company inherently include maintenance of its servers and software development. However, maintenance costs are actually quite low, as the software is relatively self-running. The company has looked at running the software through the cloud instead of its own servers, which may increase costs incrementally, with the benefit of improved data pipelining and software upgrades. However, cloud computing would not be a feasible technology for potential federal clients such as the Unites States Air Force.

In commercializing BuildFIT, the key cost driver is actually the labor costs for the engineers involved in both the development and maintenance of the software. Essentially, to support our business model, our platform must be able to (1) collect masses of real-time disparate data from non-traditional data, (2) clean and organize this data in real-time, (3) analyze and generate a continuous stream of actionable recommendations and (4) do all of this unobtrusively, securely and cheaply. The key players in achieving these goals are highly-skilled software engineers, data scientists, and analysts.

As an active energy data platform, BuildFIT requires more continuous manpower than a passive, simple data-tracking system. Beyond this, there are other auxiliary costs not directly associated with the software itself. First, BuildFIT will require hiring customer service representatives to offer 24/7 support for the platform. Additionally, marketing personnel in charge of attracting new clients will also incur supplementary costs. For example, once the team enters the public market there are costs associated with catering to them. First, it would cost the team to enter the DoD's Environmental Security Technology Certification Program (ESTCP), however this program will provide them with much needed funding and exposure. Also, installing the software in military bases would require secure servers and hardware, which is an extra cost that either the customer or BuildFIT will have to pay for.

Cost Structure

Our team has developed a rough cost model detailing the fixed and variable costs in running the business, as well as a cost breakdown to see the contribution of each to annual costs (Figure 4). This was calculated for the initial phases of development. The fixed costs include the server maintenance and wages for employees. Variable costs include contractor labor in case of BuildFIT needing to install sensors or submeters for a building, and customer service in case of any maintenance issues. Server maintenance is approximated to cost $500 per month per server. Employees include the management team, software engineers, PhD students, marketing, policy, and software interns, and customer service representatives. The respective hourly wages for these workers are shown in Appendix 1.

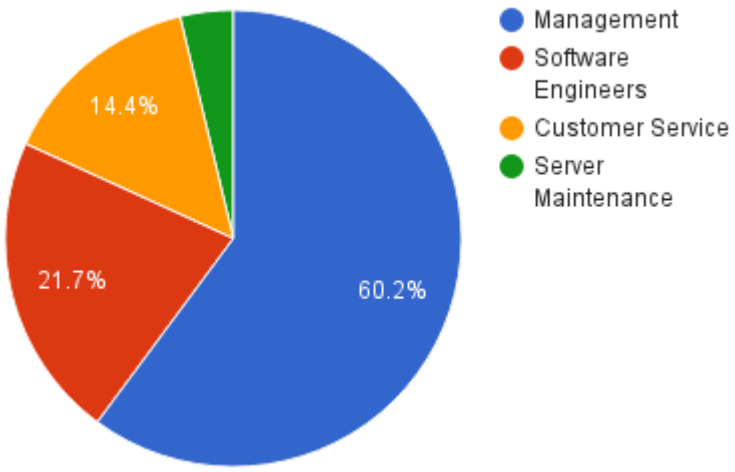


Figure 8. Monthly Operations Cost Breakdown

Breakeven Plan

Taking into account the revenue streams and cost structure our team developed, we can determine the point at which BuildFIT will breakeven, and strategies to reach that point. Assuming that the monthly operations cost is true every month, we can estimate the amount of buildings BuildFIT will have to have in their clientele. Looking at the worst-case scenario, if all clients choose the Tier 1 pricing option at $30 per building per month, BuildFIT will need approximately 2,217 buildings. For the best-case scenario of all clients choosing the Tier 3 pricing option at $90 per building per month, BuildFIT would need just 739 buildings. Currently, BuildFIT has approximately 200 buildings for 8 clients. This averages to 25 buildings per client. If this average is assumed for both the best and worst case scenarios, BuildFIT would need 30 to 89 clients.

Broader Impacts

Given that the main goals of BuildFIT is to help building managers to balance the competing priorities of building operating and maintenance costs, building performance, and building sustainability, the innovation has obvious socially conscious motivation and effects. Beyond achieving this goal, the innovation has many other broader impacts that span many different sectors.

Environmental Sustainability

The recommendations that the software gives to building portfolio managers on how to operate/invest in their buildings have profound impacts on the built environment as a whole if programs such as this are implemented widely. If a majority of the U.S. building portfolio installs BuildFIT, this will dramatically decrease the contribution of buildings to national energy consumption. In 2015, residential and commercial buildings accounted for 40% of total U.S. energy consumption, which offers a major opportunity for improvement and decrease of our consumption of resources as a nation.[18] This is one of the goals of the DOE, which is a funding source of the BuildFIT software, indicating that they believe in the potential impacts on building energy consumption. This does not necessarily mean that BuildFIT will be implemented

[18] Energy Information Administration (EIA). (2016). "How much energy is consumed in residential and commercial buildings in the United States?" Retrieved from http://www.eia.gov/tools/faqs/faq.cfm?id=86&t=1

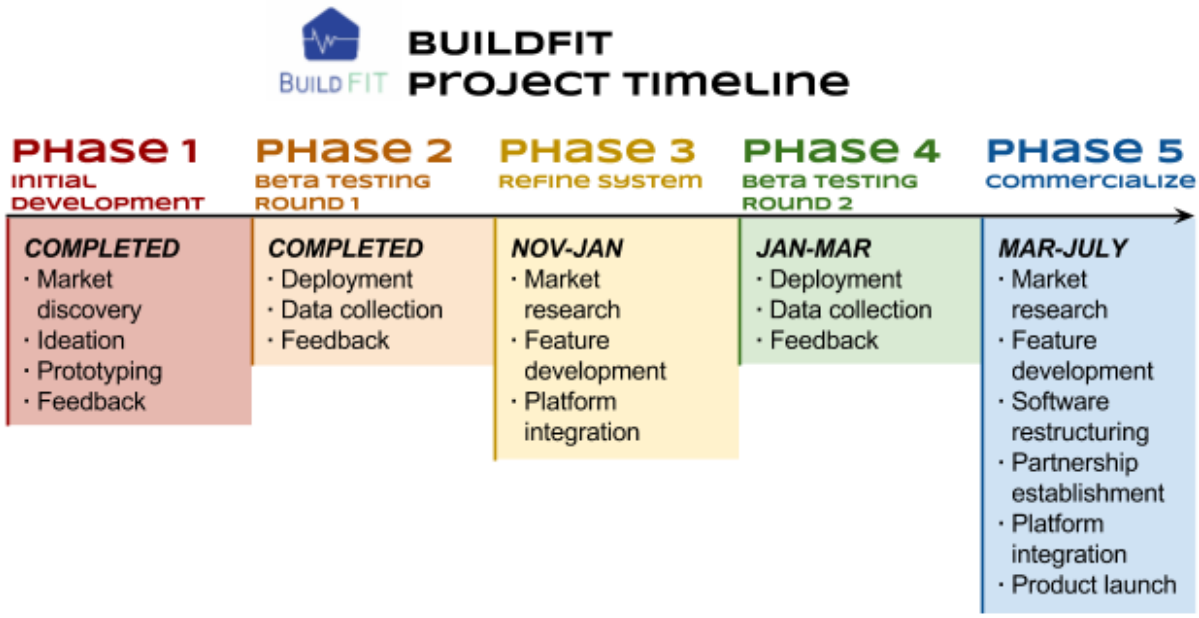
everywhere, but it will open up the potential for similar applications, or enabling technologies to come to market, and maybe even build on the active recommendations to a step further. This is definitely possible with the trending Internet of Things (IoT) market that will only continue to grow. In using less energy, this will also decrease the country's infrastructural impact on pollution and climate change.

Society and Education

The fully commercialized version of BuildFIT is intended to have an occupant component in order to connect building occupants to their energy consumption data and how they can make improvements to decrease their impact. In doing this, BuildFIT is essentially spreading awareness on the large amount of energy that buildings consume, and on the impact that one occupant can have on that building that they may not have understood before. This will capitalize on decreases in building energy consumption discussed previously in that occupants can exacerbate the positive impacts by contributing themselves and therefore minimizing consumption even more.

Project

Project Plan



BuildFIT is currently being developed at the Center for Building Diagnostics and Performance at Carnegie Mellon University's School of Architecture. The project has progressed through conceptual development and a first round of beta testing (Phase 1 & Phase 2 in the graphic above). The development will continue with improvements being made to the system to prepare it for a second round of beta testing, then continue into development for commercialization.

Project Resources

Azizan Aziz, Assistant Research Professor at the Carnegie Mellon University School of Architecture, and Bertrand Lasternas, Senior Data Scientist at the Carnegie Mellon University School of Architecture, are currently heading the BuildFIT team. Mark DeSantis, energy entrepreneur and CEO of Kwantera, is serving as a tech transfer and commercialization mentor and Ken Durrett, experienced chief financial officer, is serving as CFO. Doctoral candidates in the

School of Architecture who are focused on analytics and sustainability are also supporting the efforts.

Azizan Aziz brings more than twenty years of research experience to the team, giving him exceptional knowledge of building performance and sustainability in the architectural world. Bertrand Lasternas brings engineering and technical knowledge to the team, having earned a graduate degree in mechanical engineering and working extensively with diagnostics, controls and analytics. Mark DeSantis brings business sense and entrepreneurship skills to the team, having seen his own energy startup grow into a successful GE backed organization. Ken Durrett, CFO and member of B2B CFO®, brings financial skills and experience in increasing cash flows, promoting growth, and improving profitability for small companies. In order to help drive product development at low cost, it would be ideal for BuildFIT to hire three or four interns (one or two software engineering intern(s), one marketing intern, and one policy intern) between March and July. These skills complement each other to support the technical R&D components of the product, the entrepreneurial endeavors to build a business model and company, and the financial capabilities to successfully maneuver in a dynamic and growing marketplace.

The only capability that the team lacks is in hardware and sensor installation. Since BuildFIT is a data analytics company, it lacks the hardware expertise to install sensor networks. Their expertise in software, however, has made them capable of interfacing with the systems installed by many submetering companies. Thus, as discussed above, forming a partnership with a submetering company to perform the sensor installation will complete the set of capabilities required to operate a successful energy monitoring company. As the company grows and commercializes, it must acquire customer service representatives, which will provide a cost benefit to the company as customer service representatives have a lower labor cost than software engineers.

In order to develop a commercially ready product, approximately $400,000 will be necessary given that the foundation for the software is complete, and the expensive parts of software development have been completed. This includes $62,000 in Phase 3, $83,000 in Phase 4, $141,000 in Phase 5 and $87,000 for contingency and overhead expenses. A detailed breakdown of the budget can be found in the Appendix (Table 1). Innovation Works typically provides approximately $100,000-$200,000 in funding, thus it will successfully guide BuildFIT through Phase 4 and into Phase 5. Beyond the development of the commercially ready product, there will be added costs of gaining market penetration and acquiring costs. This has not been accounted for in the attached budget, as it is highly dependent on the outcome of Beta 2 testing (Phase 4) and the positioning of BuildFIT in terms of its relationship to Carnegie Mellon University. Presently, Carnegie Mellon allows companies to continue using research space on campus in exchange for 1% equity in the company, thus while there is still heavy development, BuildFIT should stay with the university. Additional funding and resources will be needed to separate from the university. It will be imperative, however, that BuildFIT continue to leverage its networks and technical strengths to acquire additional funding to succeed until a stable revenue stream can be achieved.

Overall Strategy

We recommend the following three-phase strategy:

> **Phase 1:** This encompasses phases 4 and 5 of the project timeline, which is for the next 6 months. We recommend targeting companies with large and modern building portfolios, and universities. This encompasses most of the Beta clients. We do not recommend aiming

for federal clients just yet, since the investment required will be immense. Potential clients include UPMC, Google, Ford, Carnegie Mellon University, and the Pennsylvania State University. The break-even point for this is between 700 and 2200 buildings. Once this number is achieved, BuildFIT can move into the second phase.

Phase 2: This phase will span approximately 18 months following the completion of Phase I. We recommend expanding into companies with medium sized building portfolios, and targeting companies in the manufacturing sector, service-oriented companies, and technology companies which host servers. All of these are energy intensive, and all of them can make significant gains in efficiency through the application of BuildFIT. During this time span, we also recommend beginning the planning and development of the product for large federal clients, and investing in branding and marketing to make the product recognizable and reliable in the eyes of federal clients. This phase is where the SBIR grant option would be most beneficial as a funding source.

Part 3: In approximately 2 years, BuildFIT will reach Phase III. We recommend implementing a shaping strategy, where BuildFIT engages in developing the building energy efficiency market. Specifically:

a. Shaping View: BuildFIT as a shaping hedger.[19] BuildFIT is investing in multiple aspects of the energy industry, from federal contractor clientele, to large/medium sized private building portfolios, to building cross disciplinary partnerships with real estate, construction, and hardware developers. These actions have the potential to influence the standards of doing business in the energy management industry, ideally allowing BuildFIT to excel as an industry leader.

b. Shaping Platform: BuildFIT needs to capitalize on interaction leverage.[20] The very definition of BuildFIT is a platform that is "reducing the cost and effort required for a diverse array of participants to coordinate their activities."[21] It can further reduce costs, beyond what it does as a product, by engaging with competitors and energy regulators like the Environmental Protection Agency and the DoE, and shaping regulations that encourage the employment of BuildFIT and BuildFIT-like products. It could also work with competitors to divide the market up, so as to allow for each company to expand peacefully.

c. Shaping acts and assets: BuildFIT needs to invest in specific acts and assets to exemplify that it is serious about expanding in to the market. This is basically signaling. This can be done by sticking to the aforementioned project timelines to exemplify that BuildFIT is achieving critical mass quickly, and building official, concrete, and legitimate institutional arrangements with federal agencies.

In addition to the shaping strategy, BuildFIT should in this phase (Phase III) invest in new applications for its product. Specifically, BuildFIT should invest in data mining and find

[19] A hedger "develops its products or services to support multiple shaping platforms." See reference 21.

[20] Interaction leverage "reduces the cost and effort required for a diverse array of participants to coordinate their activities." See reference 21.

[21] Hagel III, John, John Seely Brown, and Lang Davison. 2008. "Shaping Strategy in A World of Constant Disruption". *Harvard Business Review*, 81-89.

clients for this data. It should also invest in better application development for its product, such that it has intuitive platforms on wearables, phones, tablets, and laptops. Most importantly, it should aim to complete developing the product for federal clients, and cultivate federal clients, which are more lucrative given the fixed nature of the contracts and the relative lack of competition.

Should we add any other conclusive stuff here? I'm not sure but I feel like we might want a closing paragraph just so we don't end on a list? Idk… As is evident by the timestamp on this comment, I am sleep.

References

"About SBIR | SBIR.Gov". 2016. *Sbir.Gov*. https://www.sbir.gov/about/about-sbir.

"Buildingiq". 2016. *Buildingiq.Com*. https://buildingiq.com/.

Correspondence with Reed McManigle. 2016 Reed McManigle, Interview by Apratim Vidyarthi. In person. Pittsburgh, PA.

Energy Information Administration (EIA). (2016). “How much energy is consumed in residential and commercial buildings in the United States?” Retrieved from http://www.eia.gov/tools/faqs/faq.cfm?id=86&t=1

"Energy Management Market ‘To Almost Double’ By 2020". 2016. Envantage. http://www.envantage.co.uk/energy-management-market-to-almost-double-by-2020.html.

"Excess Federal Properties Map - October, 2011". 2016. The White House. https://www.whitehouse.gov/issues/fiscal/excess-property-map.

Hagel III, John, John Seely Brown, and Lang Davison. 2008. "Shaping Strategy in a World of Constant Disruption". *Harvard Business Review*, 81-89.

Innovation Works, 2008. *Community Report: Fostering Entrepreneurial Growth*. Pittsburgh: Innovation Works. https://www.innovationworks.org/Portals/1/documents/INW%20Community%20Report.pdf.

"ION Setup 3.0 - Schneider Electric". 2016. *Schneider-Electric.Com*. http://www.schneider-electric.com/en/product-range/61461-ion-setup-3-0/.

"Lucid Technologies". 2016. https://lucidconnects.com/.

"Skyspark". 2016. *Skyspark by Skyfoundry*. https://skyfoundry.com/skyspark/.

Stauffer, Nancy. 2013. "Reducing Wasted Energy in Commercial Buildings". *MIT News*. http://news.mit.edu/2013/reducing-wasted-energy-in-commercial-buildings.

Appendix

Table 1: BuildFIT Project Plan

BuildFIT Project Plan						
Task	**Resource**	**Hours/ No. Units**	**Hourly Rate/ Unit Cost**	**Task Cost**	**Phase Cost**	
Phase 1: Initial Development						
Phase 2: Beta Testing						
Phase 3: Revamp System (Current Phase)						
Market Research	Mark	60	$65	$3,900		
	Azizan	40	$65	$2,600		
	PhD Student	60	$20	$1,200		
	PhD Student	60	$20	$1,200		
				MR Cost	**$8,900**	
Feature Development	Bertrand	120	$65	$7,800		
	PhD Student	160	$20	$3,200		
	PhD Student	160	$20	$3,200		
				FD Cost	**$14,200**	
Platform Integration	Bertrand	160	$65	$10,400		
	PhD Student	160	$20	$3,200		
	PhD Student	160	$20	$3,200		
				PI Cost	**$16,800**	
					Phase 3 Cost	**$39,900**
Phase 4: Beta Testing						
Deployment	Mark	80	$65	$5,200		
	Azizan	80	$65	$5,200		
	Bertrand	80	$65	$5,200		
	Subsystem Co.	10	$1,000	$10,000		
	PhD Student	40	$20	$800		
	PhD Student	40	$20	$800		
				DP Cost	**$27,200**	
Data Collection	Azizan	80	$65	$5,200		
	Bertrand	160	$65	$10,400		
	PhD Student	120	$20	$2,400		
	PhD Student	120	$20	$2,400		
	Servers	5	$500	$2,500		

				DC Cost	**$22,900**	
Feedback	Mark	80	$65	$5,200		
	Azizan	80	$65	$5,200		
	Bertrand	80	$65	$5,200		
	Marketing Intern	120	$12	$1,440		
				FB Cost	**$17,040**	
					Phase 4 Cost	**$67,140**
Phase 5: Commercialization						
Market Research	Mark	80	$65	$5,200		
	Azizan	40	$65	$2,600		
	PhD Student	80	$20	$1,600		
	PhD Student	80	$20	$1,600		
	Marketing Intern	80	$12	$960		
	Policy Intern	80	$12	$960		
				MR Cost	**$12,920**	
Feature Development	Bertrand	120	$65	$7,800		
	PhD Student	120	$20	$2,400		
	PhD Student	120	$20	$2,400		
	Software Intern	160	$25	$4,000		
	Software Intern	160	$25	$4,000		
				FD Cost	**$20,600**	
Software Restructuring	Bertrand	160	$65	$10,400		
	PhD Student	120	$20	$2,400		
	PhD Student	120	$20	$2,400		
	Software Intern	160	$25	$4,000		
	Software Intern	160	$25	$4,000		
				SR Cost	**$23,200**	
Partnership Establishment	Mark	80	$65	$5,200		
	Azizan	40	$65	$2,600		
	Bertrand	40	$65	$2,600		
	Marketing Intern	40	$12	$480		
	Policy Intern	40	$12	$480		
				PE Cost	**$11,360**	

Platform Integration	Azizan	40	$65	$2,600		
	Bertrand	80	$65	$5,200		
	PhD Student	80	$20	$1,600		
	PhD Student	80	$20	$1,600		
	Software Intern	80	$25	$2,000		
	Software Intern	80	$25	$2,000		
				PI Cost	**$15,000**	
Product Launch	Mark	120	$65	$7,800		
	Azizan	80	$65	$5,200		
	Bertrand	80	$65	$5,200		
	Marketing Intern	120	$12	$1,440		
	Policy Intern	120	$12	$1,440		
				PL Cost	**$21,080**	
					Phase 5 Cost	**$104,160**
					Overhead Estimate	**$21,120**
					Sensor Installation Contingency Fund	**$20,000**
					Total Needed to Commercialize	**$252,320**

The budget has hourly wages based off the CMU average salaries as reported on Glassdoor. Timeline comparisons were based on publicly available information from competitors, most closely BuildingIQ and previous BuildFIT development timelines (Beta 1 schedule). Additional contingency funds and overhead costs were added to ensure a sufficient amount of funding will be secured. This cost process extends only as far as getting the product commercialization ready. Additional costs will be present in order to facilitate market penetration, customer acquisition, and any other incidental costs of commercialization. Thus, it is recommended that beyond the initial funding from Innovation Works, an alternative revenue stream will be necessary to support BuildFIT as it establishes a stable cash flow.

Table 2: Cost Summary

Component	Cost
System Development (Phase 3)	$39,900
Beta Testing (Phase 4)	$67,140
Commercialization (Phase 5)	$104,160
Contingency & Overhead	$41,120
Total	$252,320

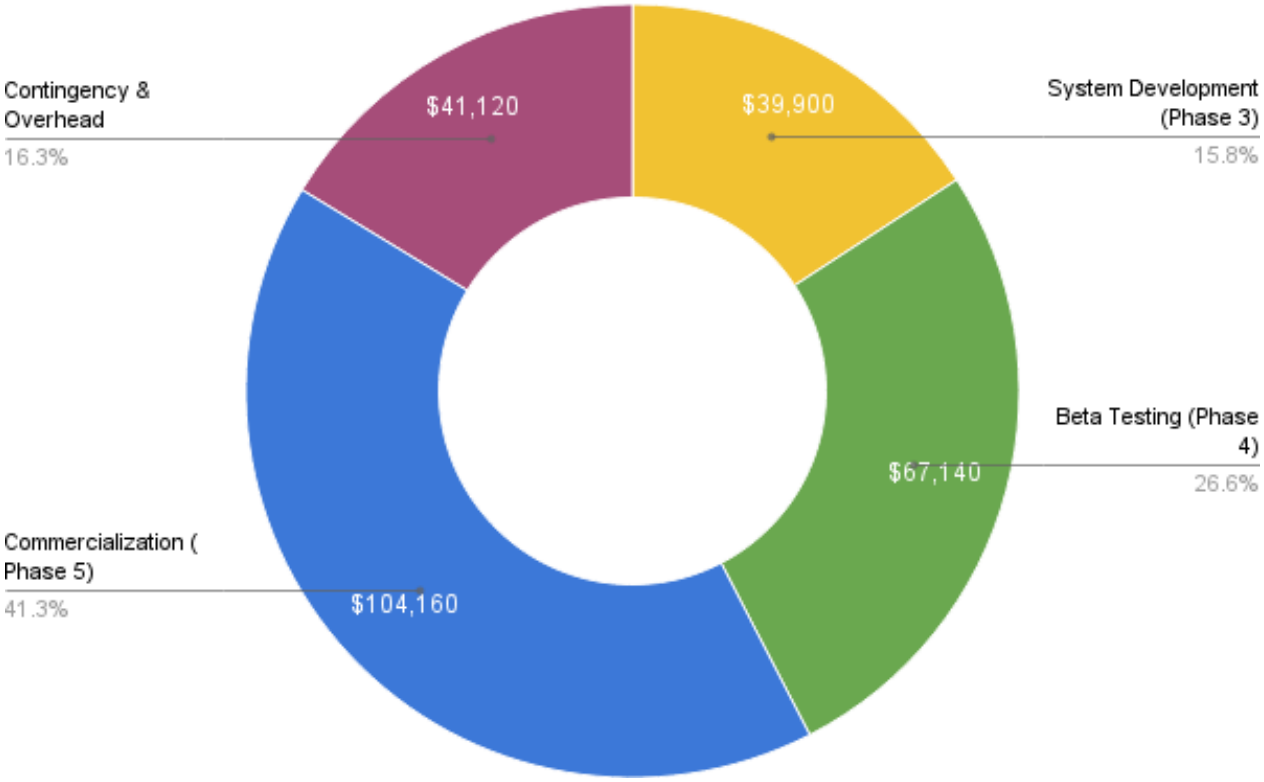


Figure 9: Cost Breakdown by Phase