Neighborhood 91

Economic Impact Whitepaper

Revision 0

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Neighborhood 91: The World's First End to End Additive Manufacturing Production Campus

Neighborhood 91 is the first development in the world to both condense and connect all components of the Additive Manufacturing (AM) supply chain into one powerful production ecosystem; it will offer the following:

- ✓ Powder, parts, post-production, testing and analysis
- ✓ Common powder storage facilities
- ✓ Efficiencies in production/post-production and delivery
- ✓ Tenants' cost savings from printing enabling a lean production cycle
- ✓ Reduced transportation costs
- ✓ Transportation logistics including airport, interstate, and rail access
- ✓ Recycling of argon, helium and other noble gases, which are essential elements of additive manufacturing and can account for up to 60 percent of the total cost.

Why Neighborhood 91? Neighbors borrow tools from each other all the time. Resource sharing is at the core of Neighborhood 91's purpose. Pittsburgh has 90 unique neighborhoods – the 91st will be a game changer for the additive manufacturing industry.

Why an Airport? Easy access to transportation for shipping parts and convening people, ready access to land for development, and linkage to the global supply chain.

Why Pittsburgh, Pennsylvania (PA)? Pittsburgh is a leader in Advanced and Additive Manufacturing, and it also ranks highly in affordability, quality of life, and a ready and willing workforce**.** Pennsylvania is the #1 state for economic diversity making it a stable place to do business.

Why Additive Manufacturing? AM, also known as 3D Printing, is the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies (like machining) akin to carving objects from a block. AM is actually a suite of processes that can be used to print metals, polymers, ceramics, and biomaterials. AM applications are flying in airplanes, orbiting in space, driving on roads, transporting freight, and implanted in humans. AM enables lightweight designs, material usage reductions, cost reductions, lead time reductions, part count reductions, performance improvements, and more.

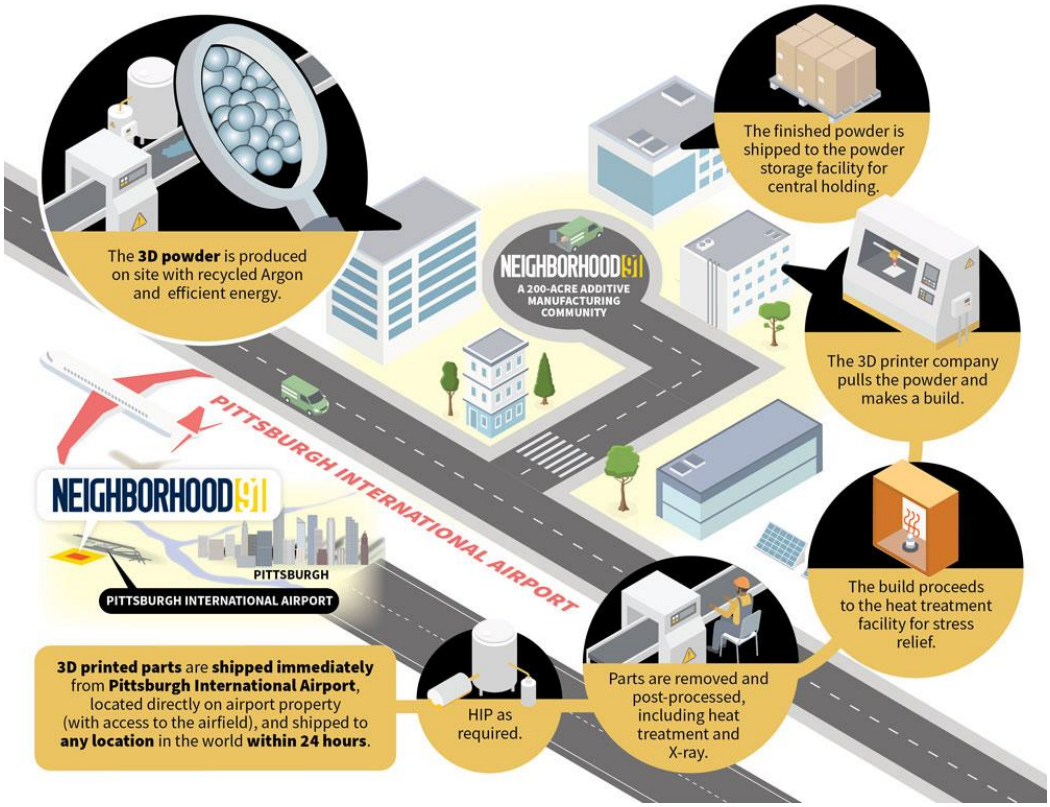

Figure 1: Neighborhood 91 Powder to Parts Model

Key On-site Aspects of Neighborhood 91

1) Argon Gas Recycling
2) Powder Production
3) Powder Facility for Storage
4) Part Manufacturing
5) Post Processing including Heat Treatment

Key Cost Attributes of Neighborhood 91

1) ~50% Reduction in Energy Cost & Stable Energy Source
2) ~25% Reduction in Gas Cost
3) ~50% Reduction in Rent
4) ~50% Reduction in Principal and Interest on Capital Expenditures

THE NEW AGE OF ADVANCED MANUFACTURING REQUIRES BOTH BRAIN & BRAWN

With respect to manufacturing, the theories regarding innovation, knowledge-based economies, and agglomeration and clustering economies have changed considerably over the years. The advanced manufacturing sector is now differentiated from traditional manufacturing in that it requires innovative thinking to exist. History also shows that **innovative thinking attracts more innovative thinking** with "innovation sectors" clustering and growing due to knowledge-based economies.

15 years ago: In his book, "The World is Flat," economic theorist, David Friedman essentially states that distance is dead, and geography doesn't matter[1]. Cell phones, e-mail, and the Internet lowered communication costs so much that location was irrelevant. This meant that good, high paying, occupations, jobs, and sectors "will quickly disperse to low-cost locations" and outsourcing.

7 years ago: In his book, "The New Geography of Jobs", Enrico Moretti discusses the concept of innovation, knowledge-based economics and their effects on the location of jobs in the United States[2]. Regarding Friedman's "The World is Flat" theory, Moretti states, "The data don't support this view." For Moretti, the knowledge economy has an inherent tendency toward **geographical agglomeration** (i.e. those with knowledge tend to live and work in knowledge-based communities). "Over the past half-century, the USA has shifted from an economy centered on producing physical goods to one **centered on innovation and knowledge**." This "innovation sector" is characterized as an economy centered on innovation and knowledge and includes **any job that generates new ideas and new products**. Moretti includes the following in his definition of the **"innovation sector": advanced manufacturing**, information technology, life sciences, medical devices, robotics, composites, and nanotechnology. Moretti states that human capital is the key ingredient in these knowledge-based jobs leveraging both people's skills and ingenuity. This concept is further supported by a 2012 report on the economic resurgence of the Midwest by the Sagamore Institute which states, "the future of

[1] The World Is Flat: A Brief History of the Twenty-First Century by Thomas L. Friedman (Farrar, Straus and Giroux, New York, 2005)
[2] The New Geography of Jobs by Enrico Moretti (Houghton Mifflin Harcourt, Boston, 2012)

the Great Lakes region lies neither in simply the 'information' economy nor in the brute force of manufacturing. Instead it is as a result of a combination both of the industrial sector and the high-value service sectors that feed into it."[3]

> *"…in the **innovation economy**, a company's success depends on more than just the quality of its workers – it also depends on the entire ecosystem that surrounds it. Cities are not just a collection of individuals but complex, interrelated environments that foster the generation of new ideas and new ways of doing business. For example, **being around smart people makes us smarter and more innovative."***
> *- Enrico Moretti*

Today: One can look to Silicon Valley as an example validating Moretti's innovation sector theory and dismissing Friedman's flat world theory; the cost of living and doing business has risen as have other quality of life factors like traffic congestion, yet the Silicon Valley region exists and grows today. In fact, there is a significant level of additive and advanced manufacturing start up activity in the region further linking the importance of innovation mindset to advanced manufacturing.

NEIGHBORHOOD 91: ANALYZING THE IMPACT

Neighborhood 91 will act as a catalyst for AM industrialization and innovation with the creation of a cost-efficient ecosystem and the collection of smart people. To characterize the impact of the Neighborhood 91 investment, multiple **numerical data models were created with relevant industry data**; notable models include a five-year parts producer budget and parts cost model, a powder producer cost model, and transport maps for current AM parts. The data models are complemented with pertinent economic theory concepts for which sources are noted.

[3] Clues from the Past: The Midwest as an Aspirational Region by Joel Kotkin, Mark Schill, and Ryan Streeter (Sagamore Institute, Indianapolis, 2012)

Neighborhood 91 is projected to produce the following key impacts:

IMPACT AREA #1: REDUCTION IN PRODUCTION COSTS

- ✓ **AM Parts Manufacturer:** 25% Reduction in Operating Costs / Become Cash Flow-Positive 1 Year Earlier
- ✓ **Powder Manufacturer:** 30% Cost Reduction for Powder Production

IMPACT AREA #2: SIMPLIFIED SUPPLY CHAIN DUE TO CENTRALIZED CAMPUS

- ✓ **80% Reduction in Manufacturing Lead Time**
- ✓ **80-100% Reduction in Transportation Cost** & Miles for Powder to Part Production
- ✓ **Reduced Logistics** and Supplier Management Costs
- ✓ **Faster Communication**

IMPACT AREA #3: WORKFORCE DEVELOPMENT AND R&D BOOST PRODUCTIVITY AND INNOVATION

- ✓ **Productivity and Revenue Boost** for Neighborhood 91 companies
- ✓ **Spill Over Benefits Creation** to other regional players across the industrial spectrum

IMPACT AREA #4: AGGLOMERATION ECONOMIES & LABOR MARKET POOLING

- ✓ **Decreased learning curve** for production processes
- ✓ **Reduced burden of under-utilized** and **under-productive equipment**

IMPACT AREA #5: REDUCES ENERGY CONSUMPTION & EMISSIONS

- ✓ **Reduced energy demand** using Additive Manufacturing over traditional processes with largest savings related to **efficient material usage,** and part and **system weight reductions**
- ✓ **Reduced Emissions due to reductions** in **Transportation** for:
  - ✓ **Product Shipping** due to centralized production campus
  - ✓ **People Travel** (Reduction in supplier visits)
- ✓ **Reduced Energy & Emissions** from **Facilities / Infrastructure**
  - ✓ Eliminate individual bulk powder storage facilities

- ✓ Reduce under-utilized, under-performing assets
- ✓ Reduce power back-up infrastructure

✓ **Reduced Energy** lost through transmission lines **(Energy efficient microgrid instead)**

IMPACT AREA #6: ECONOMIC IMPACT ON THE STATE OF PENNSYLVANIA

✓ **Creation of 6,343 jobs and $2.2B in Wages**

✓ **Total Business Output Impact of $6.9B**

✓ **Total Value-Added Impact of $3.0B**

✓ **Direct City, State & Federal Tax Contributions of $43M**

NEIGHBORHOOD 91 IMPACT AREA #1: REDUCTION IN PRODUCTION COSTS

Participation in Neighborhood 91 will reduce costs for participating businesses as well as create other less easily monetized benefits. Neighborhood 91 participants will see both complete cost avoidance and cost reductions in the following areas, which impact in the near term as well as the long term:

Cost Avoidances:

- Eliminates power back-up infrastructure (due to microgrid) or losses due to power outages with no back-up power. An uninterruptable power system can cost as much as $400,000 to acquire and install. Typical batch manufacturer will see an average of $150,000/year in losses due to power outages.[4]
- Eliminates permitting and infrastructure investments for bulk powder storage (not required due to common powder storage facilities)
- Eliminates the need to invest in industrial gas recycling, i.e. argon, which has a significant upfront capital cost.

[4] E Source Market Research Reveals That Power Outages Cost Businesses Over $27 Billion Annually; Winter Storm Jonas Makes It Worse by Kim Wooton (E Source, 2016)

Cost Reductions:

- Rent
    - The near-term benefit is in direct cost and having the Allegheny County Airport Authority, which operates Pittsburgh International Airport where Neighborhood 91 is located, as the landowner.
    - The long-term benefit is the ability to scale operations without having to completely change sites.
- Argon
- Energy
- Taxes
- Principal and interest on capital expenditures

A comparison of Neighborhood 91 participation to a baseline cost scenario was run for two types of businesses: a powder manufacturer and a parts manufacturer. Both players see a benefit due to direct cost reductions of 25-30% as a "neighbor," or tenant, in Neighborhood 91, and the parts manufacturer could achieve a cash flow-positive business 1 year earlier.

1. **Neighborhood 91 Impact on Parts Manufacturer:**
    - ✓ **Become Cash Flow-Positive 1 Year Earlier** (Reference graph in Figure 2)
    - ✓ **25% Reduction in Operating Costs**
2. **Neighborhood 91 Impact on Powder Manufacturer: 30% Cost Reduction** for Powder Production

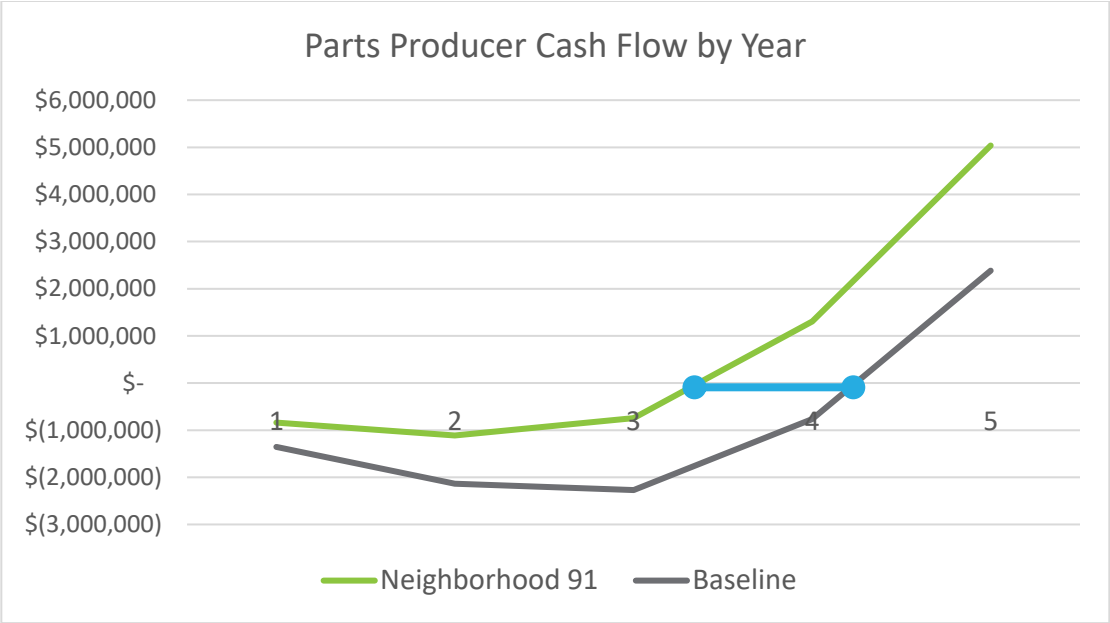

Figure 2: Parts Producer Cash Flow over 5-Year Period with Baseline & Neighborhood 91 scenarios

NEIGHBORHOOD 91 IMPACT AREA #2: SIMPLIFIED SUPPLY CHAIN DUE TO CENTRALIZED CAMPUS

Nearly all parts utilizing additive manufacturing also require other manufacturing processes like machining, surface finishing, heat treatment, testing, and inspection. The current AM production supply chain is fragmented with parts often being transported across countries and continents multiple times to complete production. Neighborhood 91's centralized capabilities significantly reduce the need for parts to be managed across a dispersed supply chain. This creates cost savings or avoidances in the form of reduced transportation, reduced logistics, and reduced supplier management. It also enables faster communication, which will improve the speed of problem resolution if not the decrease in the occurrence of problems in the first place.

Neighborhood 91 Impacts:

- **80% Reduction in Manufacturing Lead Time** (Figure 3)
- **80-100% Reduction in Transportation Cost & Miles for Powder to Part Production** (Figure 4)
- **Reduced Logistics and Supplier Management Costs**
- **Faster Communication**

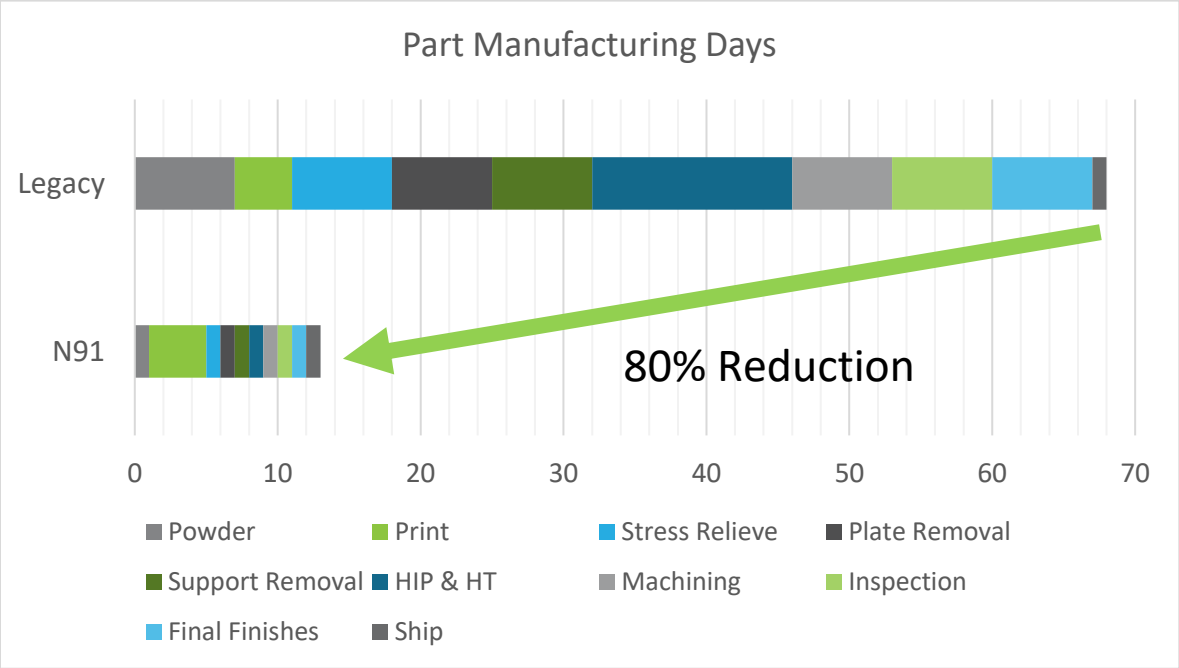

Figure 3: Part Manufacturing Days Comparison Legacy vs. Neighborhood 91

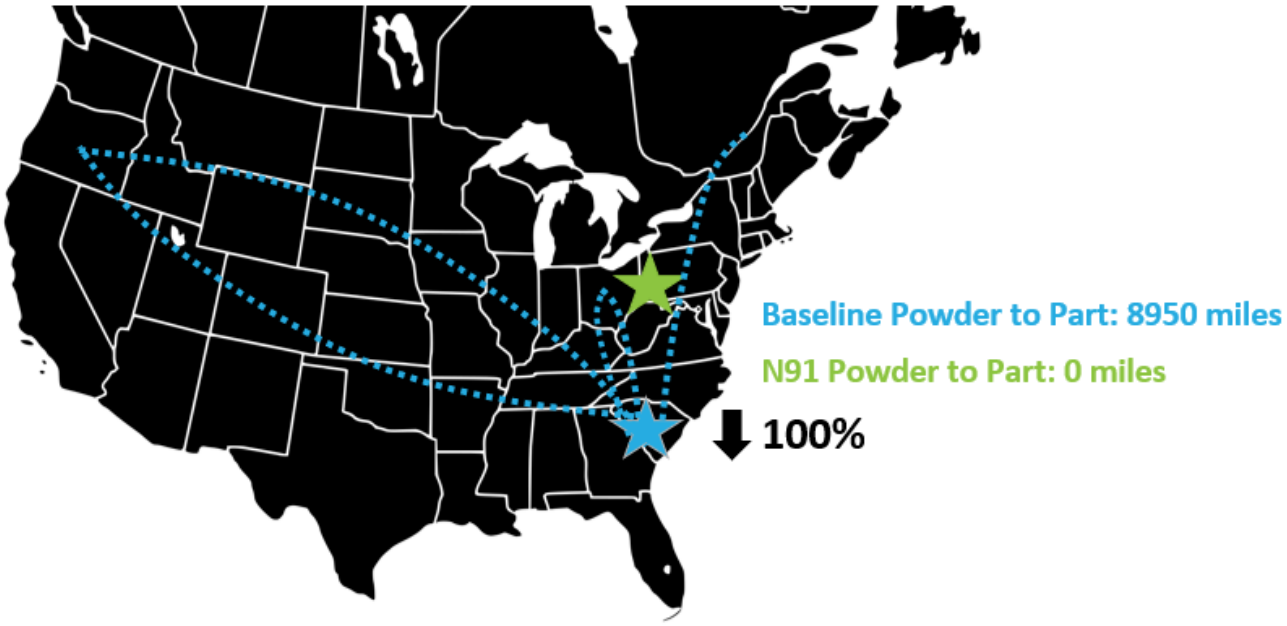

Figure 4: Transportation Miles for Powder to Part Production; (1) Baseline Scenario with Neighborhood 91 Comparison

NEIGHBORHOOD 91 IMPACT AREA #3: WORKFORCE DEVELOPMENT AND R&D BOOSTS PRODUCTIVITY AND INNOVATION

Investment in the development of a **skilled workforce** and **Research & Development (R&D)** as a part of Neighborhood 91 will boost the productivity of companies in the region. The University of Pittsburgh is a key partner in the development of Neighborhood 91, bringing leadership in both workforce development and research and development. Pitt's dual strengths of applied additive manufacturing and supply chain research in addition to piloting programs to augment the professional pipeline help fuel the neighborhood concept. Additionally, the Pittsburgh area has an accessible talent pool with a high degree of college education per capita and a high level of gender diversity. Studies show that companies with more diversity in influential leaders are more successful overall[5].

Research also shows that R&D and workforce development investments have a **spillover benefit** to other actors across the industrial spectrum[6]. In other words, entities other than those carrying out the work can also enjoy higher productivity and revenues as a result of the Neighborhood 91 investments. These spillovers relate to various types of knowledge transfer, such as those resulting from: customer-supplier relationships; collaborations, consortia, and associations; copying of best practices as they become public knowledge; and the movement of knowledgeable and skilled individuals between companies.

Neighborhood 91 Impacts:

- **Productivity and Revenue Boost** for Neighborhood 91 companies
- **Spillover Benefits Creation** to other regional players across the industrial spectrum

[5] More Evidence that Company Diversity Leads to Better Profits by Karsten Strauss (Forbes, 2018)
[6] DTI Economics Paper 5: DTI Strategy, the Analysis (UK Department of Trade and Industry Published Paper, 2003)

NEIGHBORHOOD 91 IMPACT AREA #4: AGGLOMERATION ECONOMIES & LABOR MARKET POOLING

To understand the impact of the Neighborhood 91 additive manufacturing cluster, a look at the classic economic concept of agglomeration is appropriate. Agglomeration is an economic term used to refer to the phenomenon of firms being located close to one another. Agglomeration of industrial companies can recognize economies due to several factors:

1) Reduced cost of moving goods over long distances
2) Reduced cost of moving people
3) Labor market pooling

Additive Manufacturing and the complementary manufacturing processes required to produce parts all require unique technical and business skillsets to make them successful in a production environment. Many companies attempt to stand up these capabilities in-house as they move into production to reduce their reliance on a supply chain and long part shipment times. This can make for **steep technical learning curves** and difficult business conditions due to partially utilized or under-productive equipment. The Neighborhood 91 manufacturing cluster concept does two key things: It enables process owners to **focus on developing and optimizing their core process**, and it **creates a skilled regional labor pool**. These two factors will help shorten the learning curve for production processes and reduce the cost burden of under-utilized or under-productive equipment.

Neighborhood 91 Impacts:

- **Decreased learning curve for production processes**
- **Reduced cost burden of under-utilized and under-productive equipment**

NEIGHBORHOOD 91 IMPACT AREA #5: REDUCED ENERGY CONSUMPTION & EMMISSIONS

Multiple studies show that **additive manufacturing has great potential to reduce both energy consumption and emissions**. In a 2015 study sponsored by the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, Oak Ridge National Laboratory modeled the impact of AM adoption for aircraft on energy consumption and emissions. Ninety-five percent of the savings were attributed to airplane fuel consumption due to light-weighting; the reduction in the tons of titanium, nickel, and aluminum alloys due to AM was also notable[7].

Neighborhood 91 will further reduce the energy consumption and the carbon footprint of the manufacturing supply chain with its **efficient microgrid** and co-location of the supply chain which eliminates significant parts and people travel. The microgrid will be the second of its kind at Pittsburgh International Airport; the first will power the terminal, on-site hotel and gas station and be the first of its kind in the U.S. and possibly the world. Both will be powered by natural gas, and the first will also be powered with solar arrays, providing an independent source of cost-competitive, efficient, and reliable energy.

The modeled 5-year emissions reduction related to the decrease in transportation due to Neighborhood 91 centralized supply chain is -1,374,653,798 kg CO_2e or **the equivalent emissions created to produce the energy to run 873,000 homes annually**. Figure 5 shows the 5-year data that only includes the Neighborhood 91 tenant impacts of reduced part and people travel. Additional emissions reductions will be realized due to the other categories.

[7] Energy and Emissions Saving Potential of Additive Manufacturing: The Case of Lightweight Aircraft Components by Huang, Riddle, Graziano, Warren, Das, Nimbalkar, Cresko, Masanet (Northwestern University Research Output, Evanston, 2015)

Combined AM & Neighborhood 91 Impacts:

- ✓ **Reduced energy demand** using Additive Manufacturing over traditional processes with largest savings related to **efficient material usage** and part and **system weight reductions**[8]
- ✓ **Reduced Emissions due to reductions** in **Transportation** for:
  - **Product Shipping** due to centralized production campus
  - **People Travel** (Reduction in supplier visits)
- ✓ **Reduced Energy & Emissions** from **Facilities / Infrastructure**
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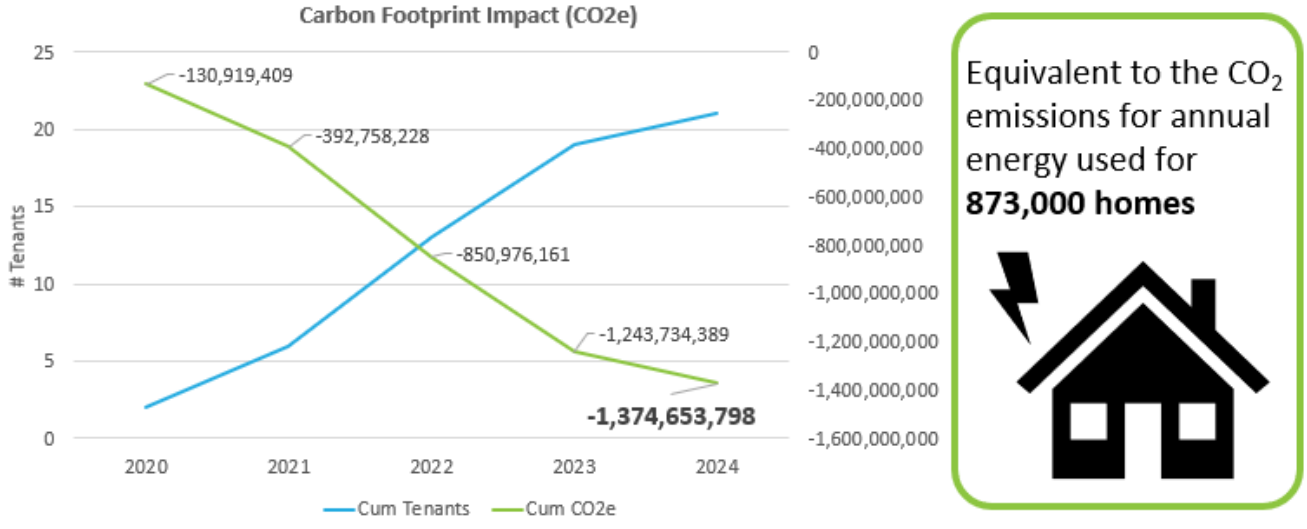

Figure 5: Carbon Footprint Impact on Neighborhood 91 over 5-year period

[8] The Effect of Additive Manufacturing on Global Energy Demand: An Assessment Using a Bottom-up Approach by Verhoef, Budde, Chockalingam, Nodar, Wijk (Energy Policy, Volume 112, January 2018)

NEIGHBORHOOD 91 IMPACT AREA #6: ECONOMIC IMPACT ON THE STATE OF PENNSYLVANIA

An economic impact analysis of the Neighborhood 91 investment was executed using the IMPLAN input-output model with investment numbers for the Neighborhood 91 plan to develop 200 acres (Table 1); the impacts are calculated for a 10-year period, although the recurring operational impacts will extend far beyond that time period. Phase 1, which is less than 10% of the total investment, is already underway; it includes the argon recycling facility, the development of 13 acres with 7 buildings, and the initial equipment investment to support Phase 1 tenants. The full Neighborhood 91 investment plan includes the following elements:

- ✓ $9.3M land value at the campus
- ✓ $123M in land improvements and infrastructure
- ✓ $135M in buildings
- ✓ $285M in equipment
- ✓ $5M for argon system
- ✓ $10M in the microgrid
- ✓ Creation of 1,000 jobs

Input-Output analysis traces the interdependence of an economy's various productive sectors by tracking the product of each industry both as a commodity demanded for final consumption and as a factor in the production of itself and other goods. Input-Output analysis produces a set of multipliers that measure the magnitude of the impact of different industries on the economy. Investment in a region creates both direct and indirect impacts. For example, not only will technically skilled jobs be created on the Neighborhood 91 campus, but the construction and infrastructure investments will support the creation of new jobs in supporting industries. The investment impacts are broken into two categories: The Land Improvement, Infrastructure, and Construction categories include the building

phases of Neighborhood 91 for the full 200 acres and one year after; the Operations category is a recurring annual impact assessment that has been calculated for a 10-year period for the purposes of this analysis.

Table 1: Economic Impact Analysis of full 200 Acres Developed for Neighborhood 91 over 10-year Period ($M)

Impact Type	Business Output[9]	Total Value-Added[10]	Job Creation	Wage Income
Land Improvement, Infrastructure, and Construction	$451	$192	1,914	$142
Equipment	$825	$333	2,443	$208
10-year Operations	*$5,584*	*$2,446*	*1,986*	*$1,816*
GRAND TOTAL	**$6,860**	**$2,971**	**6,343**	**$2,165**

Neighborhood 91 Impacts over 10-year Period:

- ✓ **Creation of 6,343 jobs and $2.2B in Wages**
- ✓ **Total Business Output Impact of $6.9B**
- ✓ **Total Value-Added Impact of $3.0B**
- ✓ **Direct City, State & Federal Tax Contributions of $43M**

[9] Business Output impact is an estimate of the total increase in business revenue.
[10] Total Value-Added impact is an estimate of the increase in gross regional product.

PENNSYLVANIA ECONOMY – BY THE NUMBERS

At different times throughout its history, Pennsylvania has been the nation's principal producer of ships, iron, chemicals, lumber, oil, textiles, glass, coal, and steel. Though the numbers declined during this century, Pennsylvania is still a major manufacturing center and industrial leader. At $793 billion, Pennsylvania has the sixth biggest economy in the U.S. and is home to 44 of the 1,000 largest public and private companies in the U.S. by sales. With top-caliber schools in the state, companies take advantage of the local graduate pool. The following excerpts describe the current state of Pennsylvania's economy:

> *"Since January 2017, Pennsylvania's economy has created 135,200 new jobs. These aren't 135,200 new CEOs, lawyers, bankers, or corporate investors — these are real middle-income jobs in vital industries such as manufacturing, mining and construction. These jobs are also paying Pennsylvanians higher wages. Last year, the average salary in the state was more than $1,250 higher than in 2017."*[11]

> *"Pennsylvania's proximity to large population centers and more affordable real estate remains fertile ground," Toronto-Dominion Bank said in a recent research note. "Health care has been leading job creation for the past half-decade," while "Pittsburgh is in the process of making the transition from steel city to tech town."*[12]

[11] Commentary: Pennsylvania's Economy is Thriving for a Reason by David Urban (The Morning Call, 2019)
[12] Pennsylvania: Recipe for Nation's Most Diverse Economy Includes More Than Just Steel and Chocolate by Lee Mille and Wie Lu (Bloomberg News, 2019)

The Brookings Institute[13] produced a report on advanced industries and their impact on America. Broadly what was true for the American context was also true for Pennsylvania. Pittsburgh appears to have performed better than the State by the numbers.

The report defines advanced industry sectors and refines the focus to emphasize advanced manufacturing, advanced services, and energy. Of interest to Pennsylvania, 8.2% of all the jobs in PA are directly related to advanced industries or 486,518 jobs. In addition, 389,210 jobs are indirectly related to this sector, and they produce 13.9% of all output for the region.

By examining the output growth from 2010-2013 to 2013-2015, the report finds that within the advanced industries, there is a stark contrast. Advanced manufacturing and services grew in both periods, but energy grew and then shrunk in both output growth and employment growth.

> *"It should be deeply troubling for leaders that more than one-half of the nation's largest metropolitan areas have grown less specialized in advanced industries since the economic crisis. That means that fewer cities and fewer regions are deepening their participation in the industries that matter most for constructing broadly shared prosperity".*

Advanced manufacturing and services are roughly connected as the services sector includes management consulting, engineering, and R&D services necessary to the manufacturing sector.

A further look into these figures shows that Pittsburgh outpaces the state. In fact, 9.3% of all jobs in Pittsburgh are directly tied to advanced sectors, which translates to 109,182 jobs. A further 87,350 jobs in Pittsburgh are indirectly created, and advanced sectors produce 15.9% of all output.

These figures help drive home the point that **advanced manufacturing, and an additive manufacturing cluster, in particular, is a win** for Pennsylvania, and that **Pittsburgh's ecosystem and employment position** make it a natural fit as the epicenter of the new cluster.

[13] America's Advanced Industries: New Trends by Mark Muro, Siddharth Kulkarni, and David M. Hart (Brookings Institute, 2019)

ABOUT THE AUTHORS

Laura Ely

Laura Ely is the ADDvisor® Services Leader at The Barnes Group Advisors; she leads a team of industry recognized additive manufacturing experts in providing specialty technical and strategic solutions to solve customer problems. As the Head of Technology at GKN Aerospace, Laura developed the strategic skills required to affect technological change in large organizations. This includes translating technical roadmaps into strategic business visions and vice versa, building businesses cases, securing capital and operating funding (~$15M OpEx and ~$7M CapEx over 4 years), protecting and exploiting Intellectual Property, and collaborating across the industrial supply chain. Laura's leadership skills are highlighted through her ability to build and enable diverse teams; she was responsible for the build out of a new team focused on the maturation of laser/wire deposition for Titanium aerostructures after negotiating a CRADA between GKN Aerospace and Oak Ridge National Laboratory, valued at $18M over 5 years. Laura has a passion for optimizing manufacturing processes. For 15 years, she has focused on improving metallic alloys and processes, specifically for laser/wire deposition, friction stir welding, spin forming, machining, and various wrought processes with application to Titanium aerostructures, Aluminum wing skins and inlet lip skins, and Copper electrical connectors, coinage, and ammunition. She directly supported aerospace production including Boeing's 787-9, F/A-18 and F-15. Her enthusiasm for additive manufacturing and promoting diversity in the workplace is contagious, and Laura shares her energy via various public forums, ranging from executive aerospace conferences to university lectures to kindergarten classrooms. Laura graduated summa cum laude with her B.S. in Metallurgical Engineering from the University of Missouri – Rolla (now Missouri S&T).

John E. Barnes

John Barnes is the Founder of The Barnes Group Advisors, the leading independent consultancy and training provider in additive manufacturing. John has a 25-plus-year career in product development and aerospace with Honeywell, Lockheed Martin Skunk Works™, Australia's CSIRO, and Arconic. He's been involved in advanced manufacturing and additive manufacturing throughout this career beginning in the late 1990s where he was part of the Sandia National Labs LENS™ CRADA. Since then, he has been in and around AM working both technical and business cases for implementation and development efforts in materials, powders, processing, and printing to mature the technology for applications. John is recognized internationally for contributions to additive manufacturing, product development, and leadership in engineering. His groups boast world firsts in medical, therapeutic, and aerospace additive manufacturing. He is a Materials Engineer by background but has developed expertise in manufacturing, airframe structures, gas turbines, and low observables. John has 14 US or international patents and patent applications, has given numerous invited presentations and is published internationally. In 2014, he was awarded Purdue University's Outstanding Materials Engineer of the Year and was given an Adjunct professorship at RMIT. In 2015, he won the Entrepreneur Award from the CSIRO in Australia. In 2017, the faculty of Carnegie Mellon University appointed him an Adjunct Professor of Materials Engineering. In 2019, America Makes made him an AM Ambassador reflecting on his contributions to the field. John holds a B.S. in Materials Science and Engineering and an M.S. in Metallurgical Engineering from Purdue University.