Background

- Welch is a struggling former coal town in McDowell County in southern West Virginia
  - The town has struggled with decades of population decline, high unemployment, high poverty, few economic opportunities, and few positive social indicators
  - Many residents in Welch and the surrounding area struggle with a pervasive feeling of hopelessness
Problem Definition & Scope
Problem Background

• The population in Welch (and McDowell County) has been declining steadily since the 1950s

• Warrior Creek Development, our sponsor in Welch, is interested in attracting new residents to the town

• In conjunction with the McDowell County Economic Development Agency, Warrior Creek is considering creating a new community of 36 homes on a 13-acre plot in Welch
Problem and Need Statement

• Vision
  • Bringing new people into Welch will help change attitudes and mindsets in the community and instill a feeling of hope.

• Problem
  • Welch lacks affordable, quality homes and broadband connectivity, which makes it difficult to attract new residents.
  • Warrior Creek has access to a 13-acre plot with roads, water, and sewer already in place. The site is missing housing, power, and access to broadband internet.

• Need
  • Our sponsors need to understand how to create a desirable, affordable community that people want to live in.
  • Our sponsors want information to support future discussions about the community with stakeholders and investors.
Our sponsor was interested in what would attract people to a new community at 13-acre site.

**Objective**
- To provide information on what is important and attractive to target markets in context of housing, power, and broadband.

- Created initial system dynamics model to explore connections between community attractiveness and population change in Welch.
  - Created surveys to gather information about housing, power, and broadband from target markets to feed model.

- Survey questions asked about housing needs/preferences, renewable energy preferences, and internet usage.
  - Number of survey responses was too low to provide estimates for the model parameters.
Scope - Updated

• As lack of survey responses became evident, scope evolved to focus less on target markets and more on the three missing infrastructures at the 13-acre site.

• Focus shifted to specific methods for providing housing, power, and broadband at the 13-acre site to maximize cost efficiency and quality.

• New scope included cost analysis and qualitative analysis of alternatives for:
  • Home construction methods
  • Alternative power sources
  • Broadband access

• Objective
  • To provide information on low cost/high quality homes, potential for renewable power sources, and broadband availability at the site.
Operational Concept
Operational Concept

- **SUPPLY**
- **BUILD**
- **ATTRACT**

Supplies: WATER, SEWER, ROADS

Location: 37°24'49.1"N 81°32'58.1"W
Stakeholder Analysis

- **Key Stakeholders (Sponsors)**
  - Warrior Creek Development
  - GMU Community Resilience Lab

- **Other Stakeholders**
  - McDowell County Economic Development Authority (Owner of 13-acre site)
  - Target markets (potential new residents)
  - Existing residents of Welch and surrounding area
  - Local construction/development organizations
  - Local alternative energy organizations/electricity utility
  - Local internet service providers (ISPs)
  - Local community engagement organizations
  - Local, state, and federal government
  - McDowell County employers
Target Markets

Warrior Creek provided three markets to target for the new community:

- McDowell County **retirees**
  - People who grew up in the area looking to return for retirement

- **Employees** at McDowell’s 3 largest employers (McDowell County Schools, FCI McDowell, Welch Community Hospital)
  - Majority of employees do not live in McDowell County due to lack of housing

- Eco-conscious **millennials** looking to leave urban life behind
  - Younger generation able to telecommute
Technical Approach
Technical Approach

• System Dynamics
  • Chose system dynamics to satisfy sponsor’s need for information on how to attract new people
  • System dynamics provides way to study multiple variables in system over time and how changes in one variable affect an entire system

• Cost Analysis
  • Cost analysis provides sponsor with information to make educated decisions on community features in relation to cost
  • Calculated labor and material costs of four construction techniques ($/sq ft) and analyzed advantages/disadvantages of each
  • Assessed feasibility and costs of three power systems at the site
  • Analyzed availability and cost of broadband internet access at the 13-acre site
Assumptions & Limitations

• Assumptions
  • 13-acre site is being developed as a community for residents new to Welch
  • Community attractiveness and population are linked
  • Construction costs calculated assuming 1,000 sq/ft, single story home located at 13-acre plot in Welch
  • Costs are estimates calculated from available data/research

• Limitations
  • System dynamics approach not feasible due to lack of data
  • High-level cost analysis due to scope shift and broad subject matter. Further in-depth analysis required
  • Construction and power costs/methods are subject to a high degree of variability – small changes may have a significant impact on outcome
System Dynamics Model
System Dynamics Model

• As previously mentioned, surveys were created with the intention of feeding the model

• Survey results were used to calculate a score for housing, power, and internet for each target market

• These scores were used to calculate an attractiveness score for each target market

• Each market’s attractiveness score was used to estimate potential migration rates for that market

• Migration rates were then related to population change

• Assumptions & Limitations
  • Attractiveness linked to migration rate
  • Population was only available at county level, not town level
  • Survey responses were too low to provide data to feed model
Limitations of System Dynamics Model

• Ultimately, survey responses were too low to provide data to feed model (only 40 total responses across all 3 groups)

• However, surveys did provide some interesting trends
  • Millennials and Retirees agreed that **affordability** and **quality** were the most important factors when deciding where to live. Third highest factor differed – Millennials chose “close to work” while Retirees chose “sense of community.” Sense of community was the lowest factor for millennials.
  • Millennials and Retirees are evenly split on alternative power. Interestingly, Retirees results trended “greener” than millennials
  • Both groups overwhelmingly responded that **high-speed internet access is “essential,”** and both groups indicated they use the internet more than 3x per day

![Millennial survey result](image)
Analysis: Construction Methods
Housing Methods Considered

• We are considering four home construction methods:
  • Traditional stick frame construction (baseline)
  • Advanced framing (optimum value engineering)
  • Compressed earth block
  • Pre-fabricated modular housing

• Warrior Creek mentioned interest in advanced framing technique

• Compressed earth block and pre-fab modular were methods recommended by STAR-TIDES network contacts as low cost/high quality options

• Method
  • Analyzed costs for labor and materials and calculated cost per square foot
  • Compared the construction time for a single home
  • Researched and documented pros and cons of each of the four methods

*STAR-TIDES: Sharing To Accelerate Research-Transformative Innovation for Development and Emergency Support
## Cost Analysis

<table>
<thead>
<tr>
<th></th>
<th>Traditional stick frame (baseline)</th>
<th>Compressed Earth Block</th>
<th>Pre-fab Modular</th>
<th>Advanced Framing</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Labor</strong></td>
<td>$39,823</td>
<td>$39,823</td>
<td>$10,136</td>
<td>$37,832</td>
</tr>
<tr>
<td><strong>Material</strong></td>
<td>$80,177</td>
<td>$59,500</td>
<td>$87,800</td>
<td>$79,477</td>
</tr>
<tr>
<td><strong>Est. Cost/Sq ft</strong></td>
<td>$120/sq ft</td>
<td>$99.32/sq ft</td>
<td><strong>$97.94/sq ft</strong></td>
<td>$117.30/sq ft</td>
</tr>
<tr>
<td><strong>Time to Construct One Home</strong></td>
<td>4-8 months</td>
<td>3-6 months</td>
<td><strong>4-6 weeks</strong></td>
<td>5-10 months</td>
</tr>
</tbody>
</table>

- According to cost analysis, the lowest cost is Pre-fab Modular Housing
- Approximate cost for total construction is $3,525,696
Modular Housing
Advantages/Disadvantages

**ADVANTAGES**

• One-third of the construction time as traditional
• Higher quality than traditional – built in factories using quality standards (e.g. Six Sigma)
• Uses 2x6 framing (also used in Advanced Framing) allows for additional insulation space
• Tighter air sealing since all areas of wall can be accessed in factory setting
• Less material waste than traditional; waste is recycled
• Less risk of cost overrun

**DISADVANTAGES**

• Less customizable than traditional construction
• Negative stigma about pre-fab housing implies poor quality (but is actually higher quality in reality)
Analysis: Power
Power Methods Considered

Wind Power

• Wind speed is a crucial element in projecting turbine performance
• Average wind speeds greater than 9 mph are required for small electric wind turbines
• Utility-scale wind power plants require minimum average wind speeds of 13 mph
• The windiest time in Welch is from November to April with average hourly wind speeds of 4.7 mph (at 32 Feet)

Solar Power

• Number of hours of sunlight is essential for solar panel performance
• Having at least 4 hours of typical peak sunlight is best for solar panels
• Welch has an average of 11.5 hours of sunlight per day
• Welch has 156 sunny days per year

Utility Power (baseline)

• Energy produced in coal-fired power plants
• 1 pound of coal can roughly produce 10kWh
• Welch electric rate is 9.71¢/kWh, which is 18.27% less than the national average
Current Grid Power Rates

• Residential electricity rates in West Virginia average 9.85¢/kWh, and 17.09% less than the national average residential rate of 11.88¢/kWh

• Residential electricity consumption in West Virginia averages 1,078 kWh/month

• Residential Electricity Bills in Welch, WV
  • The residential electricity rate in Welch is 9.71¢/kWh, making Welch’s rate 1.42% less than the West Virginia average rate
  • Welch is 18.27% less than the national average rate of 11.88¢/kWh
  • The average bill is 1,078 kWh x $0.0971 kWh = $104
Wind Power – Cost and Installation

• A 10 kW wind turbine costs approximately $40,000 (GridTek System)

• Installation $8,000 – $25,000 depending on the location to install

• (-) Federal tax credit: 18% with no maximum - Final cost after tax credits: $39,360

• Estimated energy savings per year: $104 * 12= $1,248

• Time to recover costs: $39,360/1,248 = 31 years, 5 month

• Wind Turbine life expectancy: 20 -25 years *(not including the battery life)

CONCLUSION: Wind power is not an option for Welch due to the lack of wind and the return on investment
Solar Power - Cost and Installation

- Residential 5 kW system
- Estimated system cost: $20,950
- (-) Federal tax credit: 30% with no maximum – Final cost after tax credits: $14,665
- Estimated energy savings per year: $767
- Time to recover costs: $14,665/767 = 19 years, 1 month
- Solar Panel life expectancy: 20-25 years *(not including the battery life)
- 25-year savings: $4,602
Solar Advantages and Disadvantages

• Pros
  • 30% federal tax incentive extended to 2019
  • Rising electricity costs (+11% in the last 5 years)
  • Higher-than-average electricity usage (1107 kWh per month) means more opportunities for savings
  • The National Renewable Energy Laboratory (NREL) degradation rates for solar panels have dropped to 4%
  • That means that a panel manufactured today should produce 92% of its original power after 20 years

• Cons
  • Low grid electricity costs ($.10 per kWh) make solar less attractive
  • Very poor state financial incentives (WV ranks #48 out of 50)
  • Moderate sunshine (3.1% below national average)
Analysis: Broadband
Broadband Availability in Welch

• Majority of survey respondents marked broadband access as “essential” (>90%)
  • Most indicated need for 50 Mbps or greater

• For a new community, only wired broadband options were considered
  • Due to terrain in Welch, wireless broadband is inconsistent and highly dependent on location

• According to the FCC, only two wired broadband providers exist in Welch
  • Frontier Communications, DSL provider (up to 25 Mbps)
  • Shentel, cable and fiber provider (up to 150 Mbps with fiber available)
Broadband Availability at 13-Acre Site

- FCC Provider coverage map indicates Shentel fiber service is available at 13-acre site
- Frontier DSL service available to immediate surrounding area
- Despite few options, fiber service is preferable
  - Most future-proof technology available
  - Highest speeds and reliability
Broadband Costs

• Shentel fiber provides consistently fast and reliable service up to 150 Mbps

• However, monthly consumer cost is significantly higher than many other rural fiber providers

  • Shentel’s 50 Mbps costs $100/month (note: not the fastest option)

  • Rural fiber providers in Kentucky, Tennessee, North Carolina, and Vermont provide 50 Mbps (or better) for $50-65/month. Shentel is almost twice the price!

• Survey data indicates that our target groups are looking for 50 Mbps broadband and are willing to pay $50-70 per month

• Shentel broadband service may be cost prohibitive for the target markets, and especially for existing Welch residents
Recommendations & Future Work
Conclusions & Recommendations

• Consider pre-fab modular housing
  • Offers low cost and high quality
  • Affordability and quality were rated very highly in surveys
  • Future projects may consider other pre-fab techniques (panelized, pre-cut, etc)

• Additional research is needed to determine feasibility of alternative power source
  • Full-site option may be better than individual home power sources

• Investigate options for subsidizing broadband cost
  • High cost may make community less appealing
  • Subsidies and programs may be available through federal, state, and non-profit organizations
Future Work

• Research home orientation on lot, window placement, and placement of trees to maximize sun/shade for heating and cooling efficiency

• Investigate optimization of HVAC and appliances to maximize energy savings (high-efficiency options)

• Consider possibilities for recycling/reclamation of materials from abandoned/rehabilitated buildings in the area – potential for material cost savings

• Re-examine system dynamics model – consider other ways of gathering information from target markets
Acknowledgements

• Dr. Linton Wells, GMU Community Resilience Lab
• Craig Snow, Director of Warrior Creek Development
• Dr. Kathryn Laskey
• STAR-TIDES Network contributors
### Solar power savings by month in Welch

<table>
<thead>
<tr>
<th>Month</th>
<th>Available kW / m² / day</th>
<th>Max savings / month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>3.58</td>
<td>$50.07</td>
</tr>
<tr>
<td>Feb</td>
<td>4.05</td>
<td>$51.62</td>
</tr>
<tr>
<td>Mar</td>
<td>4.76</td>
<td>$66.61</td>
</tr>
<tr>
<td>Apr</td>
<td>5.03</td>
<td>$68.16</td>
</tr>
<tr>
<td>May</td>
<td>5.29</td>
<td>$73.99</td>
</tr>
<tr>
<td>Jun</td>
<td>5.34</td>
<td>$72.28</td>
</tr>
<tr>
<td>Jul</td>
<td>5.22</td>
<td>$72.99</td>
</tr>
<tr>
<td>Aug</td>
<td>5.49</td>
<td>$76.75</td>
</tr>
<tr>
<td>Sep</td>
<td>5.22</td>
<td>$70.70</td>
</tr>
<tr>
<td>Oct</td>
<td>4.57</td>
<td>$63.86</td>
</tr>
<tr>
<td>Nov</td>
<td>3.89</td>
<td>$52.65</td>
</tr>
<tr>
<td>Dec</td>
<td>3.38</td>
<td>$47.25</td>
</tr>
</tbody>
</table>