

## 5.8 Planetary Organization:

1. Comprises multiple continents with a council of Continental leaders that select a planetary leader amongst themselves.
2. Global Peacekeeping: Ensuring global peace and addressing conflicts with worldwide implications.
3. Global Environmental Initiatives: Addressing challenges like climate change, biodiversity loss, and ocean health.
4. Space Exploration: Coordinating efforts for satellites, space exploration, colonization, and interstellar relations.
5. Global Health Initiatives: Addressing pandemics and other health crises affecting humanity at large.
6. World Trade Regulation: Establishing and enforcing rules for global trade.
7. Cultural and Educational Exchange: Promoting global understanding and collaboration in education and culture.
8. Global Infrastructure Projects: Such as planet-wide communication satellites or transportation corridors.
9. Global Broadcasts: Planet-wide broadcasts coordinated with continental and union networks.
10. Human Rights and Welfare: Establishing and enforcing global standards for human rights, labor, and welfare.
11. Global Disaster Response: Directing and managing global disaster response efforts, especially those that affect multiple continents.
12. Planetary leader represents the planet at the inter-planetary level.

# Transition Plan to Sustainable Post-Fossil Energy

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December 14, 2023

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## 1 Foundation

The foundation is a basic right to land or some land-distribution scheme, where each person is able to have enough land to grow their own food and firewood. For simplicity we will assume this is an area with 6 months growing season, and at least 500mm annual rainfall, so 1 global hectare will suffice to meet all food and firewood needs for 1 person, or roughly 24Gj of energy per hectare be that food or firewood.

## 2 Family Level

A single person can't live sustainably on their own, as they may get sick or hurt, and will need care. So a family is a more logical unit. Using Superior Highly Composite Numbers (SHCN) we will assume a family or a team of 6 people, which could be parents, children, and grandparents, or some other combination of people.

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It is presumed that the bulk of residential buildings are made with local materials using manual labour, so are not included in energy/mineral requirements.

- daily energy usage might be:
- LED lighting: 0.5 kWh/day
  - Laptop: 0.2 kWh/day
  - Smartphone charging: 0.02 kWh/day
  - High-efficiency fridge: 1 kWh/day
  - Water pump: 0.375 kWh/day
  - Ventilation: 0.18 kWh/day
  - Desktop computer and monitor: 0.6 kWh/day
  - Total = 2.875 kWh/day

For a month, this would equate to roughly 86.25 kWh. Again, these are estimates and actual usage could vary. It's also important to note that desktops may not be used every day, or for the full duration estimated here, which would affect the overall energy consumption. Additionally, if the desktop is used for more intensive tasks, the energy consumption could be higher than estimated.

In summary, for a system designed to provide 3 kWh per day on average, you might consider:

- Solar Panels: Approximately 1.5 kW total capacity, likely more to account for winter months and inefficiencies.
- Batteries: Around 18 kWh of usable capacity, translating to 36 kWh of lead-acid batteries or less if using lithium-ion batteries.

It's crucial to get a local solar professional to conduct a detailed assessment, as they can provide the most accurate system sizing based on your specific location and needs.

Summary of Mineral Estimates:  
for the appliances

Metals and Other Elements:

- Gallium: 0.5 mg per LED chip (assuming a household uses around 10-20 chips) = 5-10 mg
- Rare Earth Elements: For LEDs, laptops, smartphones, and desktops combined = 22-33 grams
- Aluminum: For LED heat sinks, laptop casing, refrigerator, desktop casing = 2.5-3.5 kg

- Copper: For laptop, smartphone, fridge, water pump, ventilation, desktop = 3-5 kg
- Lithium: For laptop and smartphone batteries = 23-50 grams
- Gold: For smartphone and desktop circuitry = 0.234 grams
- Steel: For fridge, water pump, and ventilation system = 57-115 kg
- Refrigerant: For the fridge (specific type and quantity vary widely)

Approximate Totals:

- Gallium: 0.00001 grams
- Rare Earth Elements: 22-33 grams
- Aluminum: 2,500-3,500 grams
- Copper: 3,000-5,000 grams
- Lithium: 23-50 grams
- Gold: 0.234 grams
- Steel: 57,000-115,000 grams
- Refrigerant: Varies for wiring:
- Copper: 20-50 kg
- PVC (for insulation): This would depend on the gauge of the wire and the total length, but it could be about half the weight of the copper or less.

- Tin/Lead/Silver: These would be present in much smaller amounts, typically less than a kilogram in total for a small household.

To give you a very rough estimate for the entire solar panels + batteries + inverter setup:

- Silicon: 9 kilograms (1.5 kg x 6 panels)
- Aluminum: 60 kilograms (10 kg x 6 panels for frames, plus some for mounting structure)
- Glass: 60 kilograms (10 kg x 6 panels)
- Copper: Varies, but possibly up to 10 kilograms when considering wiring and inverter components
- Lead: 540 kilograms (15 kg x 36 kWh for lead-acid batteries)
- Or, for lithium-ion batteries:
  - Lithium: 5.4 to 9 kilograms (0.3-0.5 kg x 18 kWh)
  - Cobalt: 1.8 kilograms (0.1 kg x 18 kWh)
  - Nickel: 18 kilograms (1 kg x 18 kWh)
  - Graphite: 18 kilograms (1 kg x 18 kWh)

### 3 Community Level

A family can't really be sustainable on its own, and is best part of a group, which averages about 50-60 people for maximum social cohesion and economies of scale. Can have a building for gathering together, but it would be made from locally sourced materials. Can also have a bell for an audible announcement to the local area that there is an event or an important announcement. As well there would be 5-10Watt radio station to broadcast to the meetings and announcements. Otherwise the community could have fiber optic internet.

For a community church service including a desktop computer, projector, speakers, LED lights, a 10W FM transmitter, microphones, and a router for a local fiber optic network, here's an estimate of the minimum electricity requirements and the solar or wind setup needed to maintain it. We'll also consider the energy storage required for reliability through variable conditions.

In terms of transporation each community could have a horse, oxen or two, or equivalent beasts of burden, for use in the community, and possibly contributing to the village horse/oxen team - notably each bovine/equine needs about as much land per capita as a human. Otherwise residents could walk or bike.

#### 3.1 Electricity Requirements:

- LED Lighting: 0.5 kWh/day
- Laptop (for projector): 0.2 kWh/day
- Smartphone charging: 0.02 kWh/day
- High-efficiency fridge: 1 kWh/day

#### 5.6 Union (Around 367,567,200):

1. Comprises multiple countries, with country leaders being the council and selecting a union leader amongst themselves.
2. Regional Peacekeeping: Ensuring stability and peace within the union's member states.
3. Union Security Officer: Their role would be more about ensuring the stable and peaceful interactions between countries within the union. They might also be responsible for safeguarding union-specific institutions, assets, or events.
4. Trade and Commerce: Establishing a common market and potentially having a common currency.
5. Regulation Harmonization: Creating regional standards and regulations.
6. Joint Research and Development: Collaborative projects focusing on regional challenges in science, technology, and other fields.
7. Cultural Exchange: Promoting understanding and exchange between the cultures of member states.
8. Union Broadcasts: Union-wide broadcasts, including translations as needed.
9. Environmental Initiatives: Joint efforts to address regional environmental challenges.
10. Joint Infrastructure Projects: Such as regional railways, highways, or energy grids.
11. Dispute Resolution: Mediating conflicts or disputes between member countries.
12. The Union leader represents the union at the Planetary level.

#### 5.7 Continental (Around 6,983,776,800 or a continent/subcontinent)

1. Can comprise around 17 Unions, potentially spanning a continent with union leaders being the council and selecting a Continental leader amongst themselves.
2. Continental Peacekeeping: Overseeing large-scale peace initiatives and conflicts that span across unions.
3. Continental Trade Framework: Establishing guidelines for trade between unions, enhancing economic growth across the continent.
4. Continental Cultural Events: Organizing large-scale cultural events or festivals showcasing the diversity of the continent.
5. Continental Infrastructure Projects: Such as continent-spanning communication networks, transportation systems, or pipelines.
6. Continental Environmental Oversight: Strategies for large-scale environmental concerns affecting multiple unions.
7. Disaster Preparedness and Response: Coordinating responses to continental-wide natural disasters or other major emergencies.
8. The Continental leader represents the Continent at the Planetary level.

#### 5.4 Province/Oblast (Around 4,324,320):

1. Comprises as many as 6 counties, with a council of county leaders and select an Oblast leader from amongst themselves.
2. Legislation: Enacting laws specific to the oblast.
3. Provincial Enforcement Officer: This designation would handle provincial laws, regulations, and codes that are not covered by other law enforcement agencies. They might have specializations in areas like environmental enforcement, wildlife conservation, or transportation regulations.
4. Oblast AM Radio: in the 20-50kW range may suffice for public broadcasts but may need multiple stations, better propagation at night.
5. Oblast HF Radio: in the 20-100kW range may suffice for public broadcasts, 3-10MHz at night and 10-30MHz in the daytime.
6. Oblast Radio Network: Consisting of Oblast HF, AM and County Radio Networks can be co-ordinated together for oblast wide broadcasts such as oblast meetings.
7. Major Infrastructure: Highways, major transportation hubs like airports and train stations.
8. Land and Property: Maintaining a land distribution registry.
9. Policing: Handling minor offenses and maintaining oblast police forces.
10. The oblast leader represents the province at the country level.

#### 5.5 Country (Around 21,621,600):

1. Comprises as many as 5 oblasts with oblast leaders being the council and selecting a Country leader from amongst themselves.
2. Legislation: Enacting national laws and regulations.
3. National Peace Officer: A more comprehensive role that encompasses the enforcement of national laws and regulations. They would work in conjunction with other specialized enforcement divisions within the country, such as immigration or customs, and might also coordinate with defense forces or intelligence agencies on matters of national security.
4. Country HF Radio: in the 50-250kW range may suffice for public broadcasts, 3-10MHz at night and 10-30MHz in the daytime.
5. Country Radio Network: Country HF and Oblast radio networks can be co-ordinated together for country wide broadcasts such as country meetings.
6. International Relations: Managing foreign policy, international trade, and treaties.
7. National Defense: Maintaining the armed forces and ensuring national security.
8. Major Policing: Handling major offenses and potentially having a federal investigative agency.
9. Currency and Economy: Managing national fiscal and monetary policy.
10. The Country leader represents the province at the Union level.

- Water pump: 0.375 kWh/day
- Ventilation: 0.18 kWh/day
- Desktop computer and monitor: 0.6 kWh/day
- Projector: 0.3 kWh/day (assuming 4 hours of use at 75W)
- Speakers: 0.1 kWh/day (assuming low power usage for small gatherings)
- 10W FM transmitter and microphones: 0.528 kWh/day (accounting for 24-hour operation)
- Router: 0.05 kWh/day (assuming a small, energy-efficient router)
- Laser Printer: 0.5 kWh/day

#### 3.2 Total Daily Consumption:

The total daily energy consumption with the addition of a laser printer would be approximately 4.253 kWh/day. Revised Solar/Wind Setup:

- To meet a daily requirement of 4.253 kWh and assuming an average of 4 peak sun hours:
- Solar Panels: Increasing the capacity slightly, a total of around 1.1 kW of solar panels would be needed to comfortably meet this daily energy need, considering inefficiencies.
  - Battery Storage: To provide three days of autonomy (common for off-grid systems) with the increased demand, the battery storage would need to be around 12.759 kWh. To prevent deep discharge and account for inefficiencies, a total of around 17 kWh of battery storage would be recommended.

#### 3.3 Estimated Mineral Quantities

- Solar Panels (1 kW)
  - Silicon: Approx. 10-15 kg per kW of panels.
  - Silver: Around 20 grams per kW (0.02 kg/kW).
  - Aluminum (framing): Approx. 15-25 kg per kW.
- Battery Storage (15 kWh)
  - Lithium (for Lithium-ion): About 0.3 kg per kWh, so roughly 4.5 kg.
  - Cobalt: About 0.1 kg per kWh, so approximately 1.5 kg.
  - Nickel: About 0.4 kg per kWh, so around 6 kg.
- Electrical Devices
  - Copper (total for all devices): Roughly 1-5 kg (varies greatly based on device specifications).
  - Rare Earth Elements: Less than 1 kg (spread across various devices).
- Fiber Optic Network
  - Silica: Difficult to estimate without knowing the total length of cable. Typically, a fiber optic cable has about 1-2 kg of silica per kilometer.
  - Copper (network devices): Additional few kilograms, depending on the network scale.

#### 3.4 Total Mineral Quantities

- Silicon: 25-30 kg
- Silver: 0.02 kg
- Aluminum: 15-25 kg
- Lithium: 4.5 kg
- Cobalt: 1.5 kg

- Nickel: 6 kg
- Copper: 2-10 kg (broad estimate)
- Rare Earth Elements: <1 kg
- Silica (Fiber Optic): Varies with length, potentially several tens to hundreds of kilograms.

#### 4 Village (Around 360):

1. Council comprises 6 commune leaders and elect a village leader from amongst themselves.
2. Local Governance: Addressing immediate local concerns and providing basic public services.
3. Basic Infrastructure: Maintenance of local roads, public spaces.
4. Village FM/VHF Radio: in the 10W range may suffice for village broadcasts, especially of village meetings.
5. Village Radio Network: Can co-ordinate with commune UHF radios to repeat important public broadcasts such as village meetings.
6. Public Welfare: Establishing and maintaining communal facilities like granaries, for supporting member communes.
7. Postal Station: could have a basic post office for mail dropoff and pickup.
8. Transportation: maintenance of a village van for drop
9. Biogas facility: to make Bio-CNG for the local van, forge and-or kiln.
10. Education: Establishing and maintaining primary schools.
11. Cultural Activities: Organizing local festivals, events, and promoting local traditions and crafts.
12. The village leader represents the village at the next organizational level.

For a village of 360 people, creating a multi-purpose village building using local materials is a practical and sustainable approach. Here's a detailed analysis of the requirements and considerations for such a building:

##### 4.1 Village Building Design:

1. **\*\*Assembly Hall\*\***:
  - - Size: To accommodate 360 people, assuming about 1 square meter per person, a hall of at least 360 square meters is needed. Additional space for aisles, stages, or equipment might increase this requirement.
  - - Use: Meetings, cultural events, large gatherings.
2. **\*\*Classrooms (for a school)\*\***:
  - - Size: Each classroom for 20-30 students should be around 50-60 square meters. For the entire village, assuming children make up about 25% of the population, you would need about 4 to 6 classrooms.
  - - Use: Education, small group meetings, workshops.
3. **\*\*Council Meeting Room\*\***:

#### 5.2 City (Around 55,440):

1. Council comprises as many as 11 neighbourhoods and elects a Mayor from amongst themselves.
2. Urban Planning: Zoning, city development, and infrastructure planning.
3. Bylaw Enforcement Officer (BEO): known as a code enforcement officer in some places, they enforce municipal bylaws, including animal control, property standards, parking, and other local regulations.
4. City FM/VHF Radio: in the 1000W range may suffice for city wide broadcasts.
5. City Radio Network: can co-ordinate with neighbourhood radio networks.
6. Advanced Healthcare: Hospitals and specialized medical facilities.
7. Higher Education: Colleges, universities, and vocational training centers.
8. Utilities: Water supply, sewage, and larger energy projects like hydroelectric or thorium plants to facilitate industrial production.
9. Public Transport: Buses, trams, and other intra-city transportation. As well as railway access for inter-city transport.
10. The Mayor represents the city at the regional level.

#### 5.3 County/Graff/Raion (Around to 720,720):

1. Comprises as many as 13 cities with a council of 13 mayors and selecting a county leader from amongst themselves.
2. Regional Planning: Coordination between cities/towns within the region.
3. Public Safety Officer: Given the diverse environments within counties, officers with training in multiple response capabilities can help maintain public safety across different scenarios.
4. County AM Radio: AM Radio in the 10-20KW range may suffice for public broadcasts of county meetings, better propagation at night.
5. County Radio Network: Municipal FM radio stations can be co-ordinated together for county wide broadcasts such as county meetings.
6. Major Infrastructure: Maintaining transportation (like regional roads, bridges) and the energy grid.
7. Environmental Protection: Conservation efforts, regional parks, and waste management.
8. Regional Commerce: Promoting trade and commerce across the region.
9. The county leader represents the county at the provincial level.

#### 4.13.7 Bio-CNG Usage

Using biogas instead of charcoal for certain traditional processes is indeed a sustainable alternative that can conserve wood resources. Traditional charcoal making required 10x as much firewood as charcoal it produces, and led to a lot of deforestation. Let's focus on industries traditionally reliant on charcoal that could benefit from bio-CNG:

- A blacksmith forge uses 1-3m<sup>3</sup> of Bio-CNG per hour, depending on complexity from minutes to hours (min 1m<sup>2</sup>).
- Metal casting uses 2-5m<sup>3</sup> of bio-CNG per hour, and lasts 1-4 hours (min 2m<sup>2</sup>).
- Glass making uses 2-6m<sup>3</sup> of bio-CNG per hour, and lasts 2-6 hours (min 5m<sup>2</sup>).
- Wood chipper (small industrial machinery) uses 2-6m<sup>3</sup> of bio-CNG per hour, (min 2m<sup>3</sup>).
- Ceramic kiln uses 2-5 m<sup>3</sup> of Bio-CNG per hour, 8-12 for bisque, and 24 for glaze (min 16m<sup>2</sup>).
- Lime production uses 4-8m<sup>3</sup> of bio-CNG per hour, and lasts 8-24 hours (min 32m<sup>2</sup>).
- A CNG van uses 17.7m<sup>3</sup> of Bio-CNG per 100km, (32m<sup>2</sup> for full tank).

#### 4.13.8 Conclusion

The humanure biogas facility represents a sustainable approach to waste management and energy production for a community of 360 people. By efficiently converting human waste into bio-CNG and compost, the facility can significantly contribute to the community's energy needs while reducing environmental impact. With a dedicated team for operation and maintenance, and the right technical setup, this facility can be a model for sustainable living and energy independence.

## 5 Higher levels

### 5.1 Neighbourhood/Microrayon (Around 5,040):

1. Council comprises as many as 14 village leaders and elect a neighbourhood leader from amongst themselves.
2. Intermediate Governance: Addressing concerns of multiple villages or urban neighborhoods.
3. Community Service Officer (CSO): serve in a non-sworn (non-badge-carrying) capacity and assist with tasks like traffic control, minor accident reports, and other non-criminal calls for service.
4. Neighbourhood FM/VHF Radio: in the 100W range may suffice for neighbourhood broadcasts, such as neighbourhood meetings.
5. Neighbourhood Radio Network: Can co-ordinate with village radio networks;
6. Education: Establishing and maintaining secondary schools.
7. Healthcare: Running local clinics or health centers.
8. Markets: a neighborhood is typically large enough to support a farmers' market or similar local commerce centers.
9. The neighbourhood leader represents the neighbourhood at the city level.

- - Size: A smaller room, around 30-50 square meters, could be sufficient for council meetings.
- - Use: Administrative meetings, planning sessions.

### 4. \*\*Attached Granary\*\*:

- - Consideration: Climate-controlled storage, possibly utilizing underground design for thermal stability and pest control.
- - Use: Storing grains and perishable goods.

### 4.2 Heating and Cooling:

- **Passive Design**: Utilize natural ventilation, thermal mass, and orientation for passive heating and cooling.
- **Firewood with High Efficiency Furnaces**: Sustainable if sourced locally and managed responsibly.

### 4.3 Electronic Requirements:

#### 1. **Lighting**:

- - Consideration: Climate-controlled storage, possibly utilizing underground design for thermal stability and pest control.
- - LED lights are energy-efficient and have a long lifespan.
- - Solar panels could be an option for powering lights, supplemented by the local grid or generators.

#### 2. **Radio Transmitter**:

- - A low-power transmitter (10W) for village broadcasts.
- - Energy requirements are minimal and can be met through renewable sources or local grid.

#### 3. **Computers**:

- - Desktop computer for each council member and at least one server.
- - Energy-efficient models or laptops could be considered to reduce power consumption.

### 4.4 Gravel Roads Maintenance:

- - **Materials**: Gravel, sand, and possibly some binding agents.
- - **Maintenance**: Regular grading and compaction, which can be mostly manual but may benefit from occasional mechanical assistance.
- - **Tools**: Basic road maintenance tools like shovels, rakes, and a manual or motorized grader.

### 4.5 Internet Connectivity

Fiber Optic Network: High-speed and reliable internet connectivity is essential for modern communities. Connecting to community hubs will ensure efficient information flow and connectivity.

### 4.6 Renewable Energy Sources

Wind and Solar Power: A combination of these sources can provide a reliable and sustainable energy supply. The specifics will depend on local climate conditions and geographical features.

#### 4.7 Water Supply

Cistern or Well: Both are viable options. A cistern can collect and store rainwater, while a well provides access to groundwater. Water Pump: Essential for both options to ensure a steady water supply to the building. Solar-powered pumps can be an efficient choice.

#### 4.8 Sanitation

- Compost Toilets: These are sustainable and reduce water usage.
- System for Large Building: Investigate large-scale compost toilet systems that can handle the volume from a building of this size. These systems typically separate liquid and solid waste, reducing odor and facilitating composting.

#### 4.9 Village Transportation

For a village setting, especially one prioritizing sustainability, consider the following:

- Walking and Biking Paths: Encourage non-motorized transport for health and environmental benefits.
- Village Horse Team: which could consist of horses/oxen from each community within the village, and may come together for big projects.
- Community Vehicle: For village tasks like waste disposal, resupply and as an emergency vehicle could maintain a village van (likely Bio-CNG which uses 18m<sup>3</sup>/100km).

#### 4.10 Energy Summary

To create an energy usage summary for the described facilities and estimate the renewable energy (solar and wind) requirements and battery backup, let's break down the energy needs for each component and space:

Electronic Requirements

Lighting:

- LED Lights: Assuming an average of 10-20 watts per LED bulb.
- Number of Bulbs: For simplicity, let's assume 50 bulbs for the entire facility.
- Daily Usage: Assuming an average of 5 hours per day.

Radio Transmitter:

- Power Rating: 10 watts.

- Daily Usage: Assuming intermittent use, 2 hours per day.

Computers:

- Desktop Computers: Assuming 6 for council members and 1 server, each averaging 150 watts.
- Daily Usage: Assuming 8 hours per day for desktops and 24 hours for the server.

Village Building Design

The village building design includes an Assembly Hall, Classrooms, a Council Meeting Room, and an Attached Granary. The specific energy needs for these spaces will depend on their usage and equipment. Energy Consumption Calculation

The total daily energy consumption for lighting and electronics will be calculated. This will inform the requirements for solar-wind energy production and battery backup. Renewable Energy and Battery Backup

- Solar-Wind Energy: The total daily energy requirement will guide the capacity needed for solar panels and wind turbines.
- Battery Backup: The battery capacity should be sufficient to cover at least a few days of operation, factoring in potential days without sufficient sunlight or wind.

Estimated Daily Energy Consumption

- Lighting: 3.75 kWh

- Compressor Flow Rate: Let's assume a modest flow rate for a small to medium-sized compressor. Common flow rates can range from about 0.1 to 1.0 m<sup>3</sup>/min (or 3.5 to 35 CFM). We'll use an average value of 0.5 m<sup>3</sup>/min for this calculation.

- Total Volume to Compress: 80 m<sup>3</sup> per week.

Calculation

- Time to Compress 80 m<sup>3</sup>:  $\text{Total Volume to Compress} / \text{Compressor Flow Rate} = \text{Compressor Flow Rate} / \text{Total Volume to Compress}$ .

- Converting Time to Hours: Since we are using m<sup>3</sup>/min, the result will initially be in minutes. We'll need to convert this to hours for practical understanding.

Let's calculate the time it would take to compress 80 m<sup>3</sup> of air per week with our assumed flow rate.

It would take approximately 2.67 hours to compress 80 cubic meters of air per week with an air compressor having a flow rate of 0.5 cubic meters per minute.

This is a relatively short amount of time, suggesting that running the compressor for a few hours each week would be sufficient to meet the needs of the biogas facility. This time can be spread out over the week as needed, depending on the production rate of biogas and the storage capacity.

With the adjusted runtimes of 4 hours per week for each component (air compressor, refrigeration unit, and gas compressor) and using average power ratings, the daily energy consumption for the biogas facility is approximately 5.43 kWh. This leads to a total weekly energy consumption of about 38 kWh (136MJ), if using 35% efficient biogas-to-electricity generator would use 391MJ of Bio-CNG. 1.7GJ/391MJ yields an EROI of 4, not including human and animal power, though would leave 1.3GJ or 36m<sup>2</sup> of biogas, enough to fill the van and then some.

Monitoring

- Monitoring by Human Means: Manual monitoring can significantly reduce electrical consumption, relying on trained personnel for regular checks.
- Battery-Operated Sensors: For critical monitoring like fire and gas alarms, small, battery-operated sensors can be used. These devices typically have a low power requirement and can last a long time on battery power.

Stirring of Digestate

- Animal Power: Using animal power, such as a horse/oxen, to stir the digestate is a creative and sustainable solution. This method would significantly reduce electricity usage and can be quite effective.
- Implementation: A mechanism can be designed where a horse/oxen walks in a circle, turning a shaft connected to stirrers inside the digester. This kind of setup has historical precedents in agricultural machinery and would be well-suited for a community aiming for sustainability and reduced energy use.

Conclusion

With these adjustments, the biogas facility's energy requirements become much more manageable and sustainable, potentially allowing for the entire operation to be powered by the biogas produced on-site. The use of animal power for stirring the digestate further enhances the facility's sustainability profile. This setup makes the facility highly energy-efficient and in harmony with permaculture principles

#### 4.13.6 Sustainability and Safety

- Renewable Energy Source: The facility contributes to sustainability by converting waste into clean energy.
- Safety Measures: Proper ventilation, gas leak detectors, and emergency shutdown systems are essential for safe operation.
- Environmental Benefit: Reduction in greenhouse gas emissions and promotion of organic waste recycling.

### 4.13.3 Processes and Major Chambers

#### 1. Anaerobic Digestion Chamber:

- Function: Breakdown of organic waste in the absence of oxygen, producing raw biogas (a mixture of methane, carbon dioxide, and trace gases).
- Design: A sealed, oxygen-free tank equipped with temperature control and mixing systems.

#### 2. Biogas Purification System:

##### (a) Water Scrubbing Unit:

- Function: Removal of carbon dioxide and hydrogen sulfide from biogas.
- Components: Air compressor, scrubbing column, water circulation system.

##### (b) Dehumidification (Refrigeration) Unit:

- Function: Removal of water vapor from the scrubbed biogas.
- Components: Refrigeration unit, condensate trap.

#### 3. Biogas Compression System:

- Function: Compressing purified biogas to store as bio-CNG.
- Components: Gas compressor, high-pressure storage tanks.

### 4.13.4 Outputs

- Bio-CNG: A renewable energy source for cooking, heating, or transportation. 1kg organic waste produces 0.25m<sup>3</sup> biogas, or 0.15m<sup>3</sup> Bio-CNG (5.37MJ). 320kg of fecal matter could produce 48m<sup>3</sup> Bio-CNG (1.7GJ) per week, or for 1260kg of food waste can produce 189m<sup>3</sup> (6.7GJ) Bio-CNG. For a maximum combined total of 237m<sup>3</sup> of Bio-CNG or 8.4GJ.
- Agricultural Compost: Nutrient-rich digestate from the anaerobic digester, suitable for use as a soil conditioner. Can be mixed one part digestate to three parts wood chips to use as a top dressing fertilizer.

### 4.13.5 Maintenance and Manpower Requirements

- Staffing: The facility would ideally be managed by a small team of 2-3 trained personnel, responsible for daily operations, monitoring, and maintenance.
- Technical Expertise: Staff should be knowledgeable in mechanical systems, basic chemistry, and safety protocols related to biogas production.
- Electrical Components and Requirements:
  1. Air Compressor: Used in the water scrubbing process, requiring regular power supply.
  2. Refrigeration Unit: Essential for dehumidification, requiring a consistent power source.
  3. Gas Compressor: For compressing bio-CNG, also demanding a steady electrical supply.
  4. Monitoring Systems: For tracking the quality and flow of biogas, as well as the overall system performance.

To estimate how long it would take for an air compressor to compress 80 cubic meters (m<sup>3</sup>) of air in a week (from 320kg fecal matter), we need to consider the flow rate of the compressor, which is typically measured in cubic feet per minute (CFM) or cubic meters per minute. The flow rate can vary widely based on the size and model of the compressor. Assumptions

- Radio Transmitter: 0.02 kWh

- Desktop Computers: 7.2 kWh

- Server Computer: 3.6 kWh

Total Daily Energy Requirement

Total: 3.75+0.02+7.2+3.6=14.57 kWh/day 3.75+0.02+7.2+3.6=14.57 kWh/day

Renewable Energy and Battery Backup Requirements

- Solar-Wind Energy Capacity: To meet the daily demand of 14.57 kWh, a solar and/or wind system would need to supply this amount daily.
- Weekly Requirement: 14.57 kWh/day × 7 days = 102 kWh/week 14.57 kWh/day × 7 days = 102 kWh/week
- Battery Backup: For 3 days of autonomy, 14.57 kWh/day × 3 days = 43.71 kWh 14.57 kWh/day × 3 days = 43.71 kWh

This summary provides an overview of the energy needs for the village facility, focusing on electronic requirements and excluding climate control, and assists in planning for the necessary renewable energy infrastructure and battery backup capacity.

- Solar-Wind Energy: The total daily energy requirement will guide the capacity needed for solar panels and wind turbines.
- Battery Backup: The battery capacity should be sufficient to cover at least a few days of operation, factoring in potential days without sufficient sunlight or wind.

### 4.11 Mineral Requirements

To estimate the number of solar panels or wind turbines needed for a village facility with a daily energy consumption of 14.57 kWh, and to assess the mineral requirements for different types of batteries, we need to consider several factors:

Solar Panels

1. **Average Solar Panel Output**: A typical residential solar panel has a power output of around 250 to 400 watts under optimal conditions.
2. **Daily Energy Production**: Assuming an average of 5 peak sun hours per day, a 300-watt panel produces about 1.5 kWh per day.
3. **Total Panels Required**:

$$\begin{aligned} \text{Total Panels} &= \frac{\text{Daily Energy Consumption}}{\text{Energy Production per Panel per Day}} \\ &= \frac{34.57 \text{ kWh}}{1.5 \text{ kWh/panel/day}} \end{aligned}$$

4. **Total Solar Panels Required**: Approximately 10 panels.
5. **Solar Panels**: The actual number of panels required can vary based on factors like local sunlight availability, panel efficiency, and potential shading.
6. - This calculation is based on 300-watt solar panels with an average energy production of 1.5 kWh per day, assuming 5 peak sun hours.

Wind Turbines

1. **Average Wind Turbine Output**: Small wind turbines (suitable for a village setting) can range from 0.5 kW to 10 kW. Let's consider a 3 kW turbine.
2. **Daily Energy Production**: This varies widely based on location and wind speed. Assuming an average of 5 effective full-power hours per day, a 5 kW turbine would produce 25 kWh per day.

3. 3. **Total Turbines Required**:

$$\begin{aligned} \text{Total Turbines} &= \frac{\text{Daily Energy Consumption}}{\text{Energy Production per Turbine per Day}} \\ &= \frac{14.57 \text{ kWh}}{15 \text{ kWh/turbine/day}} \end{aligned}$$

4. - **Total Wind Turbines Required**: Approximately 1 turbine.

5. - This is calculated for a 3 kW turbine with an average of 5 effective full-power hours per day.

6. - **Wind Turbines**: The effectiveness of wind turbines depends heavily on local wind conditions. The number needed could vary significantly based on average wind speeds and consistency.

The facility would likely require a combination of 10 solar panels or at least 1 wind turbine to meet its energy needs, based on average conditions. The choice of battery type for backup storage will depend on factors like budget, space, lifespan, and environmental impact, with each type having different mineral requirements. This setup can provide a sustainable and reliable energy supply for the village's needs, aligning with environmental and self-sufficiency goals.

Calculating Battery Capacity Requirements

- **Battery Capacity for 3 Days**: 44 kWh
- **Each Battery Type's Capacity**: Will vary based on the specific battery technology and efficiency.

Iron-Phosphate (LiFePO4) Batteries

- Energy Density: Typically around 90-120 Wh/kg.
- Battery Weight for 43.71 kWh: Assuming an average energy density of 105 Wh/kg, the total battery weight would be:
- Battery Weight =  $\frac{\text{Total Capacity in kWh} \times 1000}{\text{Energy Density in Wh/kg}}$
- Mineral Content: LiFePO4 batteries contain lithium, iron, and phosphate. The proportion of these materials in the battery varies based on design, but typically includes about 2-7% lithium, with the rest being iron and phosphate.
- Estimated Weight: Approximately 417 kg
- Mineral Content: Contains about 2-7% lithium by weight, with the remainder being iron and phosphate.

Lead-Acid Batteries

- Energy Density: About 30-50 Wh/kg.
- Battery Weight for 43.71 kWh: Assuming an average energy density of 40 Wh/kg, the total battery weight would be:
- Mineral Content: Lead-acid batteries are primarily made up of lead and sulfuric acid. The lead constitutes a significant portion of the battery's weight.
- Estimated Weight: Approximately 1092 kg
- Mineral Content: Primarily composed of lead and sulfuric acid, with lead constituting a significant portion of the weight.

Lithium-Ion Batteries

- Energy Density: Ranges from 150-250 Wh/kg.
- Battery Weight for 43.71 kWh: Assuming an average energy density of 200 Wh/kg, the total battery weight would be:

- Mineral Content: Lithium-ion batteries contain lithium, cobalt, nickel, manganese, and graphite. The proportions vary, but lithium typically constitutes about 3-8
- Estimated Weight: Approximately 218 kg
- Mineral Content: Contains lithium (3-8% by weight), cobalt, nickel, manganese, and graphite. The exact proportions vary based on the specific battery chemistry.

Let's perform these calculations to estimate the battery weights and get a sense of the mineral requirements for each type. Estimated Battery Weights for 43.71 kWh Storage Capacity Iron-Phosphate (LiFePO4) Batteries

Conclusion

- Iron-Phosphate Batteries: Offer a balance between weight and safety, with a moderate weight compared to lithium-ion.
- Lead-Acid Batteries: The heaviest option due to lower energy density, but cheaper and well-established.
- Lithium-Ion Batteries: The lightest option with the highest energy density, but require a range of minerals, including cobalt and nickel, which can be more costly and have sourcing considerations.

These estimates provide a basis for understanding the trade-offs between different battery types in terms of weight and mineral composition. The choice of battery will depend on factors such as budget, space availability, environmental impact, and the sustainability of sourcing the required minerals.

#### 4.12 Waste Management

- Recycling Sorting: A local facility for sorting recyclable materials can reduce waste and support local circular economy initiatives. This can be done by human power.
- Transport to County Landfill: For non-recyclable and non-compostable waste, regular transport to a county-level facility will be necessary.
- Humanure and Organic Waste Processing: A facility to process humanure safely is crucial. This can turn waste into valuable compost for agricultural use, while also producing biogas.

#### 4.13 Humanure Biogas Facility

##### 4.13.1 Introduction

The proposed humanure biogas facility is designed to process organic waste, primarily human feces, from a community of 360 people. The facility converts this waste into valuable bio-CNG (Compressed Natural Gas) and agricultural compost, utilizing anaerobic digestion, gas purification, and compression technologies.

##### 4.13.2 Inputs

1. Human Feces: The primary input is the fecal matter from 360 people as it needs to be processed to avoid pathogens. Each person produces 0.125kg/day, or 0.896kg/week, per week 360 people produce 322kg. People could drop off their household fecal production (5.37kg) once a week at their community centre (church on Sunday), and the community horse/oxen and buggy could take it to the village processing centre once a week (Monday). Which would be a weekly buggy load of 54kg.
2. Additional Organic Waste: To optimize gas production, additional organic waste such as food scraps can be included. At up to 0.5kg/day could be up to 1260kg per week. Which for a community of 60 could be up to 210kg and would need multiple trips for a single horse/oxen buggy. Food waste would be optional to contribute as they are easy to compost on site, and many people have less food waste than 0.5kg/day, but is dependent on the village biogas requirements.