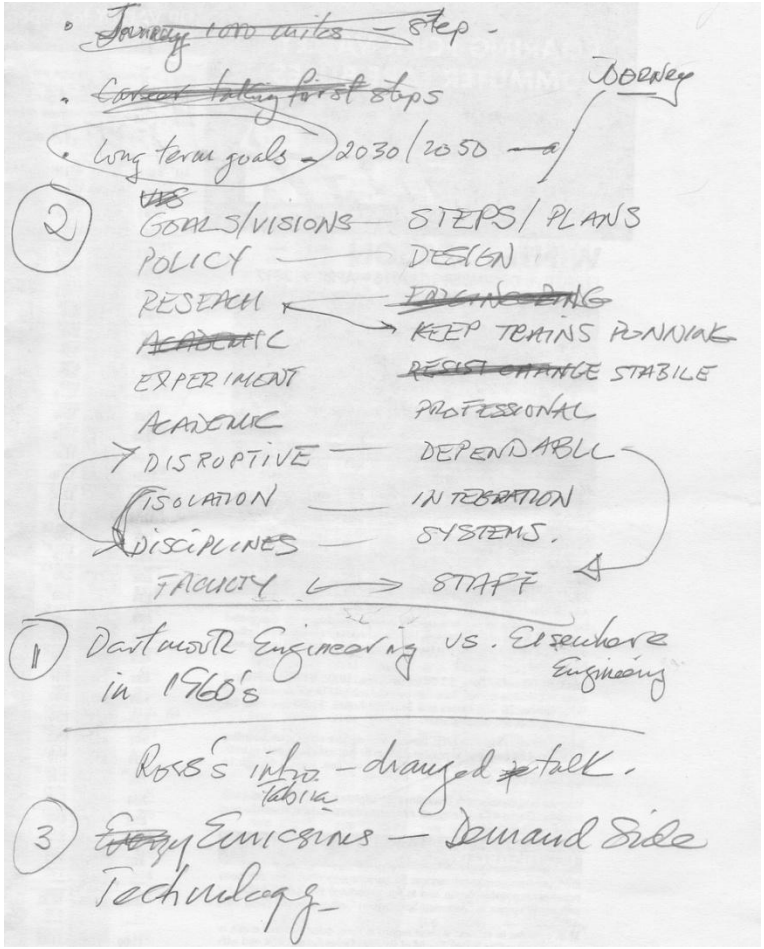
# Solar Photovoltaic (PV) Power Class of 1967 Bunkhouse Moosilauke Ravine Lodge

Background, Design Issues, Financial, Agreement with College, Schedule, Goals and Expectations

Class of 1967 50th Reunion

June 12, 2017

# Impromptu Response to Ross Virginia's Discussion of the Irving Institute




- Dartmouth engineering social compact perspective
- Contrasts between two engineer roles , in the context of Dartmouth's energy future
- Initial success with demand side efficiency, clean energy supply side will be harder

# Differing Roles and Responsibilities Making Dartmouth Green (Again)!

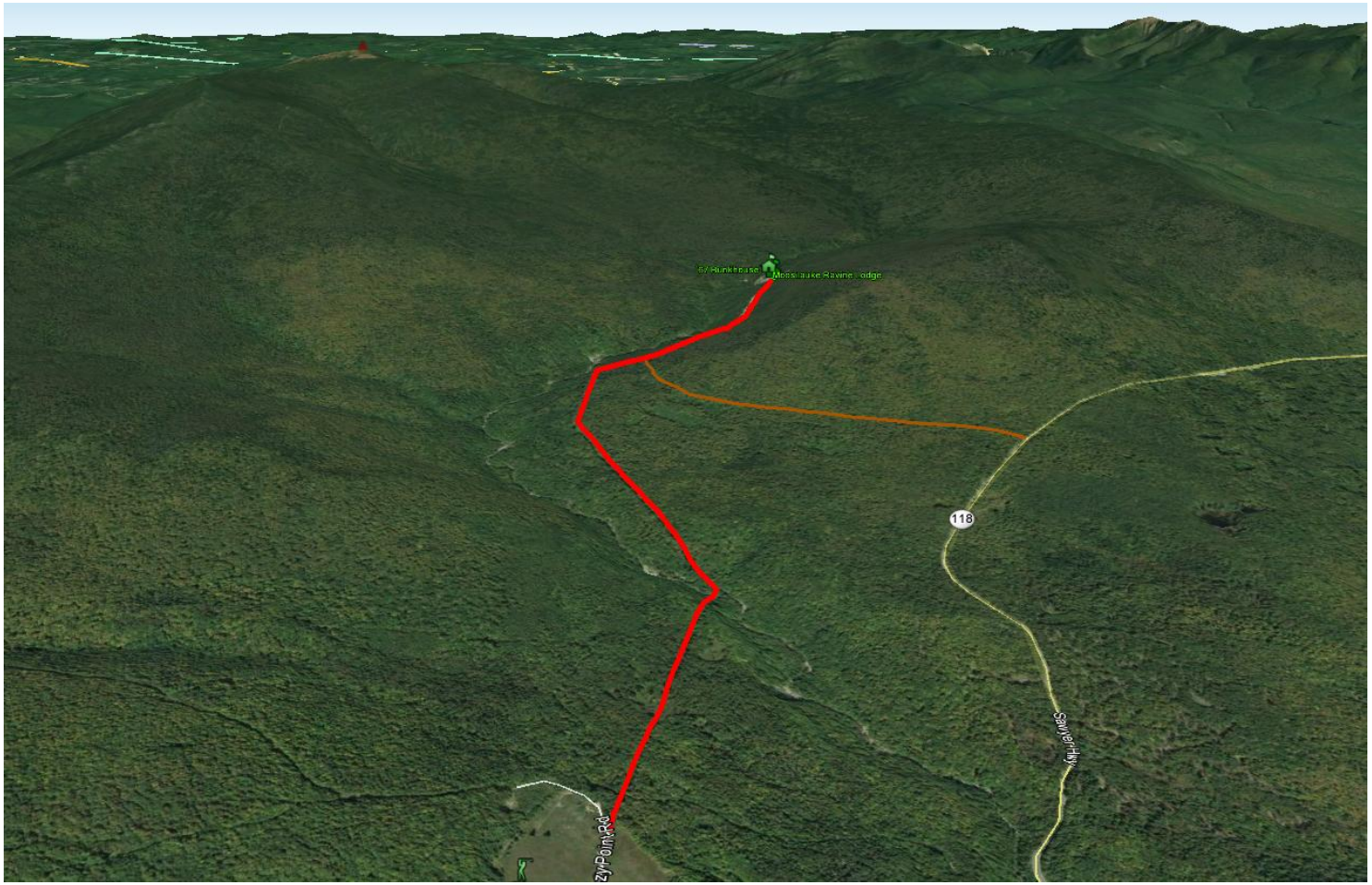
**Visions/Goals/Policy**

- Societal vision/distant goals
- Research
- Experimentation
- Academic
- Isolation (Ivory Towers)
- Disciplines (Publications)
- Disruptive
- Faculty (Students)

**Design/Planning/Process**

- First steps/long journeys
- Trains running/lights on
- Stability
- Professional
- Integration (Society)
- Systems (Infrastructure)
- Dependable
- Staff (Faculty and Leaders)

# Moosilauke 5000 Acre Wilderness
# First Steps to a “Green” Future



# Ravine Lodge: 9/26/16

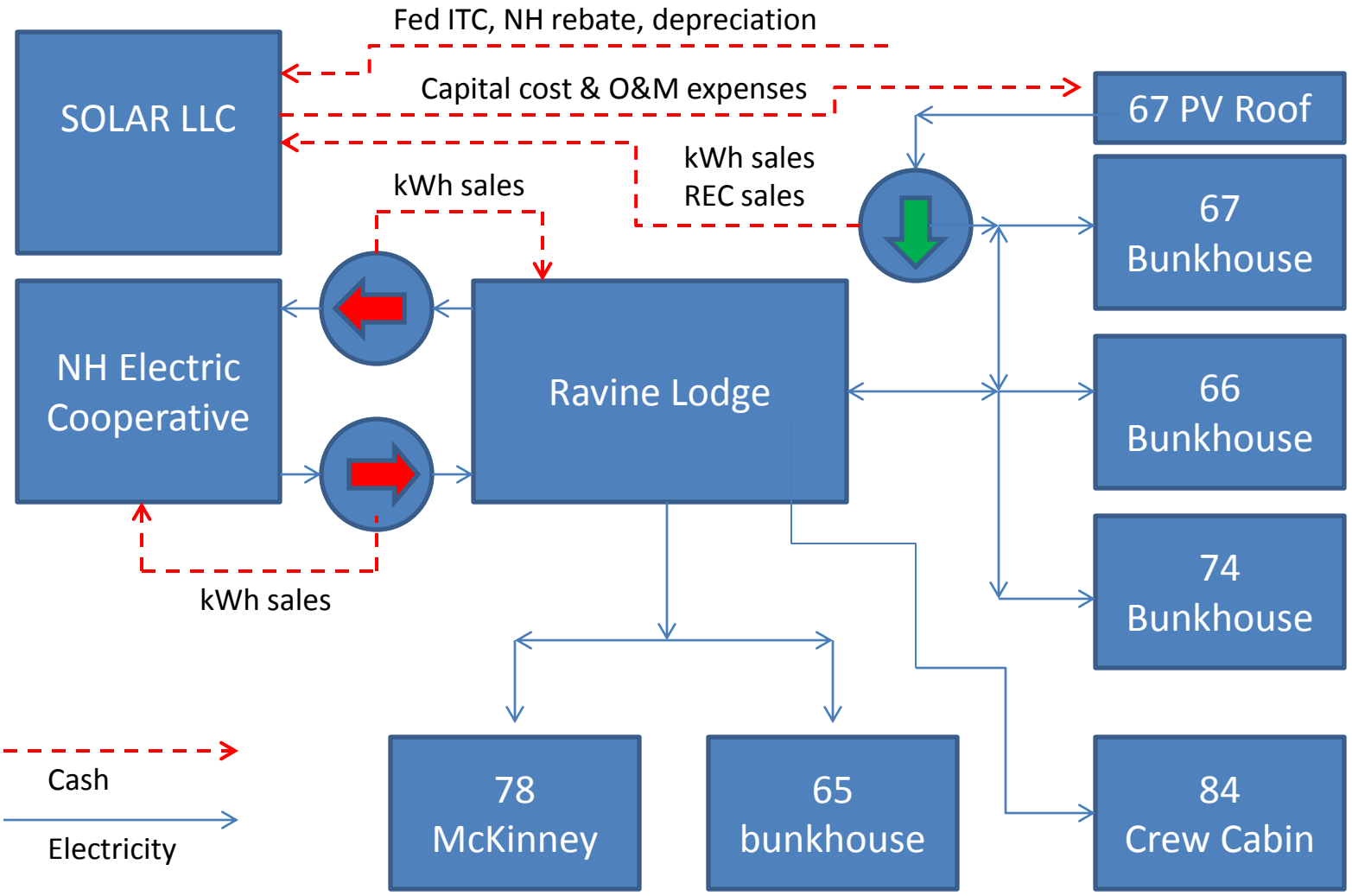
# `67 Bunkhouse: 9/26/16

# Ravine Lodge: 5/3/17

# `67 Bunkhouse: 5/18/67

# Electric System at Ravine Lodge

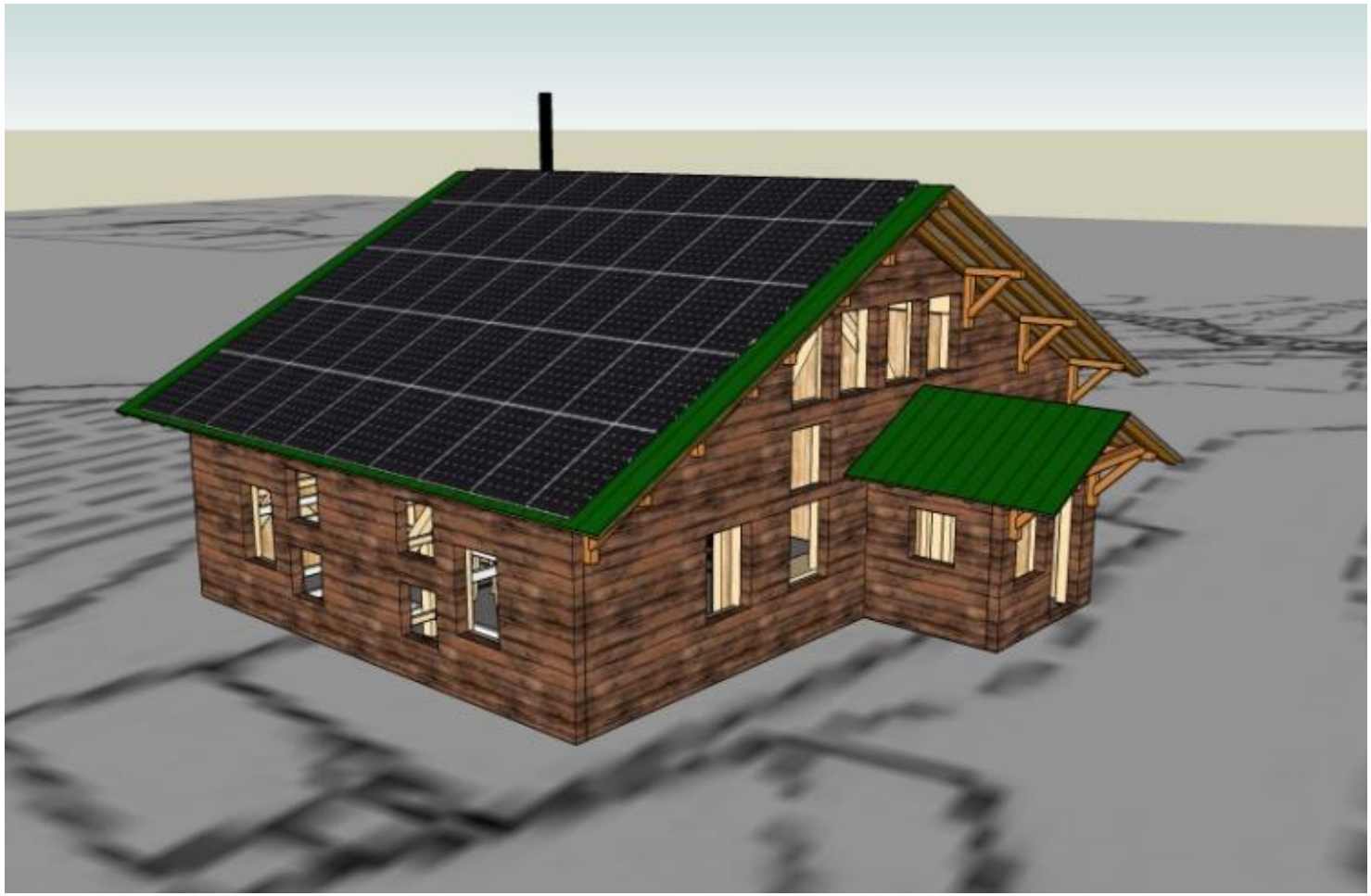
# Revenue and Electric Flows



# Moosilauke Electricity

- Currently rates are about $30 per month plus $0.12/kWh (for 400 kW service)
- Annual demand at the (old) Ravine Lodge was about 25,000 kWh annually
- Cost was approximately $4,000 annually

# `67 Bunkhouse: 10/5/17



# System Basics

- 45 SunPower Corp. AC modules (built-in inverters) and 25 year performance warranty
  - Highest efficiency commercially available
  - Five rows of nine modules fit roof perfectly
  - Aesthetic black frames, black cells, and black backing
- Five AC circuits combined in bunkhouse panel
- Dedicated “Solar Meter”
  - Metered and connected at main bunkhouse service
  - Excess serves all connected Ravine Lodge buildings

# Solar power production estimates

## RESULTS

Print Results

**20,491 kWh per Year ***

*System output may range from 19,538 to 21,397kWh per year near this location.*

*Click HERE for more information.*

| Month | Solar Radiation ( kWh / $m^2$ / day ) | AC Energy ( kWh ) | Energy Value ( $ ) |
|---|---|---|---|
| January | 3.12 | 1,284 | 161 |
| February | 3.97 | 1,482 | 185 |
| March | 4.65 | 1,882 | 235 |
| April | 5.28 | 1,990 | 249 |
| May | 5.76 | 2,178 | 272 |
| June | 5.95 | 2,138 | 267 |
| July | 6.05 | 2,234 | 279 |
| August | 5.69 | 2,102 | 263 |
| September | 4.81 | 1,748 | 219 |
| October | 3.66 | 1,425 | 178 |
| November | 2.71 | 1,052 | 131 |
| December | 2.36 | 975 | 122 |
| Annual | 4.50 | 20,490 | $ 2,561 |

# Modified solar production estimates

| Month | Solar Radiation ( kWh/ m^2 / m) | AC Generation ( kWh ) | Energy Value ( $ ) | Shade Loss (%) | Snow Loss (%) | AC Generation (kWh) | Electric Load (kWh) |
|---|---|---|---|---|---|---|---|
| January | 96.72 | 1,284 | $ 161.00 | 30% | 100% | - | 2,500 |
| February | 111.16 | 1,482 | $ 185.00 | 20% | 90% | 119 | 1,500 |
| March | 139.50 | 1,882 | $ 235.00 | 10% | 60% | 678 | 1,500 |
| April | 158.40 | 1,990 | $ 249.00 | 0% | 0% | 1,990 | 1,500 |
| May | 178.56 | 2,178 | $ 272.00 | 0% | 0% | 2,178 | 3,000 |
| June | 178.50 | 2,138 | $ 267.00 | 0% | 0% | 2,138 | 3,500 |
| July | 187.55 | 2,234 | $ 279.00 | 0% | 0% | 2,234 | 3,000 |
| August | 176.39 | 2,102 | $ 263.00 | 0% | 0% | 2,102 | 3,000 |
| September | 144.30 | 1,748 | $ 219.00 | 0% | 0% | 1,748 | 3,500 |
| October | 113.46 | 1,425 | $ 178.00 | 10% | 0% | 1,283 | 3,000 |
| November | 84.01 | 1,052 | $ 131.00 | 20% | 30% | 589 | 1,000 |
| December | 73.16 | 975 | $ 122.00 | 30% | 80% | 137 | 2,500 |
| Annual | 1,641.71 | 20,490 | $ 2,561.00 | | | 15,194 | 29,500 |
| | | | | Loss from snow/shade | | 26% | |
| | | | | Percent of load supplied from solar | | | 52% |

# Ownership

| Ownership | Electricity | Renewable Energy Credits | Federal Investment Tax Credit | NH Solar Rebate | Accelerated Depreciation |
|---|---|---|---|---|---|
| Dartmouth | Reduced operating expense | ~$0.04/kWh Foregone to retain green attribute | No benefit | $750 / kW | No benefit |
| Solar LLC PPA with College with buyout after six years | Purchased at regular rate until buyout | ~$0.04/kWh | 30% effective rebate via reduced taxes (six year holding required) | $750 / kW | 85% of cost accelerated depreciation over five years |

# College Ownership Considerations

- For Dartmouth investment must beat Endowment portfolio opportunity cost (pegged around 8%)
- Third party private investor ownership
  - Reduced energy cost savings; reduced control; reduced educational opportunity, reduced symbolic benefit
- Alumni ownership; transfer to Dartmouth
  - Engages alumni with College advancement
  - Builds Dartmouth staff expertise with green power
  - Displays environmental leadership and stewardship, enhances symbolic benefits
  - Retains control; retains investment return

# Steps to Completion

- Signed agreement with College: 6/8/2017
  - Done, $18K with final payment upon operation
  - Retires RECs, 2023 buyout,
- Power Purchase Agreement (PPA) with ReVision Energy
  - Should be signed in June 2017
- Installation and commissioning of panels
  - Preinstalled conduit, switches, junction boxes
  - One or two day installation summer 2017
  - Up and running by Dartmouth Night (10/5/17)

# Significance

- Established College policy for PPAs
- Clean power at breakeven cost for six years
- Alumni sponsored no-cost power for ~30 years
- Grows Dartmouth facilities staff experience
- Supports Education mission
  - Student awareness of solar infrastructure
  - Academic system supply and demand studies
  - Design of additional clean energy supply

# Journey's End: Thank You!