RUTGERS

Office of the President

TASK FORCE ON CARBON NEUTRALITY
AND CLIMATE RESILIENCE

# Climate Action Plan
# Supplemental Report

*Report of Working Group on Buildings and Energy*

2021

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# 1. Rutgers’ current baseline

Table 1.1: Total Greenhouse Gas Emissions (Metric Tons Carbon Dioxide Equivalent)

| **Source** | **Greenhouse Gas Metric Tons Carbon Dioxide Equivalent** |
|---|---|
| Co-gen Electricity | 43,055.56 |
| Co-gen Steam | 67,033.30 |
| Other On-Campus Stationary | 105,526.32 |
| Purchased Electricity | 136,907.30 |
| T&D Losses | 7,026.83 |
| Total GHG tonnes $CO_2e$ | 359,549.31 |

## 1.1. Rutgers’ greenhouse gas emissions in buildings and energy

Rutgers’ baseline greenhouse gas emissions associated with the building sector total 359,541 tonnes CO2e. A majority comes from purchased electricity. Also important are the electricity and heat produced through cogeneration fueled by natural gas at the Busch/Livingston campus and the Newark RBHS campus. Almost every campus has some amount of central heating and cooling production using natural gas that serves multi-building networks. The Livingston campus hosts just under 10 MW of solar electric capacity

## 1.2. Ongoing activities to reduce emissions and vulnerabilities

Currently the university is focused on reducing energy consumption in its buildings with 200 KW demand or less. This is being done with support from the PSEGS Direct Install Program. Contractors will perform energy audits of the buildings and will come up with customized solutions for each building. PSEG will cover 70% of the construction cost along with the free audits. There after the university will formulate a plan to audit the larger buildings. It will be looking at energy usage and cost along with building age and size to determine priority. The University will also Auditing one hundred eight buildings under PSEGs Engineered Solutions Program. The emphasis will be on lab buildings, research buildings and larger facilities.

## 1.3. Related ongoing educational, research, and service activities

There is various research going on throughout the University related to Carbon reduction.

# 2. Overview of potential climate solutions

## 2.1. Potential solutions

Table 2.1: Potential Mitigation Options

| **Greenhouse Gas Emissions Category** | **Specific Options for Mitigation** |
|---|---|
| Production Source: Thermal Energy | Small-scale carbon capture and sequestration |
| | Purchase offsets |
| | Purchase of Biogas |
| | Transition to geothermal energy |
| | Electrification of heating |
| Production Source: Electricity | Purchase of renewable energy credits or offsets |
| | University built and owned solar |
| | Power purchasing agreement for solar onsite |
| | Power purchasing agreement for solar offsite |
| | Power purchasing agreement for wind offsite |
| Consumption Reduction: Existing Buildings | Electrical efficiency upgrades |
| | Mechanical efficiency upgrades |
| | Envelope efficiency upgrades |
| | Behavioral energy conservation measures |
| Consumption Reduction: New Buildings | New construction standards like Above ASHRAE 90.1, a specific energy intensity, or alternative standard |

On the supply side of the energy equation, while looking at renewable energy, the university will also look at methods for degasification, that is, removing carbon from flue gasses. The goal is to compare the relative cost-effectiveness of (a) substituting non-fossil fuels for fossil fuels, (b) capturing and storing carbon as it is emitted, and (c) sequestering carbon independently in order to offset continued emissions. We cannot be 100% carbon neutral if we cannot account for our fossil fuel usage through sequestration or elimination using some other type of energy. A Request for Information will go out to various consultants to find which are best suited. The next step will be to send out a request for proposals to the consultants that are qualified and choose one to help formulate a reduction plan for natural gas.

## 2.3. Early opportunities for action

See 1.3

## 2.4. Cross-cutting issues arising in the exploration of potential solutions

The principal institutional barrier to implementation is capital availability and the identification of suitable partnership models.

# 3. Assessments of potential climate solutions

## 3.1. Energy Supply: Expanding On-Campus Solar Generation and Purchasing Off-Campus Solar or Wind Energy

Rutgers has nearly a decade of experience in operating solar generation facilities on campus, including building what was at the time of its construction in 2013 the largest campus solar facility in the nation. Rutgers' solar facilities are on Livingston campus and include a 1.4 MW solar array with 7,993 solar panels and 8 MW of solar parking lot canopies, composed of about 33,000 solar panels. Based on this experience, a natural opportunity for decarbonizing the campus electricity supply is to displace grid electricity (about 0.3 t $CO_2$/kWh) with more on-campus solar production.

Over the last decade, solar prices have dropped considerably; according to the National Renewable Energy Lab, for a 200 kW commercial system, installed system costs dropped from $5.43/W in 2010 to $1.83/W in 2018.[3] Based on the average capacity factor for Rutgers' existing installations, a 1 kW solar installation would produce about 1.1 MWh of electricity over the course of a year. Over the course of 20 years, such a system would produce about 22 MWh of electricity and avoid about 7 tonnes of carbon dioxide emissions, at an initial cost of $1830.

The costs of such a system are offset both by avoided grid electricity purchases and state subsidies. Assuming an avoided cost of $90/MWh in grid electricity purchases, the aforementioned 1 kW system would avoid $1,980 of expenditures over the course of 20 years, for a net benefit of $150, and would break even in 20 years. Currently, New Jersey Transition Renewable Energy Credits (TRECs) provide an additional subsidy of $152/MWh for 15 years for rooftop and carport systems. Factoring this in increases the 20-year net benefit of a 1 kW system to $2,430 and reduces the payback period to 7 years. While this calculation does not account for the cost of capital, factoring in this cost at either the 4.75% rate currently used by the Rutgers internal bank or the 3.92% rate of Rutgers' 2019 century-bond offering does not eliminate the substantial net present benefit.

| **Total Generation (20 y, MWh) per kW** | 22 | 22 | 22 |
|---|---|---|---|
| **Avoided Emissions (20 y, t $CO_2$) per kW** | 7 | 7 | 7 |
| | | | |
| **Discount Rate** | **0%** | **3.92%** | **4.75%** |
| Initial Cost per kW | ($1830) | ($1830) | ($1830) |
| NPV Avoided Cost (20 y) per kW | $1,980 | $1,390 | $1,300 |
| NPV TREC (15 y) per kW | $2,280 | $1,750 | $1,660 |
| **Total NPV per kW** | $2,430 | $1,310 | $1,120 |

Solar electricity generation comparable to current grid electricity purchases would require about 380 MW installed, covering an area about 1400 acres, for an initial cost of about $700 M and a net present benefit of about $450 M. This is not to suggest that such expansive solar investments are a viable option; rather, they suggest that expanding solar generation on Rutgers land has the potential to be a key climate solution, and that scalability is limited primarily by available rooftop/carport area and the availability of capital.

Further analysis is needed to determine the practical on-campus potential, but the ability to accommodate large-scale solar investment within the university's debt capacity constraint is likely to limit Rutgers' ability to

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[3] https://www.nrel.gov/analysis/solar-installed-system-cost.html

debt finance a large-scale expansion of on-campus solar power. Third-party financing will therefore likely be necessary.[4]

Two alternative financing vehicles are available to overcome this limitation. In an operating lease, the University would lease and operates the solar equipment from a private builder for part of the equipment's operating life (typically 7-10 years) and subsequently purchases the equipment at fair market value. The University would bear the risks associated with system maintenance and, depending on the terms, receive subsidies under the New Jersey TREC policy. In a purchase power agreement (PPA), a third party owns and operates the solar equipment, bearing the risks associated with system maintenance and receiving state subsidies. Purchase power agreements can also be used to procure electricity generated off of University grounds. Given the rapid emergence of the off-shore wind energy industry in New Jersey, off-shore wind energy PPAs should be considered as potential options as well as solar PPAs.

## 3.2. Energy Supply: Participating in Purchase Power Agreements

Power Purchase Agreements (PPAs) are financial agreements between developers of renewable energy supplier and customers. Through a PPA, an entity such as Rutgers would enter into a legal contract with a generator of renewable electricity (in our geographic location this would likely be a solar or wind farm) for the power output or a portion of power output, for a dedicated period of time (can be anywhere from 5-20 years). This contract to purchase electricity would replace power purchased from the grid to help reduce emissions associated with electricity use.

The PPA can be for a project 1) on University property itself (onsite PPA), whereby the developer assumes responsibility for all construction and maintenance of the system, 2) within the same grid as the entity (for Rutgers, a project could be somewhere within PJM), or 3) can be located elsewhere in the US, what is known as a virtual or financial PPA. Note, the reputational benefits may be stronger for a PPA that is on-site or within the same electrical grid as Rutgers, but from a GHG accounting perspective all 3 are accepted methods to reduce GHG emissions as long as Renewable Energy Credits (RECs) are included in the PPA and retired in the name of the university.

PPAs are widely used by Universities. Harvard was among the first to enter into such a contract, entering into an agreement with the Stetson II wind project in Maine.[5] Georgetown University is similarly using a PPA with Origis Energy to procure solar energy to cover about half of campus electricity.[6] The University of Michigan has entered into a PPA with DTE to procure off-campus renewable energy, produced in Michigan, to cover about half the consumption of its Ann Arbor campus.[7]

Compared to Rutgers-owned and -operated renewable energy generation, PPAs may be able to cover a larger percentage of electric power load than on-site generation, due to fewer siting constraints, and could be implemented more quickly. The generating compare would bear some of the risk that would be borne by Rutgers for on-site generation, and Rutgers would not be exposed to depreciation or maintenance costs. However, these benefits would come at an increased present-value cost to Rutgers compared to full ownership.

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[4] https://betterbuildingssolutioncenter.energy.gov/financing-navigator/primer/higher-education-energy-financing-primer

[5] https://green.harvard.edu/topics/climate-energy/site-emissions-reduction

[6] https://www.georgetown.edu/news/new-off-site-solar-project-to-provide-nearly-half-of-georgetowns-electricity-needs/

[7] https://record.umich.edu/articles/u-m-cut-emissions-through-renewable-energy-purchase-dte-energy/

#### *3.2.1. Emissions reductions and resilience improvements*

Determining the potential emissions reduction from expanded solar generation requires further analysis of the solar potential of Rutgers property, particularly the rooftop and carport areas that are most heavily subsidized under the New Jersey TREC policy. A solar energy system large enough to cover all of Rutgers' grid electricity purchases would reduce annual emissions by about 137,000 tonnes.

When combined with battery storage or the backup gas generation capacity, such as that provided by the co-gen facilities, solar photovoltaic facilities can help power an islanded microgrid, maintaining an electric power supply when grid electricity is no longer available.

#### *3.2.2. Financial costs and savings*

As indicated above, when factoring in both avoided electricity costs and state subsidies, a typical, directly owned solar photovoltaic system has a payback period of about 7 years and offers a significant net-present benefit at current interest rates. Procuring a large enough solar system to cover all the electricity Rutgers currently purchases from the grid would have an initial cost of about $700M and generate about $100M/yr in avoid electricity purchases and TRECs.

For a purchasing power agreement, typical rates are about $3-$5/MWh on top of current electricity rates. Thus, a PPA large enough to cover all campus grid electricity purchases would cost about $2-$3M/yr, a cost for avoided $CO_2$ emissions of about $20/tonne. If Rutgers makes a large PPA, it may wish to explore partnership arrangements in which it is a partial owner of the plant operator and thus recovers some of the added net-present cost of the PPA compared to direct ownership. It may also wish to explore cooperative ownership arrangements (e.g., entering into a partnership where multiple educational institutions own a company that operates solar facilities), to similar effect and with additional co-benefits for equitable economic development.

#### *3.2.3. Benefits to the University's educational and research mission and to campus culture*

On-campus solar photovoltaic systems are highly visible, charismatic climate solutions, and can also be integrated into educational projects using the campus as a living lab. If the University is not the direct owner of new renewable energy facilities, it should attempt to maintain the educational benefits of ownership in its partnership agreement. If the University enters into an off-shore wind PPA, it may wish to do so as part of a broader off-shore wind industry partnership with defined educational and research objectives.

#### *3.2.4. Implementation Timescale*

The 32-acre solar canopy on Livingston Campus was approved by the Board of Governors in April 2011 and was completed three years later, in March 2014. Given adequate capital availability, it should be possible to go from approval to completion in a shorter time period.

A power purchase agreement could be implemented over the course of 6 months to 1 year. The time involved would include potentially identifying a consultant to identify opportunities and help negotiate a contract. The review by internal stakeholders (Facilities, Legal, etc.), and approval by these groups could also take several months.

Timing is also dependent on whether the generating project (i.e. the solar or wind farm) is already existing, under construction, or has not yet begun construction. If Rutgers is interested in pursuing an on-site PPA for solar built on Rutgers property, the timeframe would be longer as the developer would need to work with the University to obtain the required permitting and approvals to build the project.

### 3.2.5. Needed research and planning

The next available analysis needed to expand solar generation on campus is a survey to identify areas suitable for solar deployment. Given the structure of TREC subsidies, priority should be given to rooftops and carports, particularly those associated with structures expected to have a remaining lifetime of at least 30 years.

In addition, more through exploration is needed of the trade-offs of different financing schemes and how other Universities successfully executed PPAs – steps taken, solicitation process, stakeholders involved, etc. A consultant may be necessary to help facilitate the PPA, identify project opportunities, and provide market expertise. Financial and legal research is needed to explore viable partnership models that would allow the University to recover some of the incremental net-present cost of a PPA relative to direct ownership.

### 3.2.6. Management roles

Facilities (Institutional Planning and Operation) is the lead office for implementation. The Board of Governors must approve projects. Treasury must be involved in the provision of capital Both Treasury and the General Counsel must be involved in the exploration of partnership models. The University's academic units can leverage for educational and research activities as part of living-lab efforts.

### 3.2.7. Institutional, Organizational and Cultural Challenges to Implementation

The principal institutional barrier to implementation is capital availability and the identification of suitable partnership models.

### 3.2.8. Contribution to Climate-Positive, Equitable, Sustainable Economic Development

Large-scale solar construction would create short-term construction jobs and contribute to overall state goals for grid decarbonization. Consistent with state goals, Rutgers could work with the Supplier Diversity Development Council to increase opportunities for minority-, woman- and veteran-owned businesses. In some areas, it may be appropriate to pursue community solar projects, allowing residents in neighboring communities to purchase power from solar projects, with state subsidies for low- to moderate-income households. Cooperative ownership of a plant operator with multiple educational institutions could also facilitate equitable economic development.

### 3.2.9. Equity Concerns

While direct ownership of a solar system will lead to long-term cost reductions, a PPA may raise utility costs. Care should be taken to ensure these costs are minimized and not passed onto students.

## 3.3. Energy Supply: Transitioning Away From Fossil Natural Gas

Fossil natural gas is a key part of the current campus energy system, powering both the co-generation facilities in New Brunswick and Newark and central heat plants on most campuses (see Appendix A). Combustion of fossil natural gas is responsible for about 215,000 tonnes of annual $CO_2$ emissions, nearly half of the total Rutgers emissions inventory.

As the ongoing co-generation plant upgrades have a planned lifetime of 35 years, achieving any carbon neutrality target before 2055 without offsets will require either early retirement of these facilities or substitution of renewable alternatives to fossil natural gas. This challenge is common to large universities, and a recent University of California (UC) study assessed alternative solutions.[8] This study identified three

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[8] Alan Meier et al., "University of California Strategies for Decarbonization: Replacing Natural Gas," 2018, https://doi.org/10.17605/OSF.IO/HNPUJ.

core solutions: (1) reducing energy demand through investments in deep energy efficiency, (2) replacing fossil natural gas with renewable biogas or hydrogen, and (3) electrifying end uses and employing carbon-free electricity sources. It also noted that small-scale carbon capture and storage might be a potential future solution, but does not currently exist in deployable form.

Deep energy efficiency investments are a core strategy for the buildings sector, and are addressed below. While further study is needed to determine the energy efficiency potential for Rutgers, the UC system estimated the potential for cost-effective retrofits to reduce natural gas consumption by 29% and electricity consumption by 39%. The UC study viewed biogas as an interim solution, with electrification being the ultimate option. The report recommended electrification should be made a standard for all buildings not connected to co-generation plants, and that electrification of existing buildings begin with those on the periphery of central heating loops.

The Rutgers New Jersey Agricultural Experiment Station (NJAES)'s Sustainable Energy Working Group[9] has substantial expertise on bioenergy, including biogas. In 2015, NJAES's Rutgers EcoComplex completed a revised assessment of biomass energy potential in New Jersey.[10] This study found that New Jersey has about 4.1 million dry tons of biomass potentially available for energy production, which could with appropriate technologies and infrastructure produce 650 MW of electric power.

UC has adopted an approach of funding pipeline-injected biogas projects, in which the university funds projects – located anywhere in the country – that inject biogas into a natural gas pipeline, and then draws out an equal volume of natural gas at another location. In general, the molecules withdrawn at the receiving location are not the same as those injected at the source, but the project investment leads to a reduction in the overall carbon intensity of the gas supply. They have found a premium of about \$4-\$5/MMBtu for pipeline-injected biogas over fossil natural gas; applying a comparable approach would cost Rutgers about \$16-\$20 M/year to fully offset its fossil natural gas consumption, at a cost of about \$75-\$90/t $CO_2$. However, such approaches, relying on "renewable natural gas credits" are not risk-free and should be approached carefully. As an example, California RNG credit buyers trusted a large project called "Heartland Biogas Project" in Colorado, but the project developers were not successful and could not inject promised amount of gas into the pipelines.

Currently, there is only one company in the state, Trenton Renewables, that generates biogas from Anaerobic Digestion (AD) of organic waste (food waste), but they are not injecting biogas into a pipeline. Also, a few wastewater treatment facilities are using AD technology and generate biogas, which they utilize for their own facility energy needs. A few wastewater facilities flare the biogas because their gas generation is minimal. In addition, landfills generate landfill gas and, which can be upgraded and injected into pipelines; however, the process leaks methane into the atmosphere and the carbon benefits may be negated by the leaked amount of methane.

At likely lower cost than the purchase of RNG credits, Rutgers could collaborate with a developer for a state-of-the-art anaerobic digester (AD) facility. While Rutgers does not generate enough food waste for an efficient facility, it could collaborate with surrounding communities. This facility can be located on-campus or off-campus and a developer can pay for the project. Rutgers may utilize its gas either directly or purchase credits with a negotiated rate. The AD facility can also generate compost, which will reduce the biogas carbon footprint further as by-product credit. The AD facility can be run by the developer, so it would not be an operational burden for Rutgers, and as a technology provider the developer would have the performance responsibility. Rutgers can also request funding/opportunities for internships for our students,

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[9] https://bioenergy.rutgers.edu/

[10] https://bioenergy.rutgers.edu/biomass-energy-potential/

gas clean-up and upgrading tech, compost testing research for our faculty research etc., as part of the negotiation.

### 3.3.1. Emissions reductions and resilience improvements

Fossil natural gas is responsible for a large share of Rutgers' carbon footprint; taken together, some combination of efficiency, electrification, and fuel substitution should eliminate these emissions.

Co-generation plants can provide backup power for solar electric systems and thus enable islanding of microgrids when the grid electricity supply is disrupted. Premature retirement of co-generation facilitations, before substantial, cost-effective battery storage is available, can thus decrease campus resilience. Central heating plants should therefore be prioritized for early retirement over co-generation facilities.

### 3.3.2. Benefits to the University's educational and research mission and to campus culture

Rutgers currently has some research activities related to renewable natural gas. Serpil Guran of the Rutgers EcoComplex is on the Academic Advisory Group of the Renewable Natural Gas Coalition (RNG). Guran, Gal Hochman (Department of Agriculture, Food, and Resource Economics), and a student are conducting a technoeconomic analysis of viable approaches for a New Jersey RNG industry. The EcoComplex is also collaborating with the Northern New Jersey Community Foundation to assess for a potential anaerobic digester to biogas project in Bergen County.

As with on-campus electricity generation, the thermal energy system can be integrated into educational projects using the campus as a living lab.

### 3.3.3. Needed research and planning

Additional analysis is needed to evaluate alternative approaches for transitioning away from fossil natural gas. While some relevant expertise exists on campus, a thorough analysis will likely require hiring an external consultant.

### 3.3.4. Benefits to the University's educational and research mission and to campus culture

Rutgers currently has some research activities related to renewable natural gas. Serpil Guran of the Rutgers EcoComplex is on the Academic Advisory Group of the Renewable Natural Gas Coalition (RNG). Guran, Gal Hochman (Department of Agriculture, Food, and Resource Economics), and a student are conducting a technoeconomic analysis of viable approaches for a New Jersey RNG industry. The EcoComplex is also collaborating with the Northern New Jersey Community Foundation to assess for a potential anaerobic digester to biogas project in Bergen County.

As with on-campus electricity generation, the thermal energy system can be integrated into educational projects using the campus as a living lab.

## 3.4. Energy Demand: Building Retrofits

It is almost axiomatic that the least expensive energy is that energy which is never used. For example, energy efficiency programs run by electric utility have an average cost of about $46/MWh,[11] roughly half the price Rutgers pays for grid electricity. For that reason, reducing energy demand is a core part of all climate change mitigation strategies. The core challenge of scaling this solution is one of financing, as energy efficiency investments involved up-front costs for sustained returns.

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[11] Ian M. Hoffman et al., "Estimating the Cost of Saving Electricity through U.S. Utility Customer-Funded Energy Efficiency Programs," *Energy Policy* 104 (May 1, 2017): 1–12, https://doi.org/10.1016/j.enpol.2016.12.044.

Over 2005-2014, the University of California made energy efficiency investments that reduced its annual expenditures by about $24M (about 10%), and projects potential savings by 2028 of another approximately 22%.[12] Such investments often have a payback period of 3-5 years.

In order to identify opportunities for cost-effective retrofits, it is necessary to conduct building-level energy audits. The State of New Jersey runs multiple programs that help identify and subsidize retrofits. Buildings with 200 KW average peak demand can be analyzed and retrofitted through the NJ Clean Energy Direct install program, which covers 70% of the cost. Larger buildings can be audited using NJ Clean Energy's Local Government Auditing program, which covers up to $100,000 annually for the audits.

Based on energy efficiency audits, Rutgers can submit an energy efficiency plan under the NJ Clean Energy Program (NJCEP) Large Energy Users Program. If the plan meets the program's criteria, Rutgers can receive subsidies up to the smallest of: (a) $4 million, (b) 75% of total project(s) cost, (c) 90% of total NJCEP fund contribution in previous year, which is typically about $2 million, and (d) $0.33 per projected kWh saved and $3.75 per projected Btu saved annually.

### 3.4.1. Emissions reductions and resilience improvements

While more detailed analysis is necessary, assuming an energy efficiency potential comparable to that identified by the University of California assessment suggests that about 30% of energy-related emissions can be avoided through efficiency measures. This suggests a potential of about 110,000 t $CO_2$.

### 3.4.2. Financial costs and savings

Financial costs and savings will vary from building to building. Typical payback periods are 3-5 years. In average it is a three to five-year payback. Given annual energy expenditures of about $60 million, our initial estimate is a total potential savings through energy efficiency investments of about $20 million/year for an initial cost of about $80 million. Savings from energy efficiency investments can be recycled through a Green Revolving Fund to fund further revenue-positive emissions-reducing measures. As with solar power, third-party financing options are available. For compliant energy efficiency proposals, based on Rutgers' NJCEP fund contribution, NJCEP will cover about 75% of projects totaling $2.4 M/yr.

### 3.4.3. Benefits to the University's educational and research mission and to campus culture

Facilities is working with students to put together packages to submit to NJ Clean Energy, which gives students a basic understanding of utilities and how buildings use them. More broadly, energy retrofits into campus-as-living-lab educational opportunities.

### 3.4.4. Implementation Plan and Timescale

From (1) requesting support for a building audit, to (2) getting the building audited, to (3) retrofitting takes about nine months.

### 3.4.5. Needed research and planning

Building-level energy audits are needed to identify specific retrofit opportunities. Financial research is needed to assess tradeoffs between debt financing and third-party financing.

### 3.4.6. Evaluation plan

Facilities (Institutional Planning and Operation) is the lead office for implementation. Treasury must be involved in the provision of capital.

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[12] Meier et al., "University of California Strategies for Decarbonization."

### 3.4.7. Management roles

This project will be led by Facilities.

### 3.4.8. Contribution to Climate-Positive, Equitable, Sustainable Economic Development

Building retrofits create short-term construction jobs and contribute to overall state goals for energy efficiency. Consistent with state goals, Rutgers could work with the Supplier Diversity Development Council to increase opportunities for minority-, woman- and veteran-owned businesses.

## 3.5. Energy Demand: New Building Standards

New Jersey's 2019 Energy Master Plan calls for building state-funded projects to the "highest attainable, above-code building performance standard using a whole-building approach, such as Passive House design." Rutgers already builds all new buildings to LEED Silver, but can explore elevating this to LEED Gold and requiring a certain portion of the points in the Energy and Atmosphere category within the standard to be associated with energy efficiency standards. It could also set quantitative energy-intensity maxima for buildings by type and usage. In addition, the design and powering of new buildings should be evaluated within the context of plans to gradually transition the campus away from natural gas.

### 3.5.1. Emissions reductions and resilience improvements

The adoption of building standards will allow the potential energy savings associated with demand reduction in the discussion of existing buildings above to be captured as the University builds new structures and decommissions old ones.

### 3.5.2. Needed research and planning

A thorough analysis of alternative building standards is the next step in this endeavor, and should be able to be completed within a year.

### 3.5.3. Management roles

The evaluation of options should be undertaken as a collaboration between Facilities and Planning & Design. Once developed, standards will be enforced by Planning & Design.

## 3.5 Energy Demand: Metering, Monitoring and Control Systems

Building energy efficiency generally degrades over time. On top of the potential savings from energy efficiency retrofits, systematically detecting, diagnosing, and correcting operational problems using automated or semi-automated processes can reduce energy consumption by 10-30%.[13]

Opportunities include: metering of all utilities at the building level and plant levels, upgrade of control systems in plants to better operate the distribution of energy to buildings on the plant loops, building controls for building operations and monitoring of building to better distribute energy form the plants.

There is a direct linkage between monitoring and controls on the one hand and emissions reduction and resilience improvements on the other. Smart metering and real time measurement, interconnected with controls, can ensure a building is being operated at peak efficiency for the building load at a particular time. The truism that you can't manage what you don't measure underlies this solution. For the most part, buildings operate part load. Real-time monitoring and control allow the load produced to be adjusted to

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[13] Nicholas EP Fernandez et al., "Impacts of Commercial Building Controls on Energy Savings and Peak Load Reduction" (Pacific Northwest National Lab.(PNNL), Richland, WA (United States), 2017).

meet the load required. When not metered or monitored the thermal load produced to accommodate the buildings load will be at full load and waste energy.

Metering will also make the performance of individual buildings more visible, which in turn helps identify poor energy performers that warrant priority investments in energy upgrades. Metering also provides a quantitative basis for incentivizing units to perform better operationally. Both the prioritized capital improvements and incentivized operational improvements will yield emissions reductions. Upgraded building monitoring and control systems will enhance situational awareness, operational performance, and coordination among building users and central utilities personnel, and lead to quicker problem-solving.

The U.S. General Services Administration estimates that installation of metering potentially has four sets of associated savings based on experiences within their portfolio: (1) a temporary behavioral impact of up to 2% energy cost savings when meters are installed; (2) a 2.5% – 5.0% permanent energy cost savings when costs are actually allocated to building users; (3) a 5% - 15% permanent energy cost savings when buildings are subsequently tuned up and when demand management strategies are put in place; and (4) a 15% - 45% permanent energy cost savings when an ongoing regime of building commissioning continues to maintain the building and actively manage it.[14] The benefits outweigh the costs most frequently when meter installation (item #1) is accompanied by some level of active management commitment (items #2-4). Note that the largest potential savings are associated with active management, not incentivized behavioral changes.

Improved monitoring and control of utility plants and district energy distribution loops will also result in savings. Though we cannot say by reducing X we save Y we do now that better control and monitoring will ensure that only the energy needed will be produced and used.

### 3.5.1. Emissions reductions and resilience improvements

While more detailed analysis is necessary, assuming an energy efficiency potential comparable to that identified by the GSA suggests that about 30% of energy-related emissions can be avoided through efficiency measures. This suggests a potential of about 110,000 t $CO_2$.

### 3.5.2. Financial costs and savings

More information is needed to assess the costs of monitoring, controls, and education needed to achieve the potential identified in the GSA study. The potential savings in terms of reduced energy expenditures are estimated to be about $20 million/year if applied in isolation, or about $30 million/year if combined with building retrofits discussed above.

Savings from energy efficiency investments could be recycled through a Green Revolving Fund to fund further revenue-positive emissions-reducing measures.

### 3.5.3. Benefits to the University's educational and research mission and to campus culture

When systems are monitored and controlled the data collected can be used for education and research on many levels. Metering empowers building users to participate in energy management. It “gamifies” participation by providing a means of score-keeping, for example in inter-dormitory energy saving competitions. The combination of metering and monitoring also makes buildings useful living laboratories for studying a variety of physics, mechanical engineering, psychology, and social science topics.

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[14] General Services Administration, U.S. 2012. Submetering Business Case: How to calculate cost-effective solutions in the building context. Accessed on November 1, 2020 at https://www.gsa.gov/cdnstatic/Energy_Submetering_Finance_Paper_Knetwork_2012_11_269%28508%29.pdf.

### 3.5.4. Implementation Plan and Timescale

From RFP to starting construction will take about one year. Installation of meters will take about two years. Installation of controls will take about five to ten years, depending on how aggressive the pace of investment is.

### 3.5.5. Needed Research and Planning

The Rutgers Utilities office will write a request for proposals to have all campus buildings metered to identify the costs and next steps for this high priority action to manage building energy. Metering and measuring will make it apparent where building controls will need to be upgraded in order to monitor and control in real time. At a building-level, an assessment of each building and system is needed to determine what meters are needed and how best to upgrade existing control systems. At a system level, control systems to allow building and central plant controls need to be identified.

### 3.5.6. Evaluation plan

Success will be evaluated by the installation and operation of controls and metering and the resulting energy savings.

### 3.5.7. Management roles

This project will be led by Facilities.