Roadmap to Net Zero Emissions

--- Draft November 5, 2020 ---

BACKGROUND

On October 18, 2018, the Gainesville City Commission established a goal of reaching net zero community-wide greenhouse gas emissions by 2045. The City Commission also stated that they prefer to achieve this goal as soon as feasible.

GRU has taken two significant steps toward this goal within the last two years, including signing a Power Purchase Agreement (PPA) with Origis Energy for up to 50 MW of solar photovoltaic power (expected to be online in late 2021) and moving forward with plans to increase Deerhaven Unit #2's gas-firing ability, thereby decreasing GRU's use of coal (expected to be online in mid-2021). These projects will decrease GRU's CO_2 emissions, will not increase rate pressure, and will not negatively affect electric generation reliability.

The long-term challenge for GRU in its quest towards its net-zero emissions goal will be adding significant amounts of renewable generation while minimizing rate pressure and maintaining electrical reliability. Net zero emission electrical generation in Florida is largely limited to biomass, solar, nuclear, and refused-derived fuels (while other net-zero technologies and fuels are used in small-scale and pilot projects, such as tidal and algae generation, they have not developed the track record and scale to be used in utility-scale applications). Additionally, some of these fuels face intermittency challenges (solar) or public perception challenges (nuclear, biomass, and refuse-derived).

This analysis lays out a possible path forward for GRU to achieve its goal of net zero emissions by 2045. There are obviously many alternative courses and strategies to achieve this goal. The focus of this analysis is to achieve 100% net zero energy delivered to customers in a way that supports electrical reliability and minimizes costs and risks.

ASSUMPTIONS

The following assumptions were used in the analysis.

1. **GRU's Capacity Reserve Margin.** The Florida Reliability Coordinating Council (FRCC) requires utilities to maintain a minimum 15% reserve margin for its generation planning. As such, generation capacity additions were chosen and timed such that GRU would maintain this margin as a minimum threshold.

2. **Photovoltaic Systems' Output.**

   a. **Contribution to Peak**. Photovoltaic (PV) electrical output is inherently intermittent, and its peak output does not typically align with GRU's system peaks. This analysis uses a 55% nameplate (AC) power contribution to GRU's summer peak (this 55% is mirrored from FPL's Ten-Year Site Plan) and 9% nameplate (AC) power contribution to GRU's winter peak (9% is taken from GRU's internal analysis from existing solar arrays).

   b. **Capacity Factor.** This analysis uses a 26% annual capacity factor for solar output. This 26% factor was supplied by Origis Energy as the expected annual capacity factor for its 50 MW (AC) single-axis tracking array. Due to expected technological advances in PV efficiency, the annual capacity factor for new systems is modeled to increase above 26% by 0.25% per year (note that once a system is installed, its capacity factor does not change for the length of the study. While PV panel degradation will occur, it's relatively minor impact is not included in this analysis).

   c. **Useful Life.** New PV arrays are assumed to have a useful life of 30 years, which is beyond the term of this analysis.

3. **Generation Unit Retirements.** To reach 100% net zero emissions by 2045, all fossil-fueled generation will either need to be shut down or its emissions would need to be offset with off-system sales of renewable energy.

   a. **Combined Cycle Unit 1 (CC1).** When the Kelly plant's combined cycle unit 1's (CC1) steam turbine is replaced in early 2021, the unit's estimated remaining useful life will be 30 years, which would give the unit a natural retirement in 2051. However, to reach net zero emissions by 2045, the unit's output will need to be drastically cut as they year 2045 approaches. In this analysis, CC1's output is assumed to be essentially zero in 2041 and beyond. The unit will still be available for capacity and to serve load when renewable options are not available, but CC1 would not run otherwise. Since CC1 is currently GRU's most cost-effective unit to run, there could be customer rate implications when the unit is turned off.

b. **DHR Retirement.** GRU's 2020 Ten-Year Site Plan currently lists DHR with a retirement data of 2043. DHR was originally assigned a 30-year life as the plant was previously associated with a 30-year PPA; however, large solid fuel-plants such as DHR that frequently run can have lives well beyond 30 years. For this analysis, DHR was assumed to have a useful life of 35 years, which would place its retirement in 2048. It would be determined approximately 20 years from today whether DHR's life could be extended further or if it would need to be replaced with another form of renewable generation.

c. **Other Generation Retirements.** All other generation units are retired in this analysis according to the retirement dates listed in GRU's 2020 Ten-Year Site Plan.

4. **Demand and Energy Forecasts.** GRU's demand and energy forecasts from 2020 through 2029 are taken from GRU's 2020 TYSP. This forecast uses regression analyses which includes inputs such as historical load, population growth estimates, historical weather, income projects, etc. Beyond 2029, summer and winter peaks and annual net energy for load is projected to grow by 0.58% per year (this is the average growth forecasted for 2020 – 2029).

5. **DHR Capacity Factor.** The Deerhaven Renewable generating unit's (DHR) annual capacity factor varies from 30% to 86% in this analysis. This capacity factor fluctuates to meet load as generation resources are added and retired from the system.

ANALYSIS

EXISTING GENERATION RESOURCES

The expected summer and winter capacity from GRU's existing and contracted generation resources were summed beginning in 2020. In subsequent years, as GRU's generating units retire according to their useful life, the summer and winter capacity from these units was subtracted from GRU's generation capacity from that year and each subsequent year. GRU's available summer and winter generating capacity was then compared to the summer and winter capacity required (peak demand plus 15% reserve margin). This process is summarized in Table 1. As can be seen in the red and blue-highlighted cells, GRU will need power capacity when DH2 retires at the end of 2031.

Table 1. Scheduled Generation Capacity through 2045

Year	NEL (GWh)	Summer Peak (MW)	Winter Peak (MW)	Current Forecasted Summer Capacity (MW)	Current Forecasted Winter Capacity (MW)	Summer Capacity Needed With 15% Reserve Margin (MW)	Winter Capacity Needed with 15% Reserve Margin (MW)
2020	2012	429	356	660	668	0	0
2021	2028	432	359	660	668	0	0
2022	1933	405	335	660	668	0	0
2023	1910	407	337	581	590	0	0
2024	1921	409	339	581	590	0	0
2025	1932	412	341	581	590	0	0
2026	1943	414	343	581	590	0	0
2027	1954	417	345	546	546	0	0
2028	1964	419	346	546	546	0	0
2029	1974	421	348	546	546	0	0
2030	1986	422	349	546	546	0	0
2031	1998	423	350	546	546	0	0
2032	2010	424	351	318	318	170	85
2033	2022	425	351	318	318	171	86
2034	2034	426	352	318	318	172	87
2035	2046	427	353	318	318	173	88
2036	2058	428	354	318	318	174	89
2037	2071	429	355	318	318	176	90
2038	2083	431	356	318	318	177	91
2039	2096	432	357	318	318	178	92
2040	2108	433	358	314	314	183	97
2041	2121	434	359	314	314	184	98
2042	2134	435	359	314	314	186	100
2043	2146	436	360	314	314	187	101
2044	2159	437	361	314	314	188	102
2045	2172	438	362	314	314	189	103

CAPACITY ADDITIONS

To achieve the required summer and winter capacities, and to increase the amount of renewable energy served, generation was added on an incremental basis. Three types of generation were added: solar, biomass, and reciprocating internal combustion engines (RICE).

Solar. Blocks of solar systems in either 50 or 75 MW (AC) allotments were added to GRU's generation capacity. A relatively high level of energy storage will be required in conjunction with these systems.

- **Timing of Solar Additions.** Within the past five years there have been significant reductions in the costs of PV systems and energy storage. This reduction in price is expected to continue, particularly with energy storage. Additionally, within the past five years the capacity factors of newly commissioned PV systems have seen significant increases. As GRU adds solar capacity, the optimal strategy would be to add solar in blocks between 50 and 75 MW every four to five years. With this strategy, GRU would avoid the risk of locking in too much solar at prices that potentially become higher-than-market or with technology that is out-of-date.

- **Levels of Energy Storage.** Relatively high amounts of energy storage will be required in conjunction with future solar installations. At a minimum, energy storage systems will need to be 50% of nameplate PV capacity (AC) and contain at least four hours of storage.

- **Location of Solar Additions.** GRU would also benefit from having more relatively smaller solar projects that are spaced physically apart. This physical distancing would help to minimize the drop in PV output put onto GRU's system from passing cloud cover. Current research shows that a five-mile separation between solar sites is sufficient to diversify PV system due to isolated cloud cover.

Biomass/RDF. One dispatchable biomass-fueled/Refuse-Derived Fueled (RDF) generation unit with 75 MW of capacity was added to GRU's generation capacity. Once DH2 retires in 2031, GRU will need dispatchable generation to aid in following load and supplying energy during non-daylight hours. As such, the 75 MW biomass/RDF plant is added in 2032. This capacity also boosts GRU's renewable generation of NEL by approximately 20%. It is assumed that this unit will have the same year-to-year capacity factor as DHR.

RICE. One block of 50 MW of natural gas fueled RICE was added to aid the integration of significant amounts of solar generation with GRU's system.

- **Benefits of RICE.** RICE is fast-starting and fast-responding generation that typically uses natural gas as its fuel. While RICE does not generate renewable energy, it does enable more solar generation. Due to solar generation's intermittency and extremely fast ramp rates, relatively low amounts of utility-scale solar can be added to GRU's system before that solar generation causes problems with grid stability. Fast-responding generation, such as RICE, mitigates those concerns by providing fast-starting and fast-ramping power to balance the PV systems' intermittency. The addition of RICE allows GRU to add more utility-scale solar to its system; without RICE or other fast-responding generation, GRU's ability to add utility-scale solar is very limited.

- **Timing of RICE.** The block of RICE was added in conjunction with the first block of solar. GRU will need fast-responding generation relatively early on to balance solar PV's fast-changing output and intermittency. This addition also helps to replace capacity lost from DH1's retirement, currently scheduled for the end of 2022.

SCHEDULE OF CAPACITY ADDITIONS

The generation capacity additions are show in Table 2. The impact of these capacity additions on GRU's generation capacity, CO_2 emissions, and renewable energy served is shown in Table 3.

Table 2. Generation Capacity Additions

Name	Nameplate Capacity (MW)	Summer Capacity (MW)	Winter Capacity (MW)	Year Commissioned	Retirement Year	Annual Energy Capacity Factor (%)	Annual Renewable Energy Contribution (GWh)
Solar/Storage-1	50	28	5	2024	2054	26%	115
Solar/Storage-2	50	28	5	2028	2058	27%	119
Solar/Storage-3	50	28	5	2032	2062	28%	124
Solar/Storage-4	75	41	7	2036	2066	29%	192
Solar/Storage-5	75	41	7	2041	2071	31%	200
RICE-1	50	50	50	2024	2054	20%	0
Biomass-1/RDF	75	75	75	2032	2067	30-86%	97-565

Table 3. Impact of Generation Capacity Additions

Year	Resource Added	Summer Capacity (MW)	Winter Capacity (MW)	Renewable Generation	Net CO2 Emissions (Metric Tons)
2020		660	668	25%	1,017,103
2021		660	668	24%	872,770
2022		660	668	29%	837,062
2023		581	590	30%	730,026
2024	Solar/Storage-1 & RICE-1	659	645	35%	730,132
2025		659	645	35%	730,026
2026		659	645	35%	730,026
2027		624	601	35%	730,026
2028	Solar/Storage-2	651	605	36%	694,456
2029		651	605	36%	694,351
2030		651	605	36%	694,351
2031		651	605	35%	694,351
2032	Solar/Stoarge-3 & Biomass/RDF-1	526	457	55%	480,299
2033		526	457	54%	480,299
2034		526	457	54%	480,299
2035		526	457	54%	480,299
2036	Solar/Storage-4	567	463	55%	480,299
2037		567	463	55%	480,299
2038		567	463	54%	480,299
2039		567	463	54%	480,299
2040		563	459	54%	480,299
2041	Solar/Storage-5	604	466	103%	(29,901)
2042		604	466	103%	(23,886)
2043		604	466	103%	(25,206)
2044		604	466	102%	(19,118)
2045		604	466	102%	(12,995)

DISCUSSION

REDUCTIONS IN EMISSIONS AND GAINS IN RENEWABLE ENERGY

As can be seen in Table 3, net CO_2 emissions steadily decrease until 2031. Beyond 2031, the only remaining generation sources of CO_2 are CC1 and the South Energy Center plant. CC1 is base-loaded until 2041, at which point the unit is shut off. Net zero emissions and 100% renewable energy are achieved in 2041.

SOLAR PV CHALLENGES

This case brings a total of 350 MW of solar PV capacity onto GRU's system (50 MW from Origis in 2022 and 300 MW in five installments through 2042.). This large quantity of solar on a system of GRU's size presents several challenges.

1. **Intermittency.** Solar energy production is inherently intermittent during daylight hours and nonexistent during non-daylight hours. To balance this intermittency, the solar systems in this analysis will need to include some level of energy storage, most likely through batteries. Approximately 42% of GRU's customer's energy is consumed during non-daylight hours, and so significant amounts of energy will need to be either stored for times when instantaneous PV output is insufficient or purchased from other utilities.

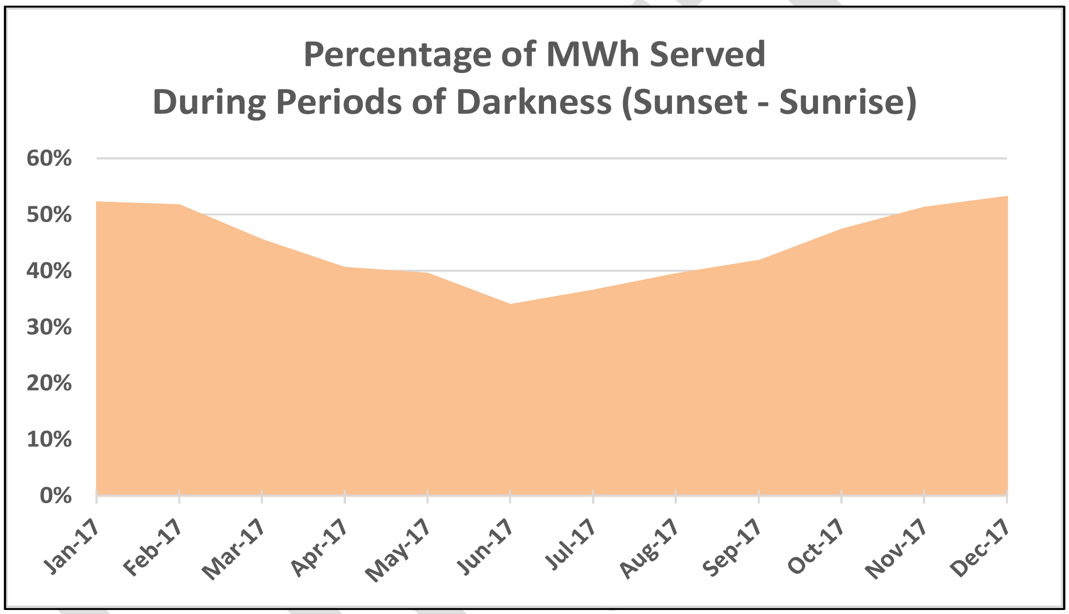

Figure 1. Percentage of Daily Energy by GRU Served During Periods of Darkness

2. **Excessive Generation.** GRU's electrical production must always be matched with GRU's electrical demand. During the shoulder months, GRU's minimum demand can fall below 150 MW. This is illustrated in Figure 2.

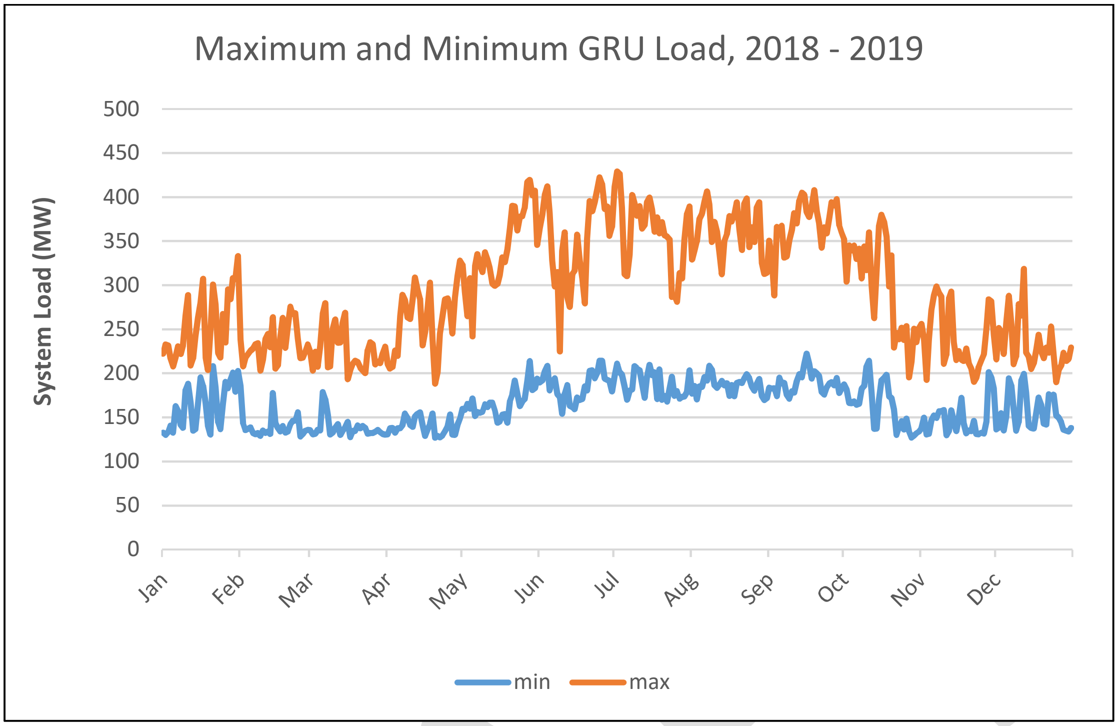

Figure 2. GRU System Maximum and Minimum Load

Solar PV system output can near 80% of its rated capacity by 10:00 am. As GRU adds more solar capacity to its system, PV systems will at times generate more power than GRU has load. Since GRU must match its generation to its load, excessive PV system output will need to be either directed into energy storage, curtailed, or sold to another utility.

3. **Load Balancing and Ramp Rate Control.** GRU's fossil-fueled generation must currently ramp their output up and down to follow changing customer load. There are limits to how quickly these inertial units can ramp up and down to follow load, typically three to five MW per minute. Solar PV output varies almost instantaneously, which can create large sudden mismatches between generation output and load. To mitigate this risk, the solar systems will likely require ramp-rate control via energy storage or other applications.

4. **Energy Storage Costs.** The solar systems installed will require relatively significant amounts of energy storage. At a minimum, the solar systems will require 50% of power storage per MW of nameplate PV capacity (AC) and at least four hours of storage. At today's prices, that energy storage would cost around $234 million. As the energy storage market matures, prices are expected to decrease, which further bolsters the strategy to install solar with energy storage in modest increments several years apart.

Solar PV and storage technologies are rapidly changing. In the past several years, energy storage costs have dramatically fallen, and they are expected to continue to fall in the coming years. Optically sky-scanning technology is evolving to permit more accurate forecasts and ramp-rate control. Single-axis tracking is now roughly the same cost as fixed-mount PV arrays. Solar PV system technologies are continuing to quickly evolve, and by spacing out its solar system additions into modest blocks (50 – 75

MW) every four to five years, GRU will be able to take advantage of more technologically sophisticated PV systems and energy storage at lower costs.

BIOMASS / RDF CHALLENGES

- **Biomass.** DHR is fueled by a plentiful, local supply of clean wood waste including pulpwood and chip-n-saw timber generated by forestry management and urban wood waste. The wood fuel is delivered by contractor-owned trucks from sources typically within 50 to 75 miles of DHR. If GRU builds another biomass plant, GRU may need to source the additional fuel supply from more distant locations, thus increasing transportation costs.

  While DHR currently runs economically and reliably, the term "biomass" has had a negative connotation within the community due to the unpopularity of the Power Purchase Agreement that DHR was previously associated with.

- **RDF.** Refuse-derived fuel is fuel that is produced from domestic and commercial waste that would be otherwise landfilled. Materials that have a recyclable value (such as metals) or would be deleterious to combust (such as PVC) are removed, and the residual material is then shredded. RDF also aids in the City of Gainesville's goals of increasing its recycling rate and landfill diversion.

  Despite RDF's benefits, RDF is often met with resistance due to its incorrect association with "mass burn" and "trash incinerator" facilities. While RDF is considered renewable and its energy plants include sophisticated scrubbers and bag houses to clean its combustion gases, RDF's use for energy requires combustion, which may be met with community resistance.

ECONOMIC CONSIDERATIONS

GRU's ability to borrow significant funds for new generation units is limited. Solar PPAs, coupled with energy storage, offer the ability for GRU to source most (if not all) of its solar PV energy and capacity without issuing debt. However, for electrical reliability GRU will also need dispatchable generation resources, which will most likely require capital funds.

The following section highlights the economic considerations of the various generation options proposed.

1. **Solar.** At least for the short-term, it is financially beneficial for GRU to source its solar energy through PPAs rather than through owning solar generation outright. However, there are factors that will change the economics of solar in the coming years, and the current PPA advantage may dissipate.

- **Investment Tax Credits.** There are currently significant investment tax credits (ITC) available for income tax-paying solar developers and for-profit utilities that install solar. However, as GRU is a not-for-profit entity and does not pay income tax, GRU cannot directly take advantage of this benefit. As such, it is currently more economical for GRU to enter into a PPA with a solar provider who can take advantage of the ITC and then pass on these savings to GRU through a PPA.

  The ITC is currently worth 26% of the installed cost of PV system if installed in 2020, 22% if installed in 2021, and 10% if installed in 2022. Solar-related companies have been lobbying congress for an extension of the solar ITC, but it is unclear if this extension will occur. If the ITC is not extended, the financial advantage of a solar PPA over solar facility ownership will significantly decrease for GRU.

- **Technology and Manufacturing Advances**. The National Renewable Laboratory's *Annual Technology Baseline* forecasts the installed cost of utility-scale PV to drop 19% by 2025 and another 24% by 2030. These decreases are expected due to continued research and development by panel manufacturers which will drive down the manufacturing cost. In the short-term, bifacial panels and tracking systems are likely to become the norm, driving up systems' energy output.

2. **Energy Storage.** GRU will need significant amounts of energy storage to achieve its net zero emission goal, perhaps as much as 165 MW of four-hour storage. At today's prices, this would amount to almost $264 million. However, there are some factors that will shape the energy storage market in the next decade:

   - **Investment Tax Credits.** Most energy storage systems installed today are coupled with new solar facilities, largely because solar-coupled energy storage systems qualify for the solar ITC. As battery costs fall and the solar ITC expires, AC-coupled stand-alone energy storage systems are expected to become more commonplace.

   - **Technology and Manufacturing Advances.** According to the June 2020 *Cost Projections for Utility-Scale Battery Storage: 2020 Update* by the National Renewable Energy Laboratory, today four-hour batteries cost approximately $370 per kWh. However, by 2025 prices are forecasted to fall by 25%, and by 2030 prices are expected to fall another 25%.

3. **Biomass/RDF.** Biomass generation is a mature technology, and no significant advances in its technology or reductions in its capital cost are expected over the next decade. According to GRU's 2019 *Integrated Resource Plan* (IRP) by The Energy Authority, a generating unit that uses biomass or RDF as a fuel has an installed cost of $3,642 per kW. If a 75-MW biomass/RDF unit is installed in 2032 as outlined in this roadmap, it would have a capital cost of $273 million. While the capital cost per MW is relatively high, the fuel for such units is generally less expensive than other solid or gaseous fuels.

4. **RICE.** Reciprocating internal combustion engines have an installed cost of $1,150 per kW according to GRU's IRP. If 50 MW of RICE is installed in 2024 as outlined in this roadmap, it would have a capital cost of $58 million. While RICE units are natural gas-fueled, their fuel cost is not expected to be relatively significant as the units would only run when solar energy and energy storage is insufficient to meet GRU's load. RICE has gained increasing popularity with utilities within the last decade due to its renewables-enabling qualities (e.g. quick start times, high efficiency at part load, etc.); however, RICE is not expected to drop in price in the near future.

OVERALL ECONOMIC IMPACT

GRU faces upward rate pressure in the coming years. Inflationary increases to operating expenses cause continuous rate pressure. Additionally, in FY2021 GRU opted to keep rates flat to assist customers with economic hardships during the pandemic; however, this decision could results in a higher rate increase in FY2022.

When considering the economic impact of the *Roadmap to Net Zero Emissions*, the question centers less on "How much will rates increase in the future," but rather "What is incremental impact of this plan over the status quo?" Future rate pressure is fairly certain, but the type of generation equipment that GRU chooses to install does have an impact on the degree of that rate pressure. GRU's 2019 IRP showed that providing 100% renewable energy could cost around 25% more than traditional natural-gas fueled generation. However, as discussed in this analysis, renewable energy costs are continuing to fall. What is cost prohibitive today may not be so in five to ten years. As such, it is important for GRU to take consistent, incremental, and moderate steps so that rate pressure is minimized in its goal towards net zero emissions.

SUMMARY

GRU's fuel options for renewable energy are largely limited to solar, biomass, and RDF. By adding these resources in modest capacity blocks several years apart, GRU can obtain the City of Gainesville's goal of 100% net zero emissions goal by 2045. This strategy will also help to assure that GRU obtains this goal in a manner that minimizes financial, technological, and electrical reliability risks.

While there are many possible routes to 100% net zero emissions, all of them with varying costs and risks, the next prudent steps for GRU would be to add 50 MW of solar and 50 MW of RICE in 2024, followed by another 50 MW of solar in 2028. GRU will need to continue to make incremental commitments about every four years to reach its net zero emissions goal on schedule.

GRU will revise this *Roadmap to Net Zero Emissions* annually to reflect the current state of renewable energy technologies, renewable generation costs, existing generation, and customer demand.