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**NEW COMPRESSED AIR ENERGY STORAGE CONCEPT IMPROVES THE PROFITABILITY
OF EXISTING SIMPLE CYCLE, COMBINED CYCLE, WIND ENERGY, AND LANDFILL GAS POWER PLANTS**

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INTRODUCTION

Combustion turbines (CT) have become the preferred means of supplying electricity to meet peak load power demands. Their attributes are low first cost, rapid installation compared to other options, low operating and maintenance costs (other than fuel) and relatively low emissions. Their problems are that they have relatively low efficiency and consume expensive fuel - as a result CTs operate only when market prices for electricity are high enough to justify their dispatch.

While combustion turbine manufacturers are steadily but slowly increasing CT's efficiency by increasing turbine firing temperatures and improving the efficiencies of major components, there are a number of other approaches primarily various thermal cycle modifications that can reduce the cost of electricity.

One such approach is the Compressed Air Energy Storage (CAES) power plant where air is compressed using less expensive off-peak electricity and stored in the underground air storage cavern. It is later released for the power generation during peak demand hours. The first CAES plant in the US, the 110 MW Alabama Electric Cooperative plant at McIntosh, AL, has been in successful operation since 1991. The underground air storage was solution mined in the local salt dome. In this plant, the underground storage is charged with the compressed air during off-peak hours to the maximum pressure of 1100 p.s.i.a. The electricity required by the CAES plant compressor train is obtained from coal-fired power plants with the fuel costs of approximately \$1.5-2.0/million Btu. Due to the fact that the peak power is generated without the requirement for power to drive the air compressor, the fuel related heat rate is approximately 4000 Btu/kWh. This CAES plant requires approximately 0.8kWh of the off-peak energy consumption (for

storage charging) per kWh of peak energy produced . Therefore the total peak energy costs produced by the CAES plant, combines the off-peak energy cost (for the storage charging) with the fuel cost of the peak energy production (with an approximate heat rate of 4000 Btu/kWh). The application of this storage principle is particularly important for utilization of the renewable energy sources like wind energy, which could be produced at night and during other off-peak hours when electric power demand and prices are both low. This wind energy could be stored in the form of the compressed air and later released for the peak power production when electric energy is at the highest price and in short supply. The integration of the wind and CAES plants will improve economics of both plants. It allows selling the wind energy at peak price and it improves the CAES plant economics by driving compressors with wind energy (when there is no demand) having the lowest costs. These same principles can also be applied to landfill gas generation facilities. Utilization of compressed air storage in addition to fuel gas storage, allows for the same amount of the landfill gas to produce 2.5 times higher electric energy (the CAES plant has a fuel related heat rate that is 2.5 times lower than for a conventional CT) and at peak periods.

A second approach is to reduce the power consumption by the combustion turbine compressor that is directly driven by the combustion turbine expander and takes over 50% of its power. There are number power plant concepts like the CHAT and HAT thermal cycles that achieve these objectives by using the humidified air as a working fluid, thus reducing the specific air consumption and parasitic power consumption by compressors. Unfortunately, these concepts haven't yet found attractive market applications because they required some combustion turbine modifications. These modifications are an expensive

development proposition and completely at discretion of turbine manufacturers. The manufacturers have not yet concluded that the potential market is large enough to justify the required investments.

This paper presents the novel Compressed Air Energy Storage (CAES-CT) concepts that utilize the aforementioned storage and humidification approaches and has the following characteristics:

- The CAES-CT concepts utilize the existing reserve capacities of combustion turbine (CT) and Combined Cycle (CC) plants, as explained below. These concepts do not require development of highly customized specifically engineered (for various powers and geologies) CAES turbomachinery trains with reheat and recuperation, with associated the complications and costs. The use of existing CT power plants avoids costs associated with new projects development like site permits, licenses, etc.
- These CAES-CT concepts could be easily applied to meet a variety of the CAES plant power and storage requirements by achieving required storage capacities through combining CTs of various capacities with various numbers of units. The CAES plants based on the conventional concept with a customized turbomachinery trains have no such flexibility.
- The existing CTs as a rule present a state-of-the-art proven technology with the highest performance characteristics and the lowest possible NOx emissions.
- The stored compressed air could be easily humidified before injection into CT/CC plants (with associated efficiency improvements and storage cost reductions) without the aforementioned complications associated with HAT and CHAT concepts.

The paper also will demonstrate advantages of the integration of the renewable energy sources with the CAES-CT concepts – with large (100-300 MW) CAES plants using salt, hard rock and aquifer geological formations for the underground air storage and with small (5-15 MW) CAES plants using the man-made storage vessels including the buried high pressure piping.

NOVEL CAES PLANT CONCEPTS BASED ON USE OF COMBUSTION TURBINE/COMBINED CYCLE POWER PLANTS FOR TURBOMACHINERY (CAES-CT AND CAES-CC)

For the overwhelming majority of electric power customers (in the USA and abroad) power demands reach their peak during summer, when high ambient temperatures reduce the power output of combustion turbines and combined cycle plants to the minimum. The simplified explanation for reduced power production is that lower inlet air density, a result of the high ambient temperature, reduces mass flow through a CT with a respective reduction of the power produced. Similar situation exists at high elevations.

Therefore a GE Frame 7FA CT nominally rated at approximately 174 MW at ISO conditions (59 °F with 60% relative humidity), will produce maximum power of approximately 191 MW, when the ambient temperature is 0 °F, but will produce only approximately 150 MW at 95 °F. The

significant power loss by a CT during high ambient temperature periods (when the price for replacement electricity is at its highest) requires a power generation company to install additional units to meet summer peak demands. Power losses for a CC power plant during high ambient temperature operations are similar to those for a combustion turbine. Therefore CT/CC plants operate for the most of the time with significantly lower capacities than the maximum power generation, which occurs at low ambient temperatures. Therefore existing capacity reserves of CT/CC plants could be utilized for producing additional peak capacities via injection of the stored compressed air. This approach allows development of the CAES plants by adding only the air compression and storage facilities. Highly customized and expensive turboexpander trains are not necessary.

This method was invented by Dr. Michael Nakhamkin of ESPC, as described in U.S. Patent #5,934,063 (Reference 1) and in Reference 2.

Figures 1a and 1b (including humidification) illustrate schematic diagrams of the CAES-CT concept (with operating parameters), where the power of the GE 7FA-combustion turbine, operating at 95 °F ambient temperature, is augmented using compressed air stored in an underground compressed air storage system. The major components of the CAES-CT plant are as follows:

- A commercial combustion turbine with the provision to inject the externally supplied compressed air at any point upstream of the combustor. Engineering and mechanical aspects of the air injection for CAES-CT plants are similar to steam injection for power augmentation, which is a standard CT's power augmentation option provided by a number of OEMs;
- An auxiliary compressor system consisting of commercially available off-the-shelf standard compressor modules and sized for the incremental airflow (and not for a full airflow) to be stored and later injected into a CT/CC plant;
- Compressed air storage, which could be underground storage in salt, hard rock or aquifer geological formations or above ground storage in various pressure vessels;
- Balance-of-plant equipment and systems including interconnecting piping, valves, controls and an optional recuperator.

This CAES-CT plant has three modes of operation:

- A conventional combustion turbine operation, where the CT is disconnected from the compressed air storage.
- A CAES mode of operation, where during peak periods, compressed air flow from the storage is injected upstream of the combustors to complement the CT's compressor discharge air flow. The compressed air from the storage could be optionally preheated in the recuperator and humidified. The storage is charged with the compressed air by the auxiliary motor-driven compressor during off-peak hours utilizing renewable resources, nuclear or coal generated power.
- Power augmentation mode of operation, when a CT/CC plant power is augmented during peak hours by additional airflows supplied by the auxiliary

compressor operating simultaneously with a CT/CC plant in the event that sufficient air is not available from storage.

CAES-CT Concept

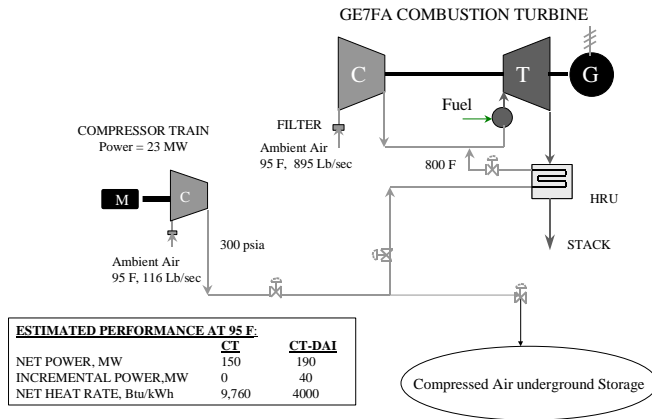


Figure 1a. The CAES-CT Concept

Figures 1a and 1b illustrate that the additional compressed air flows from the compressed air storage of 116 lbs/sec and 58 lbs/sec (with further humidification), respectively, being injected upstream of the combustors will increase the combustion turbine power output from 150 MW to 190 MW. The performance characteristics presented in Figures 1a and 1b should be considered as estimates only because the maximum amount of injected air, at any given ambient temperature, could be restricted, also, by a number of design or operational limitations, like the electric generator and electrical system restrictions, etc.

The additional CAES plant capacity of 40 MW achieved by only one CT demonstrates that practically any required CAES plant capacity could be achieved by combining capacity reserves of various number of existing CT/CC plants. In addition to the power increase, the fuel-related heat rate of this additional capacity, is significantly reduced to typical CAES plant levels of approximately 4000 Btu/kWh for the CAES-CT plant (Figures 1a) and of 6200 Btu/kWh for cases with humidification (Figure 1b). In spite of a higher heat rate for the case with humidification, it is important to remember that for the same additional power the humidification concept reduces the underground storage by a factor of approximately two (2) (as compared to the dry air concept) with corresponding cost and schedule savings.

The total operating cost of the CAES-CT plant must include the fuel cost consumed during the plant operation (peak periods) and off-peak energy cost for recharging the compressed air storage system with the compressed air. The fuel and off-peak energy related costs of electricity (COE) (without O&M costs) produced are calculated as:

COE, \$/kWh = Heat rate, BTU/kWh) x (cost of fuel, \$/BTU) + (the off-peak energy consumed for the storage recharging, kWh) x (cost of off-peak energy, \$/kWh) / (total additional kWh produced by the CAES-CT plant in the power augmentation mode of operations).

The CAES-CT concept could be similarly applied to CC plants with the difference that the CT is replaced by a CC. The CAES-CC plant operations are similar to the CAES-CT plant; the only

difference is that in the CAES-CC plant, the increased power of the CT will be complemented by additional power produced by the steam turbine of the bottoming cycle due to the added CT exhaust flow.

CAES-CT Concept with Humidification Equivalent to 3.5% SI

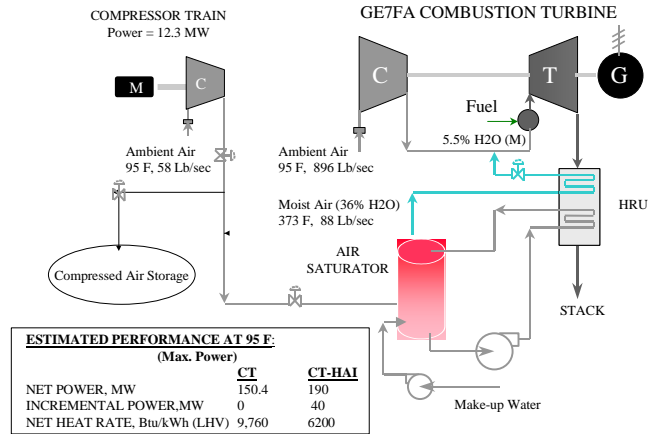


Figure 1b CAES-CT Concept with Humidification

The effects of the dry and humidified air injections on a CT performance and operations (including the compressor surge, maximum torque, combustors operations, disk space temperatures, etc.) had been analyzed and test validated on the GE 7FA combustion turbine (Reference 4).

ENGINEERING AND CAPITAL COSTS

ESPC has performed the conceptual engineering and cost estimates for the CAES-CT concept based on GE Frame 7FA, with the compressed air storage sized for continuous six (6) hours operation with the incremental (CAES) power of approximately 40 MW. The overall plant has been optimized based on the lowest specific incremental capital costs (incremental costs divided by incremental power) as a primary criterion with strong consideration of cost of electricity generation. This included, concurrent optimization of parameters, performance and economics of the compressed air storage in a salt dome (with assumed characteristics), the compressor train and other equipment involved including the compressed air charging costs. The resulting storage requirement is approximately 3.8 million cubic feet (with depth of approximately 1000 feet and the maximum minus minimum pressure difference of 150p.s.i.a.) with an estimated construction cost of \$4 million. These data are based on prorating of actual parameters and costs of the underground storage in the salt dome for 110 MW CAES plant. The compressor train has been sized for two hours of compression for each hour of peak power generation at 95 °F, i.e. for half of the supplementary flow from the cavern (58 lbs/sec).

Estimated total incremental cost for equipment and systems required for the conversion of the Frame 7FA combustion turbine into the CAES-CT plant with aforementioned operating requirements is approximately \$8.5 million dollars, which is approximately \$215/Kw.

(40 MW additional power at 95 °F ambient temperature). This compares favorably with the approximately \$600/kW specific cost for a turnkey installation of a large capacity CAES plant and it is, also, significantly lower than turnkey specific costs of a CT.

LARGE SCALE UNDERGROUND STORAGE FACILITIES

During engineering of the 110 MW CAES plant for Alabama Electric Cooperative, and in the course of a number of feasibility studies, ESPC, jointly with a number of contractors, developed empirical equations for engineering and cost estimates for various underground reservoirs in various geological formations including the software for integration and optimization of CAES plants. Also, EPRI (Electric Power Research Institute) conducted very extensive geological studies to identify locations in the U.S. with geological characteristics acceptable for development of underground storage facilities for the CAES power plants and produced a data base of construction and operating costs. The published report and produced maps confirm that more than 80% of the U.S. territory has salt, hard rock and aquifer formations acceptable for creation of underground storage facilities in a cost-effective manner. It should be noted that at any given moment more than \$30 billion worth of strategic materials are stored in underground formations.

ABOVE GROUND AIR STORAGE FACILITIES

ESPC conducted extensive exploratory engineering to develop a cost-effective aboveground compressed air storage approach. This approach allows the CAES-CT concept to be applied without considerations of local geology limitations. Various industrial pressure vessels, buried high-pressure piping and other alternatives were analyzed. As a result, the above ground compressed storage in the buried high-pressure piping was selected, based on the capital cost and other considerations. The conceptual arrangement of the sub-surface compressed air storage system is presented on Figure 2 and in Reference 3, 5 and 6. The above ground storage optimization resulted in the significantly higher storage pressure (to reduce the volume) and in the overall CAES-CT plant parameters and operations different from those for the underground storage. Optimized above ground storage systems could be competitive with large underground storage facilities on the \$/kW basis when storage capacities are limited to three (3)-five (5) hours.

NOX EMISSION IMPACTS

There is no available data to accurately predict NOx emissions for the CAES-CT concepts, but there are conceptual characteristics that lead to the conclusion that these emissions should be lower than those for the CT plant:

- CAES-CT uses advanced CT combustors (potentially DLN) with similar air/fuel ratios, which should lead to expected low NOx emissions.
- The incremental power of a CT associated with the storage is generated with a typical CAES plant incremental heat rate of approximately 4000-4300 Btu/kWh with

corresponding reductions in fuel consumption per kWh produced and NOx emissions.

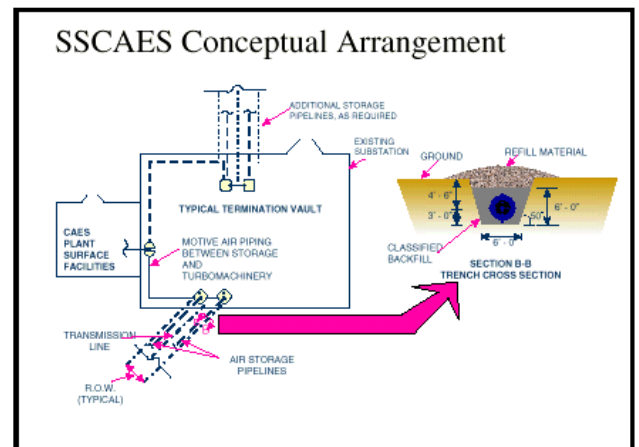


Figure 2 Conceptual Arrangement of the Sub-Surface Compressed Air Storage.

- Total CAES-CT emissions including the CT power and CAES incremental power should, also, be further reduced by approximately twenty percent due to reduction by 20% of the total integrated heat rate

SMALL SCALE COMPRESSED AIR ENERGY STORAGE WITH THE COMPRESSED AIR STORAGE SUB-SURFACE FACILITIES (SSCAES) PLANT

The development of the SSCAES plant is a joint effort of EPRI and ESPC with support from manufacturers and covered by the US Patent # 5,845,479 (see Reference 3) and described in EPRI's report (Reference 5). This section of the paper presents the latest performance and economics of small 8-12 MW CAES plants with the compressed air stored in the subsurface high-pressure vessels/piping. The engineering of the SSCAES plant was based on the Rolls Royce Allison (RRA) combustor/expander/electric generator (CEG) package. As typical for any CAES plant, the power generation estimated heat rate is approximately 4000-5000 Btu/kWh. This does not include the power required for air compression, which is obtained from other sources (like wind energy, coal or nuclear plants) during off-peak hours, when electricity is inexpensive and available from other sources.

The SSCAES plant utilizes off-peak energy to drive motor-driven boost compressors to compress air and store the high-pressure air for expansion during peak demand periods. It could be practically located at any site regardless of the availability of specific geological formations required for a conventional CAES plant.

WIND POWER PLANTS INTEGRATED WITH COMPRESSED AIR STORAGE

One of the key economic issues that disadvantages wind power is that it is intermittent and therefore non-dispatchable. Since capacity credits cannot be obtained, wind power is at a significant economic disadvantage relative to other forms of generation.

Another disadvantage is that in various areas of the United States and other areas of the world, as well, the velocity of the local winds and therefore the amount of power that can be generated does not peak at the same time that power demand peaks. If the wind typically blows during the late evening hours, wind power will only have a value equivalent to base load power in many areas, on the order of \$15/MWH or less.

One approach to offsetting these deficiencies is to combine wind power with a SSCAES plant. In this system, as shown in Figure 3, electricity produced by wind turbines during periods of low demand is used to compress air that is stored in a pipe network of the type shown previously in Figure 2. Studies indicated that the compressed air should be boosted by a system of compressors to the pressure of approximately 1500 – 2000 p.s.i.a and stored in the underground HP piping. When wind power is available and can be marketed, that power is supplied directly to the grid. At those times when wind power can be generated, but there is no market for the power, it is used to drive a compressor that injects air into a Sub-Surface pipeline network. That air is withdrawn during peak demand times and fed to a natural gas fired expander to deliver a total of 15 MW to the system. A heat recovery system is used to preheat the pressurized air by exchange against the hot expander exhaust.

As shown in Figure 4, the humidification of the injected air reduces the amount of air that is required to be stored. This significantly reduces the investment required for both the air storage system and the compressor. The additional cost of the systems for humidification is small in comparison to the cost savings.

The detailed cost and performance data are presented in the References 5 and 6. The specific costs for the SSCAES for an arbitrarily selected peak power generation periods of four-hours and eight hours for charging the pipe network system are estimated as \$630/kW with the power generation fuel-related heat rate of 4030 Btu/kWh (without accounting for the off-peak energy provided by wind). For the air humidification case, the specific costs are reduced to \$550/kW but heat rate increases to 6030 Btu/kWh. A more sustained off peak availability of wind power results in longer charging periods and reduces the cost of the compressor. It should also be noted that there is a 60 % reduction in the amount of natural gas burned to produce the peak power in the cases without humidification and a 40 % reduction in the case with humidification. This translates into comparable reductions in CO₂ emissions.

These economics can be markedly improved by dispatching the wind-generated electricity to the SSCAES-CT plant described above due to significantly reduced costs associated with utilization of existing CT plants. Estimates show that specific costs, for the same operating conditions as above, will be reduced to approximately \$400/kW for the compressed air storage without humidification and to \$330/kW with humidification.

LANDFILL GAS POWER PLANTS INTEGRATED WITH SSCAES PLANTS

Landfill Gas (LFG) is generated by the anaerobic decomposition of municipal solid waste (MSW) placed in sanitary landfills. Its composition is about 55 percent methane (CH₄) and 45 percent carbon dioxide (CO₂) but also includes some oxygen (O₂) and nitrogen (N₂) from air introduced during the collection process. Usually, it is saturated with water

vapor and contains trace amounts of volatile organic compounds and some other gases including chlorides.

Methane and carbon dioxide are greenhouse gases. However, methane is considered 30 times more potent than carbon dioxide. Federal and most state regulations require the collection and control of LFG. If a landfill is of sufficient size to justify economic recovery of the energy contained in the methane, LFG may be successfully and profitably recovered. There are approximately 500 LFG energy recovery facilities in the United States and Europe. The practical economic life of most LFG energy recovery facilities is 10 to 30 years.

LFG energy recovery facilities typically utilize internal combustion engines (ICE) or combustion turbines (CT) for power production. The operating challenges include:

- Variation in gas composition and production rate over time.
- Full load operation heat rates of 11,000-12,000 Btu/kWh, due to fluctuating fuel production rates and composition.
- Difficulties with the gas cleanup system due to fluctuating fuel production rates and composition.

In the SSCAES-LFG plant described in this section of the paper, the LFG is collected, pressurized to the level of approximately 1500p.s.i.a and stored in the underground HP piping of the same type described earlier in this paper for the SSCAES plant. This allows:

- Averaging of its composition, which benefits the fuel combustion system operation of any engine that is used.
- Controlled release and averaging composition of the LFG, which facilitates better and easier cleaning.
- Controlled release for power generation to meet varying power supply market demands.

Clean LFG is used to fuel the SSCAES plant. The compressed air is boosted by a system of compressors to the pressure of approximately 1500 – 2000 p.s.i.a and is stored in the underground HP piping, similar to the LFG system.

For a given LFG production, the SSCAES-LFG plant will generate twice the kW/hrs of electricity, as compared to an ICE or a CT using the same amount of landfill gas fuel. This ratio is equal to the ratio of the effective heat rate of an ICE or a CT over the SSCAES-LFG plant's heat rate. Doubling or tripling the amount of electricity that can be sold by a SSCAES-LFG plant during high electricity demand hours results in significantly better economics of that plant compared with ICE or CT generation using that same amount of LFG fuel. These conclusions are generic and applicable to various landfills differentiated by sizes and characteristics.

Figure 5 presents the schematic and heat and mass balance for an SSCAES-LFG concept based on using the RRA combustor/expander/generation (CEG) skid mounted package. The SSCAES- LFG plant can conveniently be divided into two distinct parts:

1. The LFG fuel conditioning and storage system consists of the following major components:
 - LFG collection system in the landfill;
 - LFG cleaning equipment;
 - The boost compressor for compression of the clean LFG;
 - LFG storage in the underground HP piping;
 - Interconnecting piping, valves, controls.

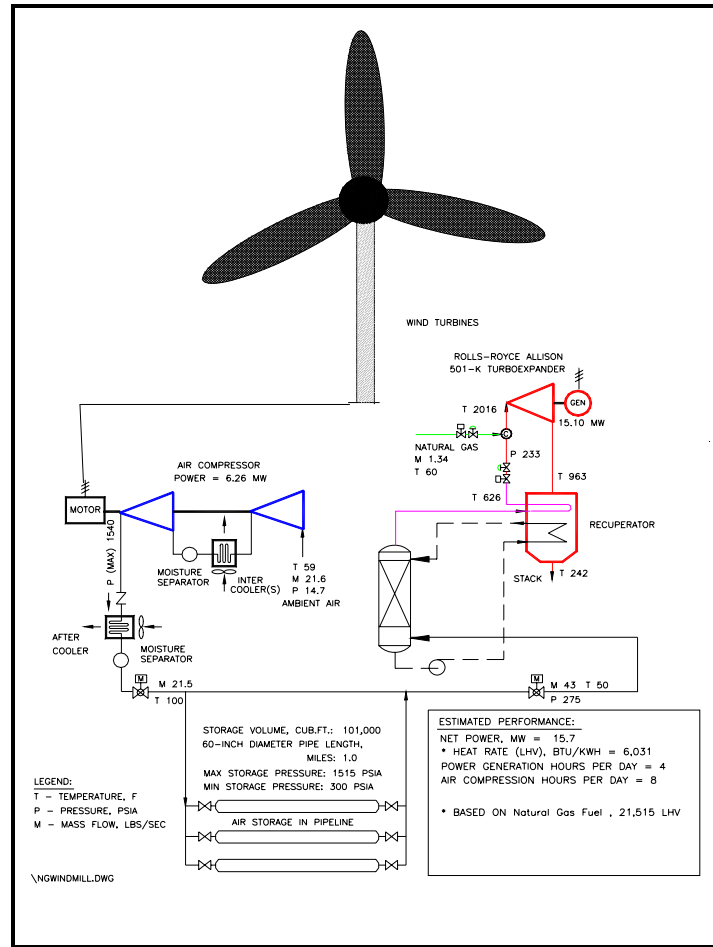
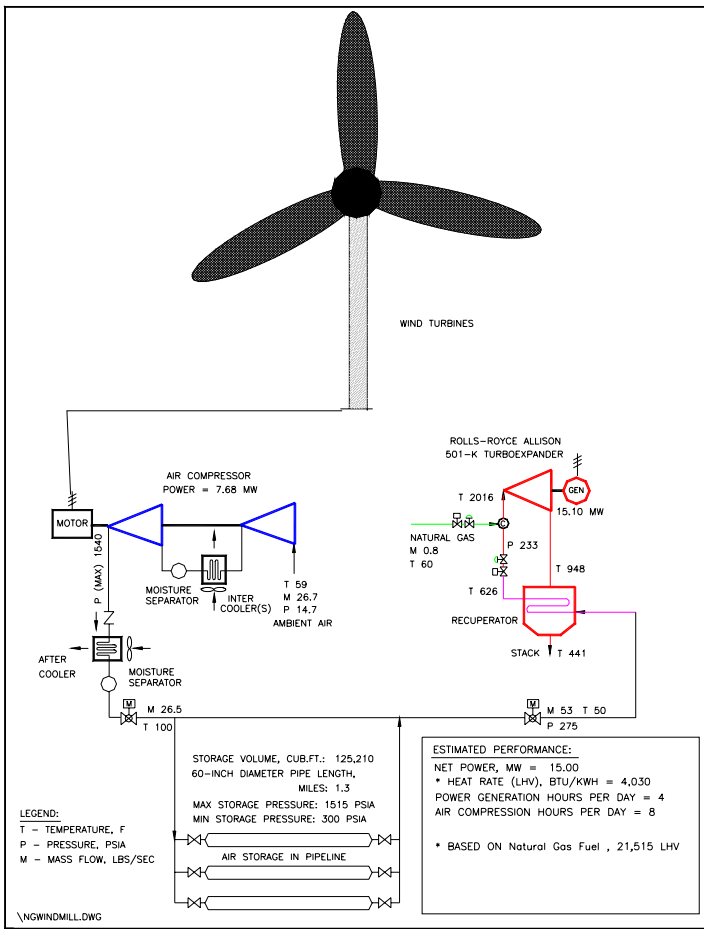


Figure 3. Heat and Mass Balance Diagram of an Integrated Plant with Wind Turbines Compressed Air Storage and a RR Allison 501-K Turboexpander

Figure 4. Heat and Mass Balance Diagram of an Integrated Plant with Wind Turbines, Compressed Air Storage, Air Humidification System and a Rolls-Royce Allison 501-K Turboexpander

2. A typical SSAES plant (the bottom of Figure 5) properly integrated with the LFG conditioning and storage system, consists of the following major components:
 - Motor-driven multistage and intercooled compressors;
 - The CEG package provided by RRA;
 - The compressed air storage in the underground HP piping;
 - BOP equipment, systems and controls.

Since the compressed air and LFG are stored in the conventional high pressure piping, the plant could be located where LFG is available, independent from the availability of specific underground storage formations typically needed for large CAES plants. Extensive piping systems for the storage of both air and LFG can be easily accommodated within the constraints of a typical landfill.

The LFG storage volume and LFG pressure are each a subject of optimization with the overall objective to collect the LFG as it is generated and store it for release during peak hours. The compression and storage techniques and methods are consistent with those for the SSAES plant.

Figure 5 includes a simplified heat and mass balance with major operating parameters and performance characteristics. The most important characteristic is the heat rate of 4,954 Btu/kWh, which is less than a half of the typical heat rate for the similar size ICE and CT plants of 11,000-12,000 Btu/kWh. The LFG storage allows concentrating the energy sale on times when it is needed and more valuable. SSAES-LFG plants deal with small sizes of the CAES plants in the range of 10-30 MW, which is consistent with typical landfill sizes.

Performance and capital cost estimates were generated for landfill sites of different sizes (Reference 6). The cost analysis and comparison were performed relative to the use of the simple cycle combustion turbine and ICE at the same landfill sites.

Total plant capital investment for landfills with fuel production ranging from 12 to 31 MMBtu/hr ranges from \$9.5 million to \$14.4 million. For these cases, the cost of the air storage system is about 11 times greater than the cost of the LFG storage system.

The SSCAES-LFG plant advantages could be summarized as follows:

- Based on the same LFG production by a landfill, SSCAES plants will generate twice the electrical energy compared to ICE.
- SSCAES-LFG plants can produce energy during peak hours when electrical energy price is high and needed rather than continuously to consume the LFG as it is generated.
- Based on a purely economical consideration, for the cases with typical premiums for peak electricity, SSCAES-LFG plants are significantly more cost effective as compared to ICE/CT plants.

The higher LFG production, the higher optimum capacity of the SSCAES-LFG plant; for assumed electricity price distributions, for a given LFG production the optimum capacity shall provide for the power generation of approximately five (5) hours/day.

For flat electricity prices, there is no economic incentive for the LFG storage for use during peak hours and therefore traditionally selected ICE/CT units are recommended.

SSCAES-LFG plants are based on standard and often off-shelf equipment. The only component requiring some engineering development is the expander that can be provided by RRA or others.

CONCLUSIONS

Novel CAES-CT plant concepts have the following characteristics:

- The CAES-CT concept allows the CAES plant advantages to be utilized in the most cost effective and practical manner by utilizing existing power capacities of CT/CC plants without expenditures and complications associated with development of customized reheat turbomachinery trains.
- The air injection into a CT is mechanically similar to the steam injection for the power augmentation. The special compressor train for the storage charging could be provided by a number of OEMs and there are a number of companies capable of construction of underground storage facilities.
- By utilizing various numbers of CT's and their capacities one can achieve any specific energy storage requirements as well as peak power generation profiles.

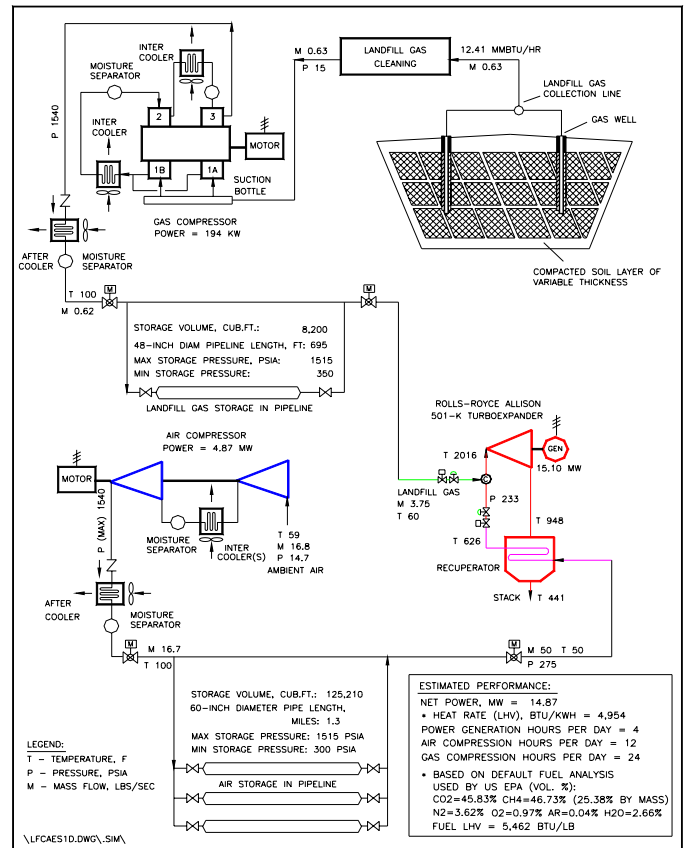


Figure 5: Schematic and H&M Balance Diagram-SSCAES-LFG based on RRA 501-K Expander - Landfill Capacity of 13 MMBtu/hour

- Specific incremental capital costs for the CAES-CT plant based on the GE 7FA CT are estimated as \$205 - 220/kW and are significantly lower than for other alternatives including the purchase of a new CT or CC plant. Also, fuel related heat rate is significantly reduced, and off-peak power consumption could contribute to improvement in the power generation system utilization.
- There are sufficient technical reasons to anticipate that NO_x emissions for CAES-CT and SSCAES concepts will be lower than those for the CT used as a basis for these concepts.

SSCAES plant is based on the small capacity modified CTs with the compressed air storage in the man-made buried high-pressure piping. Specific costs of \$300-600/kW (for CAES-CT and CAES concepts, respectively) is competitive with other storage options.

These CAES plant concepts could be delivered in a variety of sizes (by using various sizes of CTs) and as described above being integrated with wind power plants, LFG facilities and other renewable energy sources, will significantly improve their economics and operations

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