Solutions Development for Renewable and CHP Projects for the Federal Government

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ABSTRACT

Many federal energy-savings performance contract (ESPC) projects have more opportunities than the traditional demand-side energy conservation measures (ECMs). Federal organizations can incorporate more advanced technologies, like renewable energy sources, into their project bundles when the energy services company (ESCO) takes advantage of creative financing, incentives and rebates available. This article will cover the following aspects of solutions development for renewable and combined heating and power (CHP) projects for the federal government. Included will be a discussion of more advanced ECMs available to a particular location.

1. Solutions development process overview
2. Samples of conventional ECM projects
3. Samples of advanced ECM technologies
4. CHP projects
5. Renewable projects

INTRODUCTION

Conventional demand-side energy conservation measures (ECMs) help federal facilities reach their energy savings goals. Executive Order 13123 requires federal facilities to aggressively save 35 percent of energy by the year 2010, compared to a base year of 1985. An energy-savings performance contract (ESPC) is one way to help federal agencies reach these goals. However, most government agencies are not meeting their energy goals and need to take advantage of less traditional ECMs, creative financing and available incentives. If energy savings utilize renewable fuel, the agency will benefit greatly toward meeting this energy savings goal. Federal agencies do not need to count the Btus from renewable sources, and the result is two-fold. The energy consumed does not need to count in the annual energy usage, and the energy is still consumed to power a building system.

A positive result from the demand-side energy savings projects reduces energy consumption and provides infrastructure improvements by shifting utility savings dollars to pay for the capital investments. Most areas of the country have utility rates that do not allow incorporating advanced ECMs without other savings and incentive dollars.

Accurate baseline development is still the place where savings start, and it makes the difference between a successful and unsuccessful project in the solutions development process. Adding more advanced technologies, like combined heat and power (CHP) and renewable projects, normally hurts the cash-flow of the total ESPC bundle. The energy savings company (ESCO) needs to research the technologies available beyond lighting, water and HVAC ECMs, and determine if rebates and incentive dollars are available in a particular area to help fund the project.

This article reviews how to develop accurate and cost-effective baseline methods used for more advanced ECMs. Accurate baseline energy estimating is required so the follow-up measurement and verification will determine real savings. Performance contracting solutions development for various ECMs presents an infinite number of calculation options. How does an engineer measure and collect the proper system and utility data to achieve a calibrated baseline?

CONVENTIONAL ECM PROJECT EXAMPLES

1. Lighting
2. Water and sewer for plumbing fixtures
3. HVAC retrofits
4. Central plant retrofits (boiler and chiller systems)
5. Energy management control systems
6. Building system improvements

This article does not include a detailed discussion of conventional ECMs.

ADVANCED ECM TECHNOLOGY EXAMPLES

The following are examples of more advanced technologies an ESCO should consider when bundling an ESPC project:

1. Tower-free cooling and thermal storage
2. CHP plants, which may include use of landfill gas (LFG)
3. Solar hot water systems
4. Ground-source heat pumps (GSHPs)

(This list is not exhaustive. There are a variety of other advanced ECM technologies, including natural daylighting, photovoltaic (PV) roofs and streetlights, and energy information systems and metering.)

This article covers what is required in modeling and analyzing the listed ECMs and performing the solutions development. Recommendations for capturing incentives and rebates for these ECMs also will be discussed. The preliminary analysis is a cost-effective calculation necessary to be able to recommend the economic viability of the different types of ECMs.

TOWER-FREE COOLING AND THERMAL STORAGE

Figures 1, 2 and 3 show a plate-and-frame heat exchanger normally used for tower-free cooling systems in a chiller plant. When evaluating tower-free cooling systems, the solutions developer needs to consider the potential impact in the following areas:

1. Tower-free cooling systems need a dry climate, and year-round run-hours or high electric costs to have a good payback.
2. Some rate structures only capture energy savings (not demand). If the rate structure has a ratchet the savings will not include demand savings (kW) and only capture energy savings (kWh).
3. DOE2 Energy Simulation Model using eQuest may be necessary to adequately simulate the results.
4. The cooling towers will need to be sized larger than the chiller(s) normally need to get adequate cooling from a plate and frame heat exchanger.

Figure 1. Plate and Frame Piping

Calculating Baselines and Savings

Baseline = Cooling energy of cooling system

Cooling System Energy = Cooling equipment, chillers, towers, pumps and HVAC

Energy Savings = (Cooling system energy saved by not running cooling equipment)—(extra energy required for towers, pumping and HVAC)

Note: Tower-free cooling requires more tower energy and possibly more AHU and pumping energy because of higher chilled water temperatures generated.

COMBINED HEAT AND POWER PLANTS

Combined heat and power (CHP) plants can take many shapes and sizes. In addition, depending on the heating (and/or cooling) and power

Figure 2. 1,700-Ton Tower–Free Cooling System

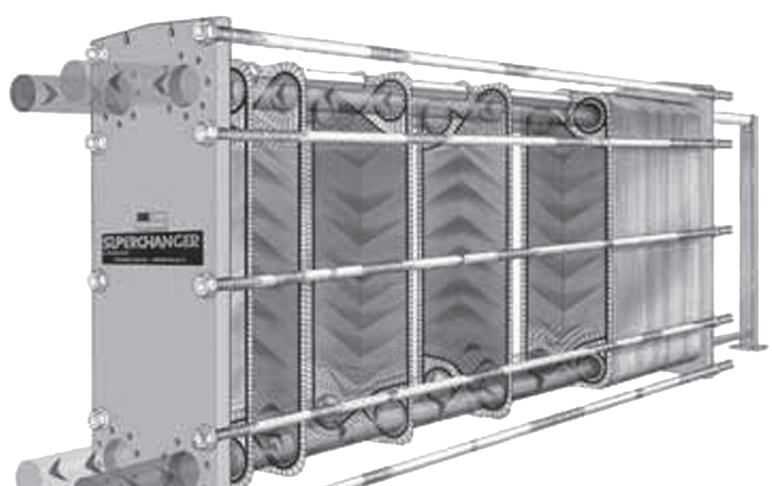

Figure 3. Plate and Frame Heat Exchanger

needs, the types of fuels, engines, turbines and waste heat equipment can vary greatly based on the existing systems that will connect to the plant.

Honeywell is developing packaging and control technologies for various CHP plant sizes to optimize the offering and reduce the capital costs for the system. In addition, the company recently installed a large (5 MW) CHP plant at Fort Bragg as part of an ESPC for the U.S. Army. This system was installed at the largest of 14 central plants on the post, and provides electrical power and chilled water. Figures 4, 5 and 6 show details of the CHP plant installed. The program to develop the CHP plant was funded by the U. S. Department of Energy and administered by the Oak Ridge National Laboratory.

The 5 MW CHP project included the typical demand-side projects—lighting, controls, HVAC and efficiency upgrades. Integrated energy services and natural gas and power procurement programs were able to fund a variety of additional upgrades and systems:

1. Central plant modernization - $30 million
2. Cogeneration project - $11 million
3. Energy security and reliability
4. Integrated energy management center
5. Micro-grid with on-site generation

Additional CHP lessons learned: these systems work best in locations with good utility and state incentives. In addition, alternate fuels

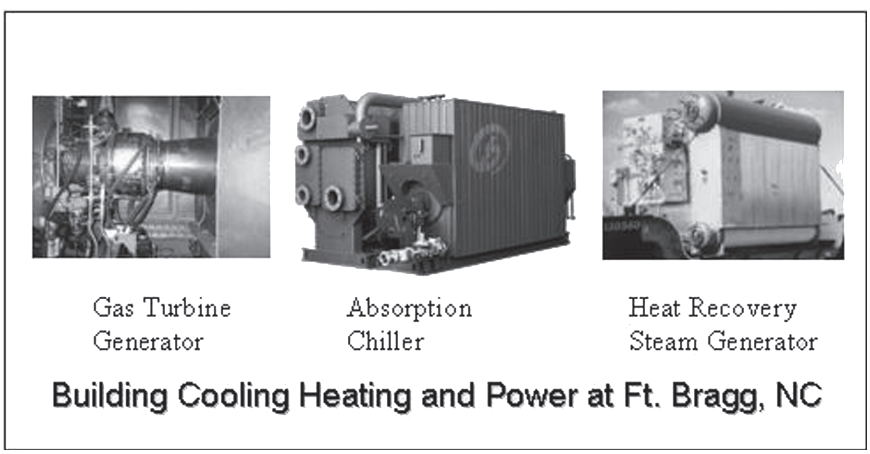

Figure 4. Typical CHP Components

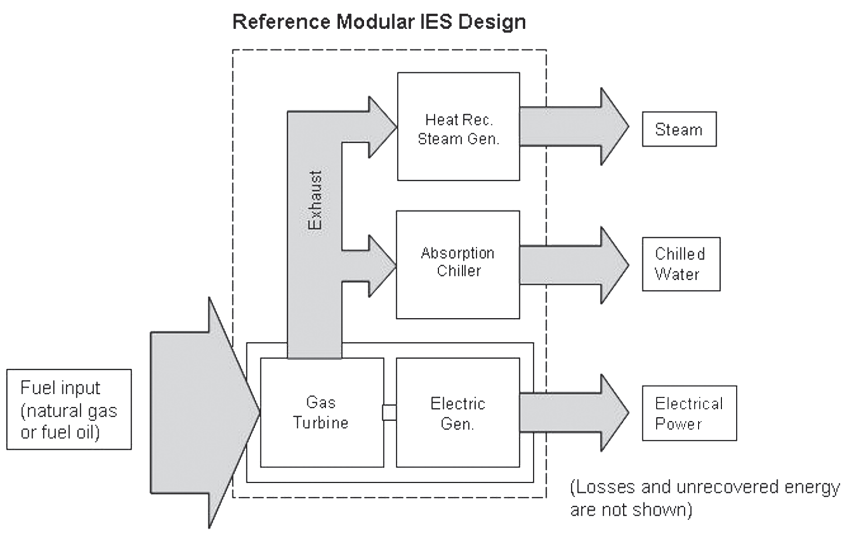

Figure 5. CHP Heat Balance

such as LFG can make the economics better that using natural gas or fuel oil.

Calculating Baselines and Savings

Baseline = Cooling and heating system energy

Cooling and Heating System Energy = Chillers, boilers, pumps, towers and HVAC

Energy Savings = Difference between the fuels used for generating chilled water, steam and hot water, and electrical savings; difference in off-setting electricity generated

CHP PLANTS USING LANDFILL GAS

An Air Force base located close to a city landfill recently evaluated a CHP plant. Natural gas costs for the base are $8.30 per million Btu (MMBtu). LFG is currently being negotiated and will vary between $2 and $5 per MMBtu. The following performance parameters are being studied for feasibility of this CHP plant.

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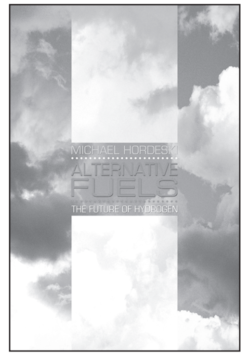

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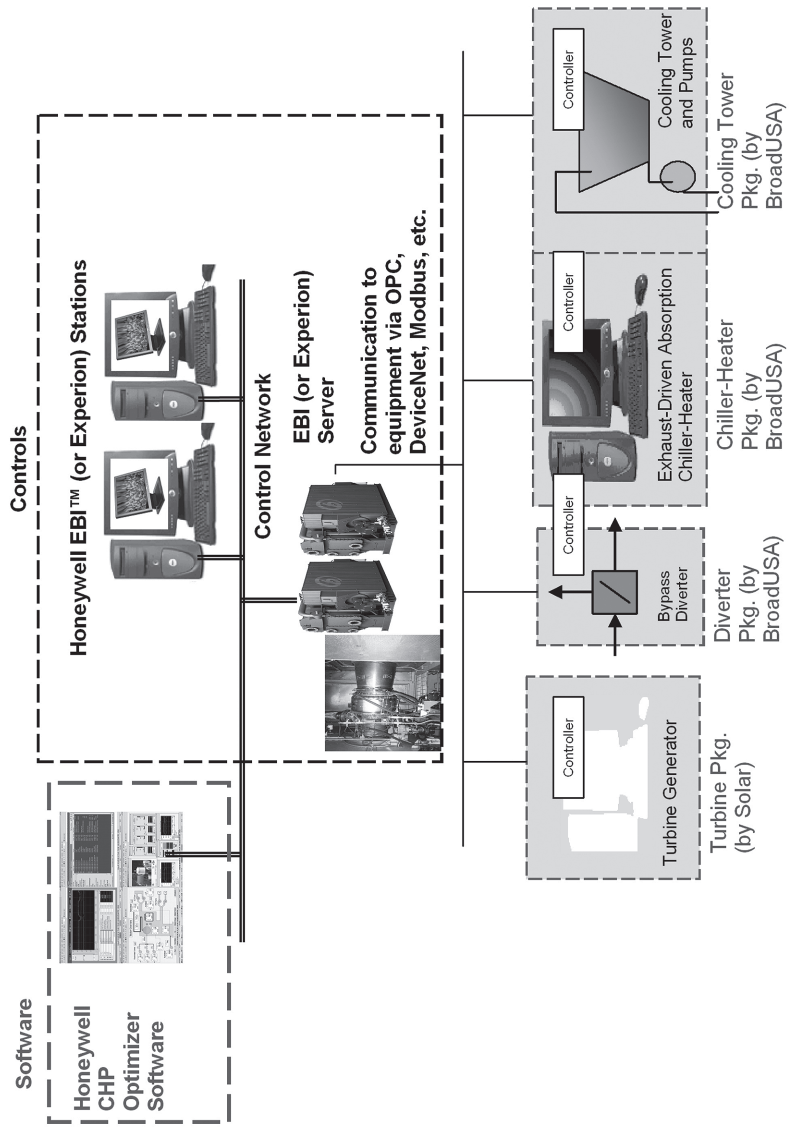

Figure 6. Modular CHP System Controls

1. Produce 1,500 kW generation
2. Provide 400 to 1,000 tons of absorption cooling
3. Connect CHP system to existing 1,500 ton central plant with two gas-fired absorbers and two electric-driven chillers
4. Evaluate piping chilled water and hot water to area buildings to utilize a high percentage of the waste heat from the CHP
5. Optimize the tower-free cooling and thermal storage system in the chilled water plant
6. Connect the chilled and hot water plants to more buildings to gain better economic from the system

SOLAR HOT WATER SYSTEMS

There are many types of solar hot water systems to consider when developing a project. Honeywell has found that very high-quality solar panels and system components are required to last the life of the ESPC. Solar systems are very expensive and need capital or incentive dollars to cash-flow. Figure 7 shows a typical solar hot water system for a domestic hot water system.

The following system characteristics are needed to provide good economics for solar hot water systems.

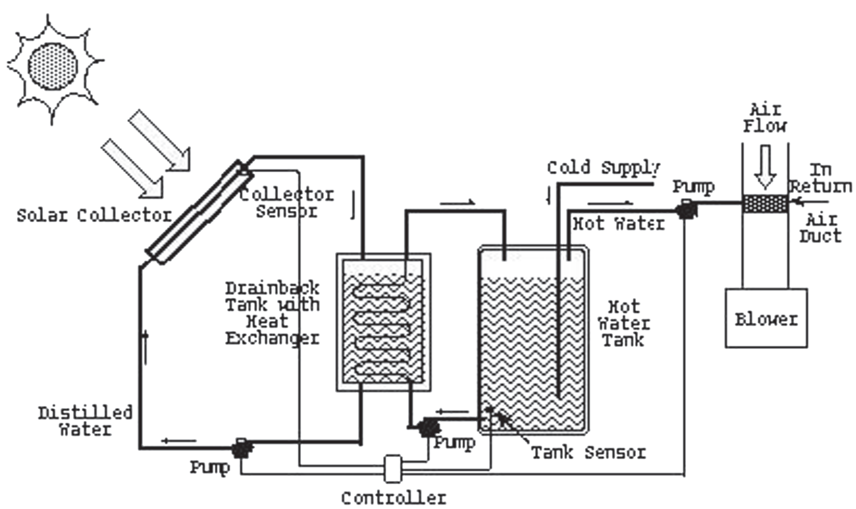

Figure 7. Solar Hot Water System

1. Good baseline domestic hot water usage
2. Incentives from state or utility company
3. Good location for solar panels

Calculating Baselines

Baseline = Savings = All solar hot water energy generated by solar system (electricity and gas)

GROUND-SOURCE HEAT PUMPS

Figures 8 and 9 represent two types of GSHP systems. Figure 8 shows a GSHP system with vertical wells and Figure 9 illustrates a horizontal system. Analyzing the viability of GSHP systems for a facility requires detailed soil information. This information is gathered through expensive testing, which provides the necessary soil conductivity and other parameters so the right piping system can be designed for the heat pump units.

Following are parameters that have to be considered when evaluating GSHP systems:

1. Heating coefficient of performance (COP) of 3 to 5 with 32°F entering water temperature (EWT)
2. Cooling energy efficiency ratio (EER) of 13 to 25 with 77°F EWT
3. 16 to 500 MBtuh heating, 1.5 to 35 tons cooling
4. 150 to 300 ft deep pipe bore holes
5. 1.5 gpm per ton, 1 ton per well (~250 to 350 ft deep)
6. $750 to $950 per ton or $2,500 to $3,500 as retrofit costs

Additional GSHP lessons learned: GSHP ECMs need capital dollars from the end user that are funded for upgrading the HVAC to provide good economics.

High costs make GSHPs very difficult to cash-flow, even when considering rebates. However, simple GSHP systems can provide a payback when bundling with other cash-generating ECMs. Figure 10 illustrates and Table 1 summarizes a system that the Air Force is considering for implementation.

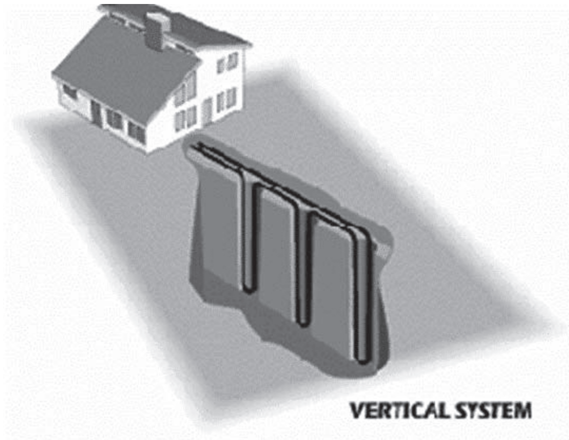

Figure 8. Vertical GSHP System

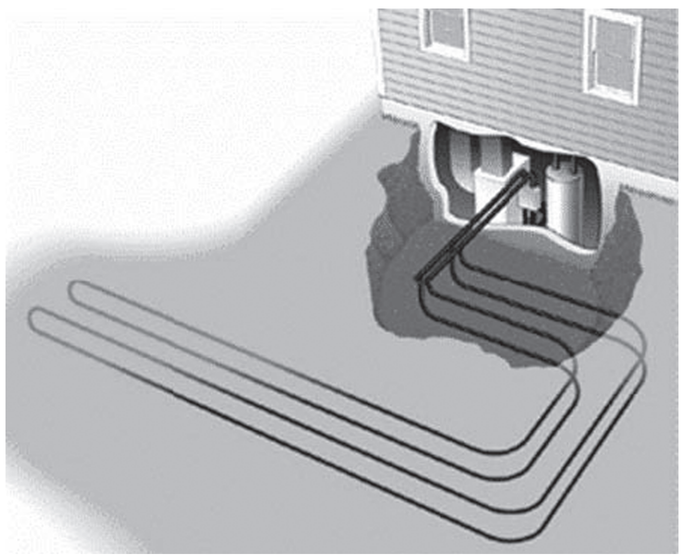

Figure 9. Horizontal GSHP System

Calculating Baselines and Savings

Baseline Energy = Electric and gas energy consumed by existing HVAC

Energy Savings = Difference between energy consumed because of higher COP of GSHPs

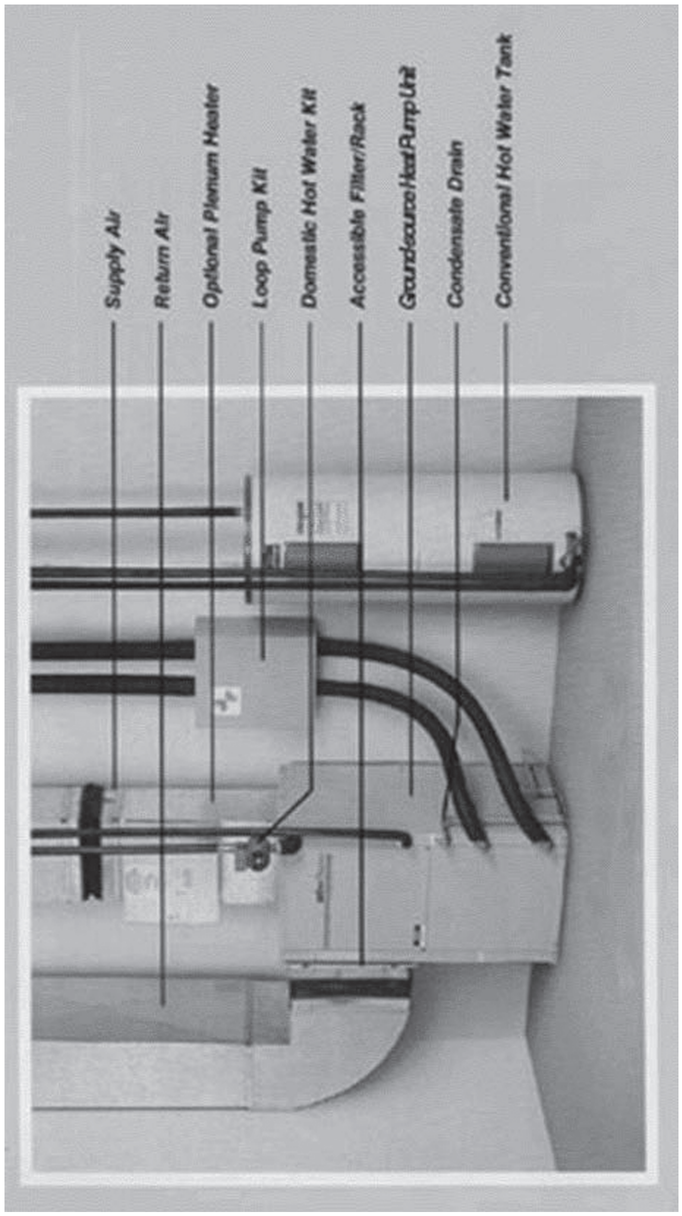

Figure 10. Ground-Source Heat Pump Domestic Water Heat Recovery

Table 1. Payback Example for Ground-Source Heat Pump System and other HVAC Systems

	Air Force Base Example—37,000 ft² Office			
Performance	*Air-Source Heat Pump*	*Gas Furnace with Air-Source Air Conditioner*	*Recommended Level GSHP*	*Best Available GSHP*
Cooling efficiency Heating efficiency	11.0 EER 2.9 COP	11.0 EER 90% AFUE	14.1 EER 3.3 COP	25.8 EER 4.9 EER
Annual cooling energy	37,700 kWh	37,700 kWh	30,700 kWh	20,400 kWh
Annual heating energy	29,800 kWh	1,970 therms	12,600 kWh	10,900 kWh
Annual energy cost	$4,050	$3,838	$2,598	$1,878
Annual savings	Base case	$212	$1,452	$2,172
Lifetime energy cost	$81,000	$76,760	$51,960	$37,560
Lifetime savings	Base case	$4,240	$29,040	$43,440
Installation cost	$24,130	$20,109	$40,217	$48,261
Simple Payback	Base case	94.9 years	27.7 years	22.2 years
O&M or incentive ($)	Base case	$15,869	$11,177	$4,821

Note: Electricity cost = $0.06/kWh, Gas cost = $0.80/therm, Economic project life = 15 years, 0% escalation rate.

CONCLUSION

ESPC projects for federal facilities can become much larger when mixing the traditional demand-side ECMs with more advanced ECMs. The latter incorporate new, innovative technologies like renewable energy sources and CHP systems. Coupled with more creative financing, incentives and rebates, this approach can make the project more significant and beneficial.

ABOUT THE AUTHOR

Mr. Jeff Stringfield, P.E., works for Honeywell International and is the solutions development team leader for federal projects in the western states and Asian Pacific. Jeff works in Honeywell's federal energy services business unit and is responsible for solutions development of several federal customers, including many of the Region 5 Air Force projects (including South Korea). Jeff is a mechanical engineer from Kansas State University and an MBA from Arizona State University. He is registered in 15 states. He may be contacted at jeffrey.stringfield@honeywell.com.