A National "Green Energy" Economic Stimulus Plan Based on Investment in the Hydrogen and Fuel Cell Industry

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Introduction

This paper addresses the effects of growth in the hydrogen and fuel cell industry on employment, gross domestic product, tax revenue and the environment as key metrics for a National "Green Energy" Economic Stimulus Plan. Data from numerous sources, including the Fuel Cell Economic Development Plan developed for the State of Connecticut suggest that there are favorable market conditions for the expansion of the hydrogen and fuel cell industry in the United States, public investment is appropriate and justified, and investment in hydrogen and fuel cell technology would provide a favorable return. In addition, there are favorable sites for deployment of hydrogen and fuel cell technology to meet pressing energy needs, improve environmental performance, increase economic development, and create new jobs. The conclusions drawn below reflect predictions for an emerging industry accounting for up to 50 MW of manufacturing production.

Conclusions drawn from this work[1] related to job creation, domestic product and tax revenue include:

Job Creation

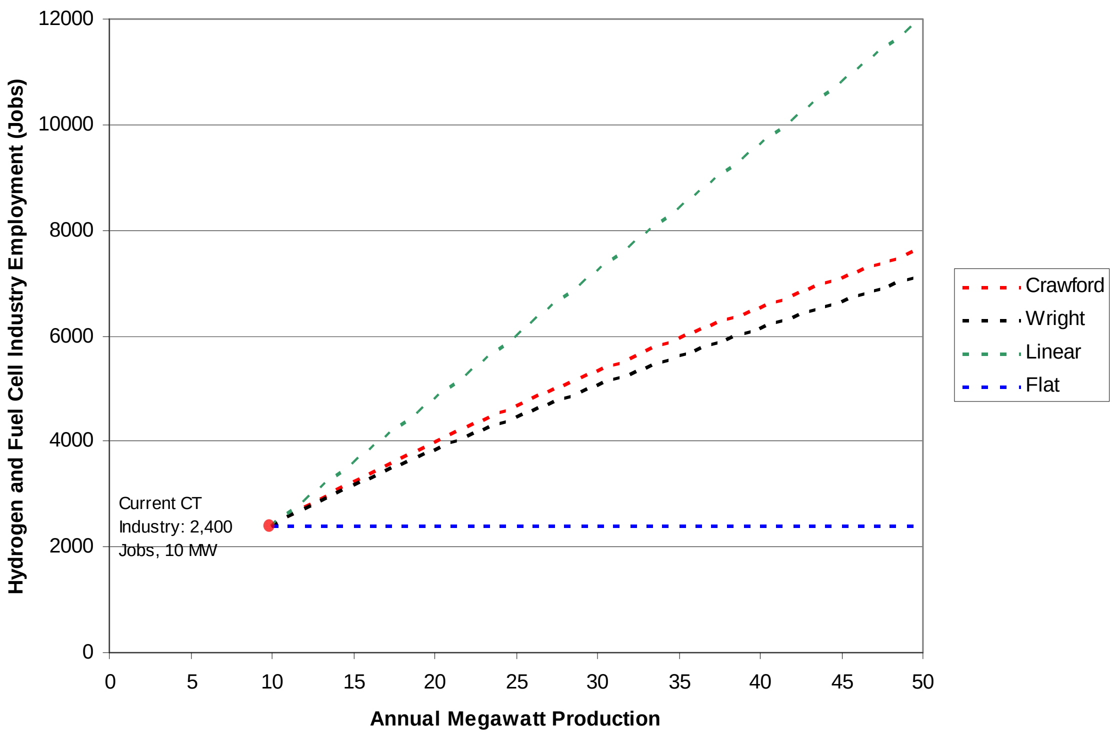
Approximately 2,400 jobs[2] currently support the annual production of 10 MW of fuel cell capacity in Connecticut. In order to attain cost parity with conventional distributed generation technologies, it is estimated that outputs in the hydrogen and fuel cell industry would need to reach 50 MW of manufacturing production annually. As manufacturing production increases, it is expected that there will be an increase in worker productivity. As shown in figure 1, Crawford and Wright models are used estimate productivity gains and job growth in the hydrogen and fuel cell industry based on a 20 percent rate of improvement for each time production quantities are doubled. It is estimated from these models that the number of jobs needed to support the annual production of 50 MW is

[1] The Fuel Cell Economic Development Plan, January 2008, is a primary source of data for this paper

[2] The 2,400 jobs is an estimate that includes direct, indirect and induced jobs associated with Connecticut's hydrogen and fuel cell industry. Indirect jobs are those in the supply chain which are supported by the hydrogen fuel cell industry. Induced jobs are those created elsewhere in the economy by wages spent.

between 7,100 and 7,700.[3] In the production growth from 10 MW to 50 MW, productivity would rise from 1 MW per 240 jobs to approximately 1 MW per 148 jobs, which is a 62.16 percent increase in productivity. A linear growth model estimates that 12,000 jobs would be needed to support the annual production of 50 MW, but this model assumes that no productivity gains occur with increased output. Flat job growth would require the hydrogen and fuel cell industry to increase productivity by 500% to reach a 50 MW annual production output. Productivity is assumed to increase; neither linear nor flat job growth is anticipated.

Figure 1 – Employment



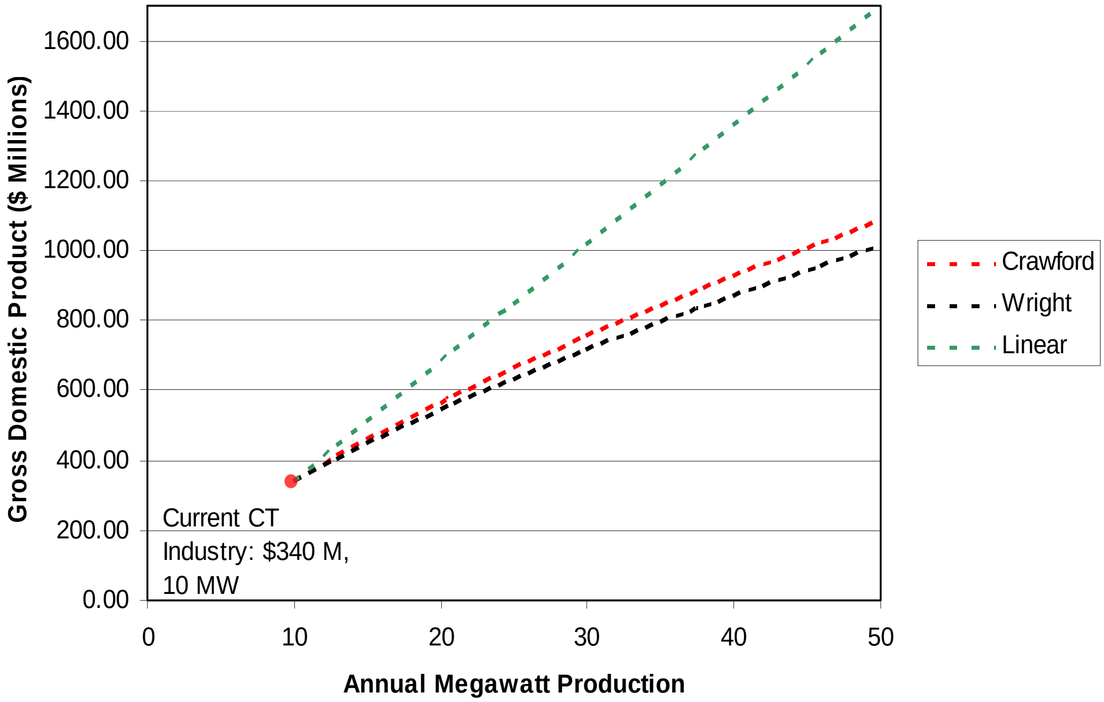
[3] The Crawford and Wright learning curve models are two methods of estimating the effects of increased production on worker productivity. Learning curves were originally employed by Boeing to predict the cost of new airplane models and have since been adapted to other manufacturing disciplines. The Wright learning curve model uses the guideline that doubling the output results in a gain of efficiency equal to the learning rate, resulting in an increase in productivity, while the Crawford uses the same series except with an additional logarithmic decay as production increases so that each successive doubling of output has less impact on the productivity.

Domestic Product

The current 10 MW annual output in the hydrogen and fuel cell industry corresponds to $340 million in gross state product. Under the assumption that marginal revenue per each additional MW remains constant throughout the hydrogen and fuel cell industry's growth up to the annual production of 50 MW, the resulting gross domestic product in the industry would be approximately $1.7 billion. However, higher production quantities will likely result in lower marginal revenues. With the assumptions that 1) the marginal cost associated with the production of an additional MW decreases at the same rate as the marginal labor requirements derived from the Crawford and Wright models and 2) that the price declines of fuel cell products follow these cost estimates as the hydrogen and fuel cell industry scales up to an annual production of 50 MW, then the annual gross domestic product from the hydrogen and fuel cell industry is estimated to be between $1 billion and $1.1 billion equal to a gross domestic product of approximately $20 to $22 million per MW.[4] The projections shown in Figure 2 represent the potential value of gross domestic product generated by the hydrogen and fuel cell industry for annual the production of 50 MW.

[4] Calculated as a part of a 50 MW block of production

Figure 2 – Gross Domestic Product



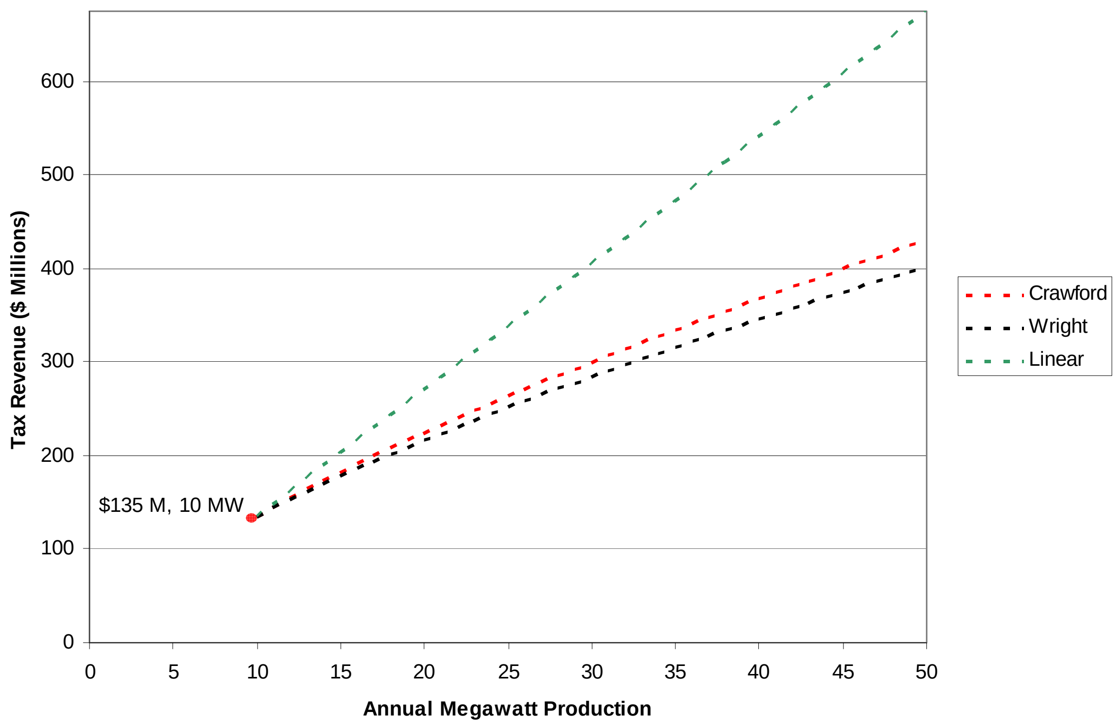
Tax Revenue

Based on the gross domestic product estimates derived from the Crawford and Wright models above and an average state corporate tax rate of 6.57 percent, and an adjusted federal tax rate of 32.7 percent,[5] it estimated that 50 MW of production would yield state tax revenues between $66 and $72 million and federal tax revenues between $331 and $354 million. Local taxes were estimated using $2 million dollars for 10 MW of production in Connecticut and then scaled to the national property tax rate average.[6] That adjustment coupled with the assumption that the property tax base will rise through capital investment at the same rate as gross domestic product, yields an estimated local tax revenue of between $4.5 and $5.5 million for 50 MW of production. In total, 50 MW of production would result in a total of $401.5 to $431.5 million in federal, state and local

[5] The state and federal tax rates are from the Organization for Economic Co-operation and Development's (OECD) 2008 report on corporate tax rates in OECD countries.
[6] The average property tax rate in Connecticut is 1.72 and the average property tax nation wide is 1.38 (Moody's Economy.com, April 2007)

taxes annually, equal to between $8 million and $8.6 million per MW.[7] Figure 3 represents the total tax revenue for local, state and federal for 50 MW of production.

Figure 3 –Local, State, and Federal Tax Revenue



Economic Multipliers for Connecticut's Hydrogen and Fuel Cell Industry have been shown to be favorable for economic development and job creation as follows:

Table 1 – Economic Multipliers[8]

	Employment	Industry Revenues	Employee Compensation
Multiplier	2.31	1.84	1.72

[7] Calculated as a part of a 50 MW block of production

[8] The multiplier is a calculated number derived by the IMPLAN input-output model for Connecticut's economy and the industry sector. The input-output model is developed utilizing data from the census bureau, Bureau of Labor Statistics and the US Bureau of Economic Analysis.

The employment multiplier of 2.31 indicates that for each job the hydrogen and fuel cell industry directly supports, an additional 1.31 jobs are indirectly supported elsewhere in the economy. Likewise, the revenue multiplier of 1.84 suggests that for each dollar of revenue generated by the hydrogen and fuel cell industry, an additional 84 cents of revenue is received by other businesses. The compensation multiplier of 1.72 indicates that for every $1.00 paid to employees within the hydrogen and fuel cell industry, an additional 72 cents is paid by other employers in the supply chain.[9] While these economic multipliers have been identified for Connecticut, a similar relationship could be expected for other states.

These near-term projections of industry growth are encouraging; however, this growth is modest compared to the potential opportunities of a mature global market. It has been estimated that the global fuel cell/hydrogen market, when mature, could generate between $43 billion and $139 billion annually.[10] Revenues to Connecticut companies in a mature global market could be between $14 billion and $54 billion annually, which would require an employment base of tens of thousands.

The market for hydrogen and fuel cell technology is expected to grow for the following reasons:

- World electric consumption is projected to more than double between 2003 and 2030. This growth will place a high demand on distributed generation for use in many regions that lack transmission infrastructure.[11]

[9] Presently, Connecticut's hydrogen and fuel cell industry employs 1,156 employees; an increase of 229 jobs since early 2006. Under existing trends, it is projected that by the year 2010, Connecticut would be positioned to increase direct employment to over 1,600 jobs.

[10] Connecticut Fuel Cell Economic Development Plan

[11] In the stationary market, fuel cells could capture approximately 7,000 MW of the distributed generation market in the U.S. between 2010 and 2020. The distributed generation goal pursued by the Distributed Energy Office of the Department of Energy (DOE) is that 20 percent of all new commercial building generating capacity additions be from distributed generation sources by 2020. - "Distributed Generation Potential of the U.S. Commercial Sector", Ernest Orlando Lawrence Berkeley Laboratory, May 2005, http://eetd.lbl.gov/ea/EMS/EMS_pubs.html, World Alliance for Decentralized Energy, November 2007

- Transportation demands for petroleum currently exceed domestic supply. To ensure energy security and reduce price volatility, alternative fuels such as hydrogen, and alternative technologies such as fuel cells will be required.[12]
- Increased energy efficiency for transportation and electric generation will be required by all global consumers as traditional fuel prices increase. For example, oil prices have risen steeply from nearly $30 per barrel in 2003 to a peak of approximately $150 per barrel in 2008; arriving much sooner than the U.S Energy Information Administration's (EIA) prediction of $100 per barrel in 2030.
- Reduced emissions of greenhouse gases (GHG) and primary air pollutants from mobile and stationary sources will become mandated by most if not all countries.

While hydrogen and fuel cell technology offers significant opportunities for improved energy reliability, energy efficiency, and emission reductions, barriers have slowed market penetration. These barriers include: high costs, lack of understanding and recognition of fuel cell reliability and durability, unappreciated environmental values, lack of investment needed to undertake research and development, insufficient infrastructure, and strong competition from rate-base supported conventional grid generation.

The most significant barrier to increased market penetration is cost. However, increased production rates and improved design and technology will reduce unit costs. Models suggest that if production were to increase for stationary power applications from a level

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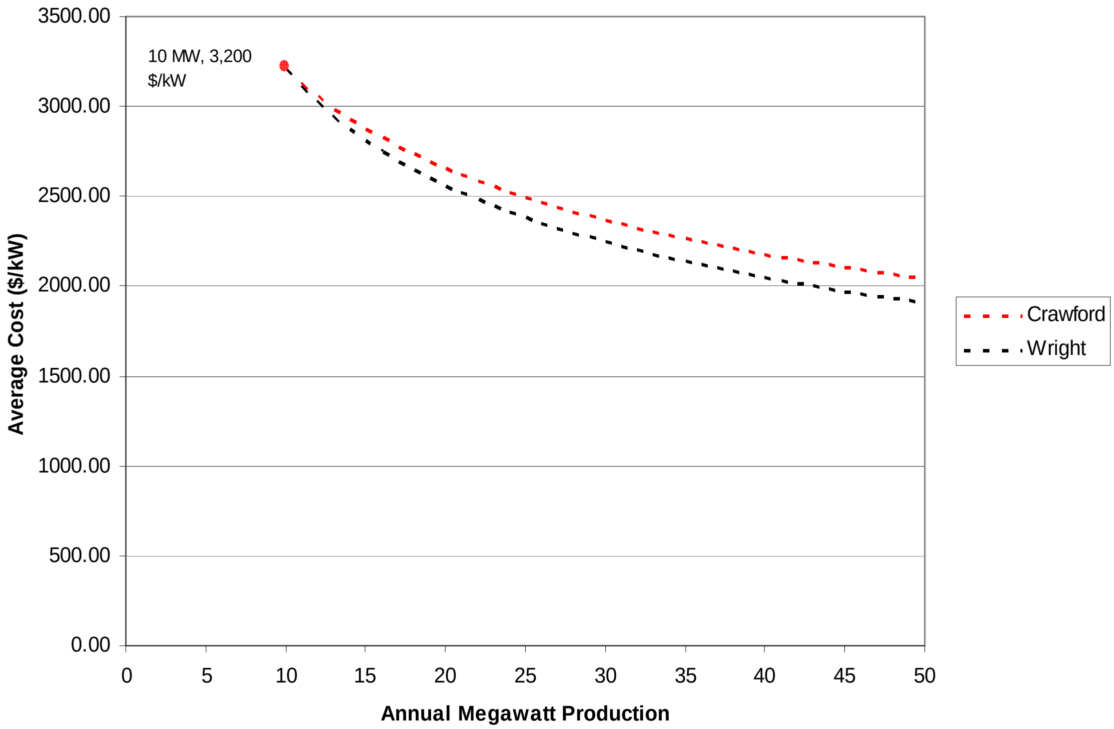
[12] In the transportation market, the potential market for fuel cell technology in passenger vehicles range from 2.1 to 21 million cars per year with total delivered fuel cell capacity between 150 GW and 1,500 GW, and total fuel cell revenues between $4.5 and $45 billion. The potential market for heavy duty vehicles range from 1 to 4 million vehicles per year with total delivered fuel cell capacity between 150 GW and 600 GW. Assuming a power plant cost of $75 per kW, total global fuel cell revenues could be between $11 and $45 billion annually. Nearly all cars and trucks run on gasoline or diesel, and they are the main reason why the U.S. imports more than 55 percent of the oil it consumes (this consumption of oil is expected to grow to more than 68 percent by 2025). Two-thirds of the 20 million barrels of oil Americans use each day is used for transportation. - http://www.hydrogen.gov

of approximately 10 MW per year to a level of 50 MW per year, unit costs would drop to approximately $2,000 per kW; a level closer to parity with conventional distributed generation, as depicted in Figure 4.[13]

Figure 4 - Cost Reduction Gains and Fuel Cell Production[14]



With investment to produce 50 MW of fuel cell capacity per year, domestic industries will be able to reduce unit costs and potentially capture a larger share of the global market. A long term investment for increased deployment will also help to address key market drivers including renewable energy goals, GHG reduction goals, and projected energy capacity deficiencies at particular locations on the grid and at customer sites.

The potential annual energy savings, and reductions in the emission of GHG and primary air pollutants associated with the displacement of 50 MW of conventional electric generation, would be as shown below:

[13] This data is based on production of large stationary fuel cell units in Connecticut
[14] The cost per kW includes reductions from investment tax credits and does not include site and installation costs

Table 2 - Potential Average Annual Emissions Reduction and Energy Savings Using Fuel Cells

Potential Average Annual Emissions Reduction and Energy Savings Associated with the Displacement of 50 MW of Conventional Fossil Fuel Generation			
Air Emissions		Energy Savings	
NO_X	280 tons	Btu	1.75 – 2.0 Trillion
SO_2	234 tons	No. 2 Oil Equivalent	12.5 - 15 Million Gallons
CO_2	180,456 tons		

This means that for each MW of conventional fossil fuel generation replaced with fuel cells, NO_x would be reduced by 11,213 lbs, SO_x by 9,373 lbs, and CO_2 by 7,218,240 lbs. The use of 50 MW would reduce NO_x emissions by 280 tons, SO_x by 234 tons, and CO_2 by 180,456 tons. If fuel cells could capture approximately 7,000 MW of electric demand for distributed generation in the U.S. by 2020, as projected by the State of Connecticut Fuel Cell Economic Development Plan, over 25 million tons of greenhouse gas emissions could be reduced annually.

In addition, fuel cells would increase transportation efficiency by two to three times, as shown below:

Table 3 - Average Energy Efficiency of Conventional and Fuel Cell Vehicles

Average Expected Energy Use (mpge[15])					
Passenger Car		Light Truck		Transit Bus	
Hydrogen Fuel Cell	Gasoline Powered Car	Hydrogen Fuel Cell	Gasoline Powered Light Truck	Hydrogen Fuel Cell	Diesel Powered Transit Bus
81.2	29.3	49.2	21.5	7.04	3.9

[15] Miles per gallon equivalent (mpge) is a unit of measure that relates the efficiencies of different systems

Conclusion

The targeted deployment of hydrogen and fuel cell technology would effectively meet electric power and transportation needs. For stationary power applications, there are many buildings that have characteristics favorable for the operation of stationary fuel cell power plants, including government public buildings, state prisons, universities, hospitals, and many other sites. In transportation applications, transit operations and fleets are excellent applications for initial hydrogen-fueled and fuel cell-powered vehicles. These include: transit buses, delivery fleets, service vehicles for utilities and industry, postal vehicles, and waste collection vehicles.

The challenge for government is to support a strategic economic stimulus plan for deployment that will enhance the development of a "green energy" fuel cell/hydrogen market while providing opportunities for job creation. Consistent with findings from the Connecticut Fuel Cell Economic Development Plan, investment in hydrogen and fuel cell industry could create jobs, while bolstering a "green energy" industry that will have potential for global market penetration. As the global market matures, a favorable return on investment would be expected. Without such action, the United States may face loss of sales, missed economic opportunities, and emigration of employment as other countries compete for fuel cell and hydrogen development activities. With a well established workforce, patents for advanced technology, and a large share of the existing fuel cell power market, the United States has the opportunity to create and sustain a synergistic critical mass of jobs and technology in the fuel cell industry, potentially overflowing to the general energy sector.

In summary, this work[16] suggests favorable market conditions for national investment and the creation of jobs in the emerging hydrogen and fuel cell industry. Support for an

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[16] Much of the data for this white paper has been derived from the Connecticut Fuel Cell Economic Development Plan.

For a full copy of the Fuel Cell Economic Development Plan please visit: www.ccat.us/energy/fuelplan.php, annual minimum development of 50 MW of fuel cell power facilities could create upwards of 7,000 jobs, over a $1 billion of gross domestic product, and over $400 million in federal, state and local tax revenue. Government investment in such a block of fuel cell capacity would create "green jobs" while simultaneously producing needed "green energy" to both stimulate the economy and protect the environment, consistent with federal policy for job creation, economic development, environmental protection and energy management. Furthermore, the timing to move forward with such an initiative is appropriate to capture early markets for future global market penetration.

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www.chfcc.org/Publications/final_plan.asp, or
www.ct.gov/ecd

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