Projecting the Economic Impact of an Expanding Connecticut Fuel Cell Energy Sector 2017 -2042

Prepared by:
Peter Gunther, Senior Research Fellow, CCEA
Fred Carstensen, Director, CCEA

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Table of Contents

Introduction 1

Methodology 2

- Employment 5
- Population 6
- Real Gross Domestic Product 7
- Personal Income 8
- Personal Disposable Income 9
- Personal Income Taxes 10
- Fiscal Impacts 11

Conclusions: *Seize the Day!* 12

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Introduction

The fuel cell industry, in which Connecticut is a leading player, is growing rapidly: by 2024 Global Market Insights projects sales of $25.5 billion, with double-digit annual growth in virtually all markets. Shipments globally exceeded 60,000 units in 2015, while the megawatts grew an astounding 65%, to 300 MW. (This includes all applications of fuel cells: the primary markets are for stationary power, portable power, and transportation.) The U.S. industry accounts for half of that total. The Northeast is a major player in the sector; fuel cell production is of particular significance in Connecticut, whose firms currently account for more than half of fuel cell production in the region, generating more than total 3400 jobs (direct, indirect, and induced). [1] This study provides long-term projections of the potential economic impact of fuel cell production in Connecticut flowing from the assumption that the state will retain its relative market share. On that basis*, it is clear that the fuel cell industry would be a major contributor in restoring Connecticut's economic vitality, particularly in retaining high tech research and advanced manufacturing jobs, generating increased investments, and delivering more tax revenue.*[2]

As noted, Connecticut is one of the leading states in the production of fuels cells. In 2015, the analysis sees Connecticut Cell Fuel industry revenues reaching $308 million in that year. This analysis then projects two possible growth paths for the industry. Based on recent analysis of growth patterns in emerging sectors, the first approach assumes rapid annual growth in the near term out to 2034, and then reverts to a slower annual growth path.[3] The second growth path achieves the same level of growth by 2042, but does so at a constant growth rate.

The Connecticut Center for Economic Analysis (CCEA) assesses the dynamic economic impacts of both growth paths utilizing its REMI version 1.6.6 for the Connecticut economy. The CCEA analysis reveals considerably higher impacts, specifically in net present value (NPV) terms, the more rapid short-term growth approach generates. Such growth is important not just for fuel cell companies, but also for Connecticut's entire economy measured in terms of employment generation and government revenues.

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[1] This employment projection comes from a previous static IMPLAN analysis. Because REMI approaches employment projection from a different perspective and uses more conservative multipliers, the CCEA analysis is more conservative than the IMPLAN projection.

[2] From late 2007 to 2012, Connecticut's economy, measured in output, contracted, among the worst recessions in the nation. As of October 2016, Connecticut has not yet recovered in either employment or output to the previous peaks.

[3] The growth path for emerging sectors is typically rapid early growth with slower growth later, thus it follows a logistic function; using a constant growth path understates total impacts.

Methodology

Equation (1) describes revenue growth paths where time is in calendar years less 2011. Thus 2016 less 2011 is time (t_1) so the first year of the series t_1=5. (N.B. The parameters are to the fourth decimal to allow for reproduction of the results. These are not unique solutions and are therefore open to sensitivity analysis.) Both revenue curves, for both scenarios—the rapid (logistic) growth and the straight line growth—shown in Chart 1 below, result from using current industry revenues and 2042 revenues at 10 times those of 2017.

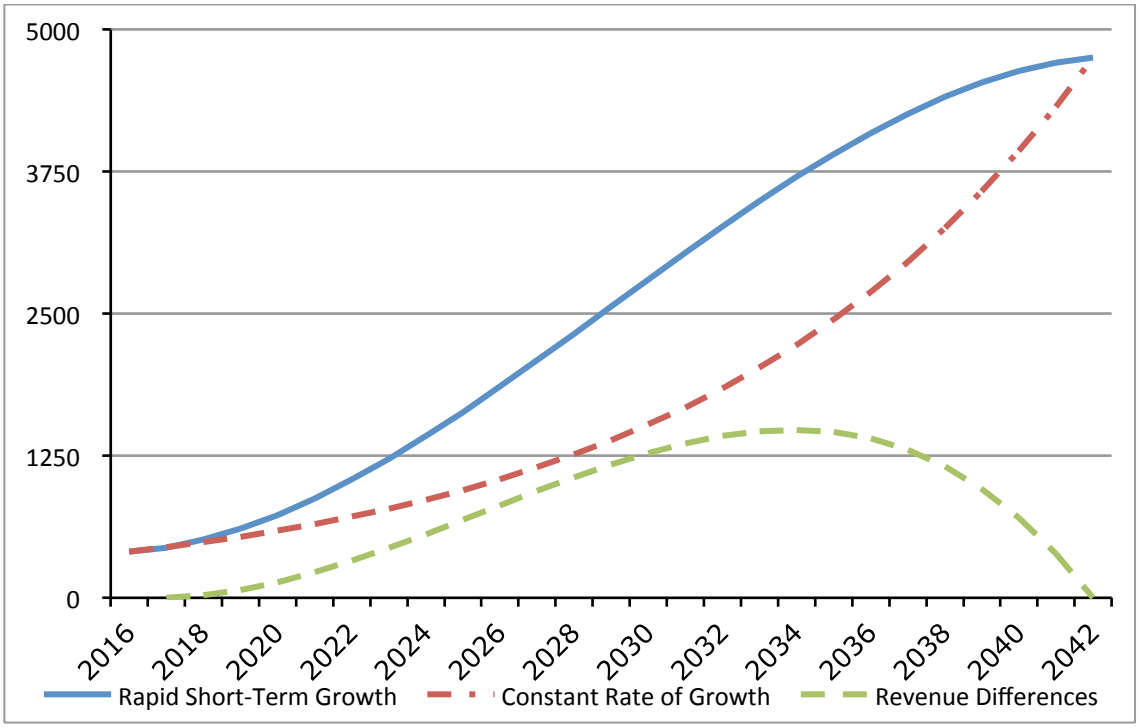
Equation (1) : $(\text{Revenue})_t = 962783391.2330 – 222{,}974{,}186.7204*t + 24{,}197{,}418.6756*t^2 – 422{,}783.3902*t^3$

For t = 5 in 2015 to 32 in 2042.

Given recent rapid growth, cell fuel revenues are expected to approach $405 million in 2016. With short-term rate of growth slowing 2016-2017, CCEA has limited 2017 revenues to $443 million before regaining rapid growth through the near-term to 2034. Hypothetically, as the industry matures going out to 2042, annual revenue growth having peaked in 2034, subsides gently until 2041-42, by which time is declines to one percent and annual revenues reach $4,752 million; annual growth remains at one percent thereafter.

An alternative growth path for getting to the same 2042 total revenue is to growth at a constant rate from 2016 to 2042, which implies an annual growth rate of 9.937% [this meets the requirement of the constant growth rate that begins with the 2016 revenue base and ends with 2041 revenues of $4,752 billion). Chart 1 depicts the two annual growth paths with the vertical distance between the curves in any given year being the difference in revenues generated. The difference in annual revenues increases out to 2034 when it peaks at $1,477.5 million, a 66.3% bonus over the constant growth path. Over the period out to 2042, the rapid growth scenario produces additional revenues of $20,826 million relative to constant rate of growth, which the entire area under the difference curve shows. In NPV terms, discounted at 5%, differences in annual revenues aggregate to $9,826 million.

Chart 1: Alternative Growth Paths for Connecticut Fuel Cells 2015-2042 (Millions $)



Note: the typical approach to projecting revenue growth is to rely on a simple steady rate, but the historical pattern for emerging sectors such as fuel cells is an accelerating rate of growth during the initial growth period—thus the rapidly rising logistic revenue curve shown here—followed by a decelerating rate of growth as the sector approaches maturity. Fuel cell production appears now to be on such a trajectory; the result is a dramatic difference in aggregate annual revenues with much large economic impacts earlier in the growth dynamic. This emphasizes the importance of strong support for the Connecticut industry in the near term, helping to retain its leading role during the strongest growth period.

REMI

REMI is a general dynamic equilibrium economic model which Regional Economic Models Inc. in Amherst, Massachusetts developed. Working in tandem with the national economic model from the Regional Seminar of Quantitative Economics and the University of Michigan[4], CCEA uses REMI to simulate county and state economies out to 2050. In doing so it establishes differential rates of growth

[4] CCEA remains an active participant in RSQE's annual deliberations. See RSQE, **The Economic Outlook for 2015**, University of Michigan at Ann Arbor, 2016.

in income and employment among counties and utilizes them to establish population shifts both within the state and inflows into Connecticut that come in response to economic opportunities. Capturing the migratory impacts allows the model to take further account of the changing demands that migrants generate over time for housing and private and public goods and services as part of establishing total gross and net economic impacts.

This application focuses on the different growth paths alone in a limited REMI application. It does not take account of the role of fuel cells in increasing energy reliability or lowering greenhouse gas (GHG) emissions in Connecticut because CCEA has no data on the extent to which the cells are marketed in Connecticut as well as other jurisdictions. If markets are equally distributed in closely adjoining and nearby states, the amenity value of lower GHGs in attracting population would also be balanced so that the migration would be at least muted and likely not much of a force in enhancing Connecticut's relative growth. To the extent that fuel cell applications are more concentrated in Connecticut rather than neighboring states, this analysis does not capture the value of creation of beneficial amenities capable of enhancing the state's attractiveness.

While CCEA knows that the level of direct employment generated by Connecticut's cell fuel industry was 1,133 in 2015, that information is not utilized in the modelling because its use with revenues would result in double counting. To project the industries' entire impact, REMI was run with just annual revenues in each growth scenario treated as incremental. The resulting additional employment opportunities erode citizens' relocating to find work. In so doing, the immediate results have parallels to those achieved in an earlier static report[5] which utilized IMPLAN, an alternative static macro-economic model for the Northeastern United States with some specific state analysis.

Through REMI, CCEA measures economic activity in Connecticut via economic indicators:

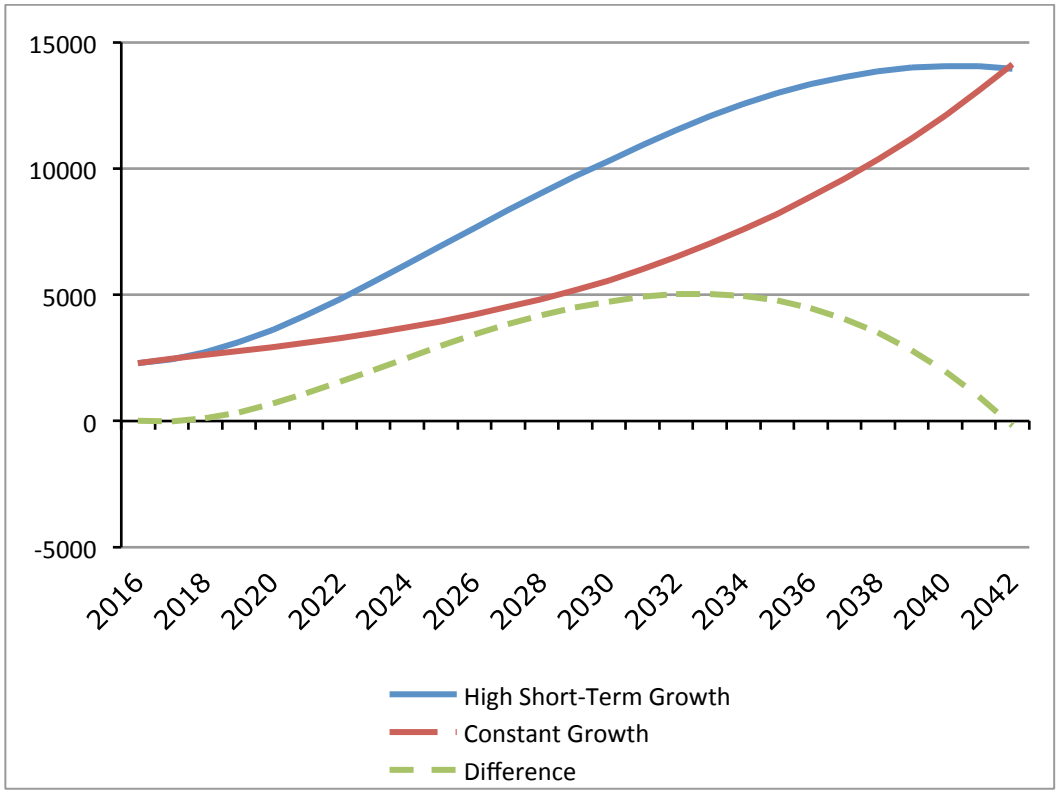
- Employment;
- Population;
- Real Gross Domestic Products (RGDP)
- Personal income;
- Personal disposable income;
- Personal income taxes; and,
- Fiscal impacts.

[5] Todd Gabe, 2015 Economic Impact of the Northeastern Hydrogen Energy and Fuel Cell Industry.

Employment

Not unexpectedly, employment impacts grow faster with more rapid growth but then slow as growth cools in the late 2030s and early 2040s. Chart 2 illustrates that the general pattern of employment growth follows similar patterns to revenue growth shown previously for each scenario, with the more rapid growth case generating more employment sooner; the largest difference occurs in 2033 at 5,040 jobs. These job increases impact on the rest of the economy through induced effects. In the high growth short-term case, employment multipliers rise modestly throughout and remain above those of the constant growth case until 2032 at 2.98[6], when the latter finally begins to catch-up. More importantly on average, the high growth scenario generates an average of 1,025 jobs a year more than the constant growth scenario.

Chart 2: Incremental Employment 2016-2042 (# Jobs)

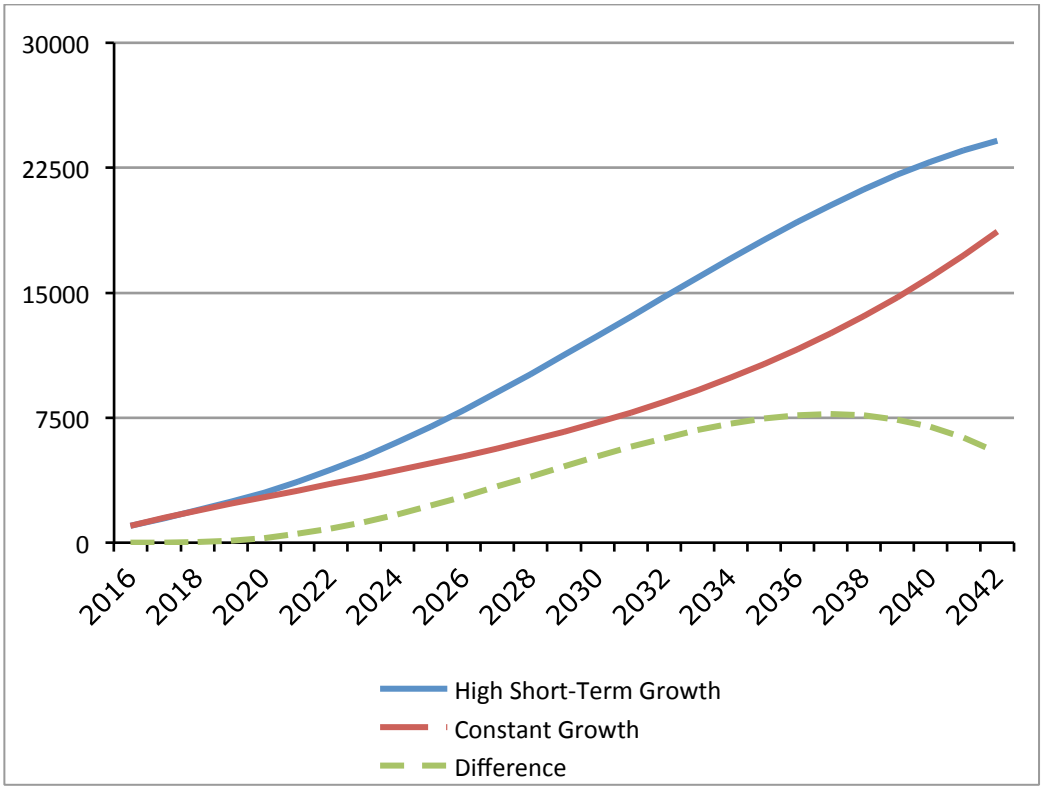


[6] REMI does not detect traditional number on direct, indirect and induced jobs. As a proxy the above uses industry employment in manufacturing energy cells generated in REMI as the denominator and all incremental jobs as the numerator. REMI total employment and multiplier estimates for 2015 are lower than IMPLAN's, mentioned in the introduction, and are therefore more conservative.

Population

Chart 3 demonstrates how population reacts positively to the employment the fuel cell industry generates and related direct and induced impacts. Over time additional workers will be required and these workers will raise their families in Connecticut. The population difference is expected to remain positive at the end of the comparison period when considering all lags associated with those demographic dynamics. The largest difference in incremental population is 7,715 in 2037. In total the high growth case will attract or retain 24,000 people including dependent children of the workers by 2042, filling 14,000 direct, indirect, and induced jobs.

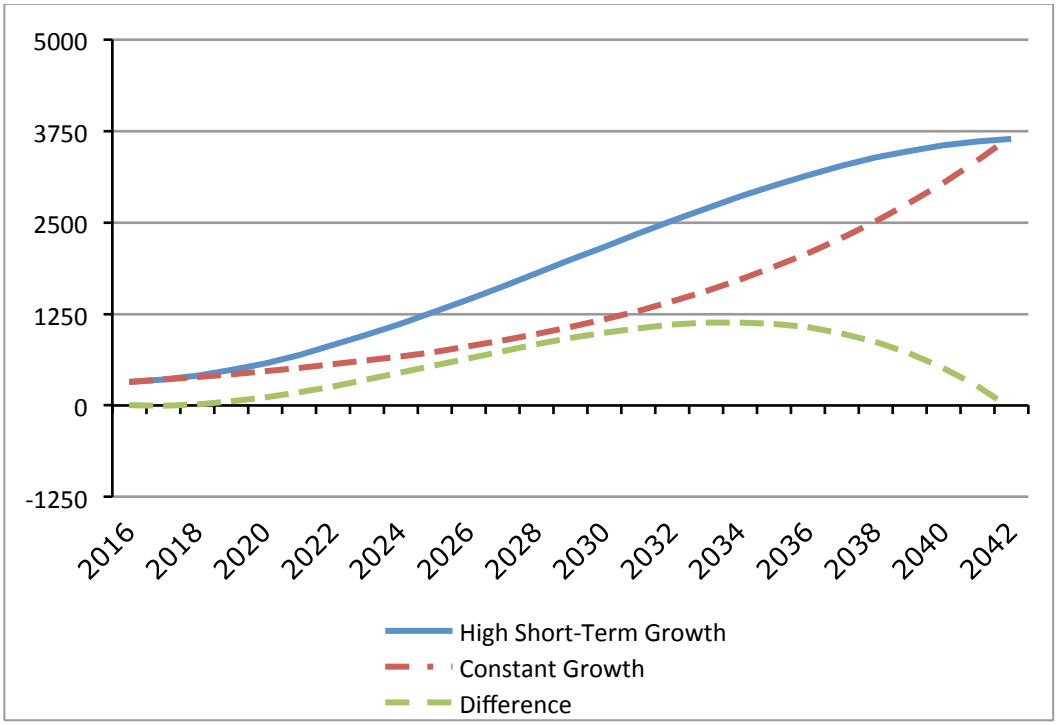
Chart 3: Incremental Population 2016-2042 (# People)



Real Gross Domestic Product

Of the income measures in this report, RGDP is the only one in constant 2009 dollars.[7] It has the advantage of being net of inflation and for those reasons is reported. The rapid growth scenario generates an additional $16,024 million in RGDP 2015-2042; annual differences peak in 2034 at $1,034 million.

Chart 4: Incremental RGDP 2016-2042 (Millions 2009 $)

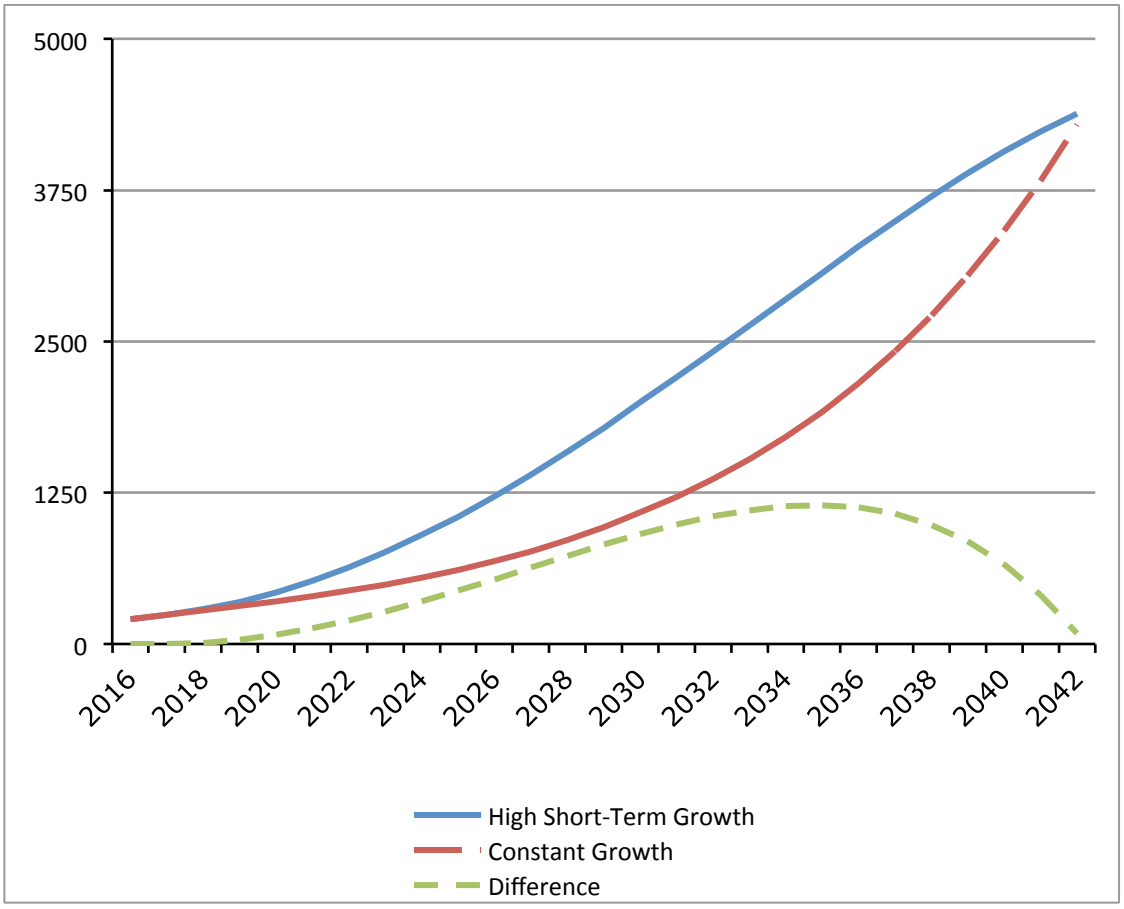


[7] National accounts, on which REMI draws for RGDP, are kept in constant—inflation adjusted—dollars. Currently 2009 is the base year; periodically the national accounts are updated with more recent base years. But they are always expressed in constant dollars.

Personal Income

Unlike RGDP in constant dollars, REMI measures personal income (PI) in current or as spent dollars. Rather than excluding inflation, PI includes it. For that reason, the PI results may exceed those for RGDP. In 2042, fuel cells add $4,223 million to Connecticut PIs. Of the two growth paths, the fast short-growth one generates an additional $53,596 million in PI over 2015 to 2042, an additional $15,754 over the entire period relative to what the constant growth case generates, as Chart 5 shows

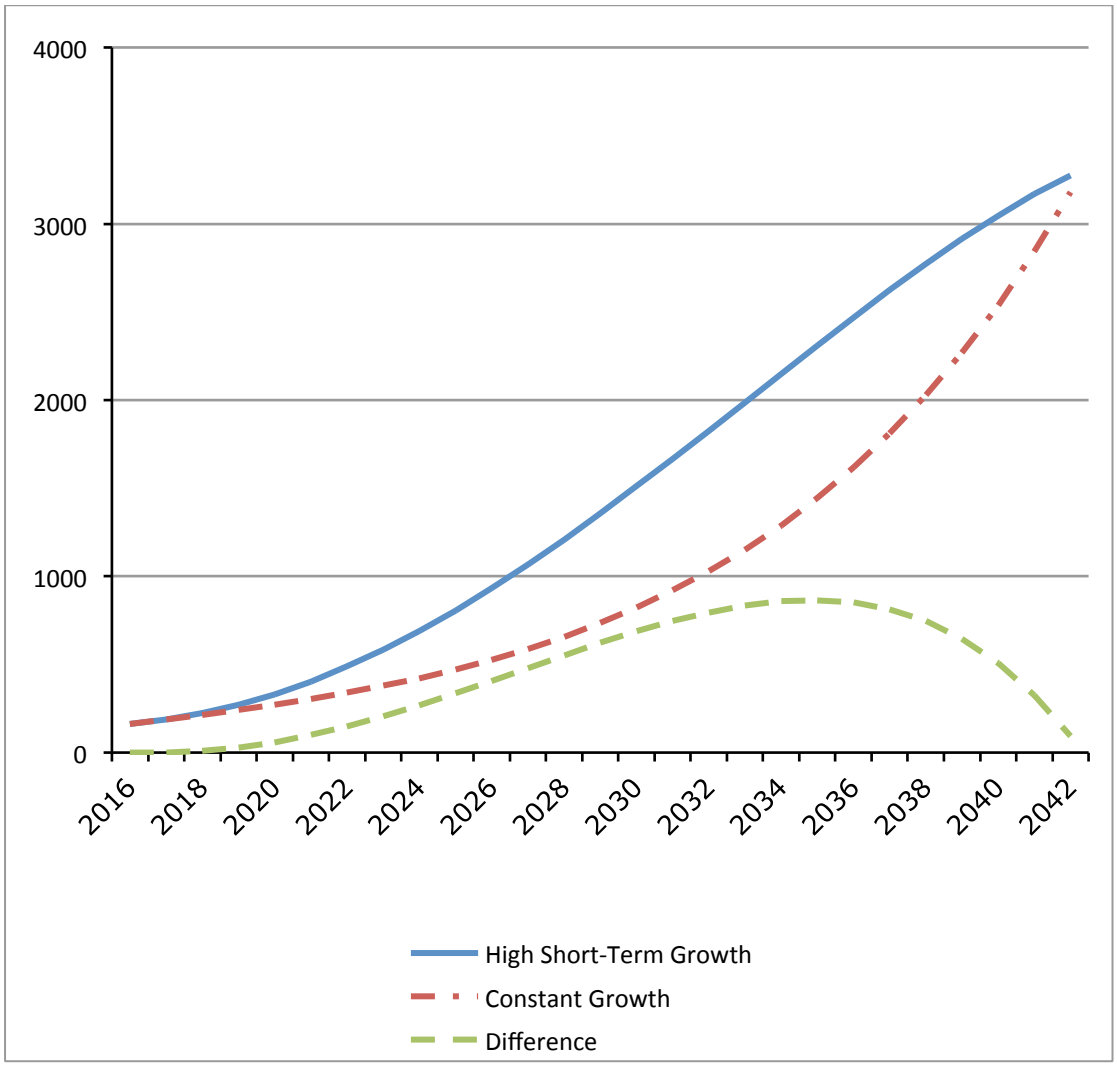
Chart 5: Incremental Personal Income 2016-2042 (Millions Current $)



Personal Disposable Income

To all intents and purposes Personal Disposable Income (PDI) is PI less personal income taxes. It is an important measure because it determines the additional funds which citizens have at their own disposal to spend as a result of the expansion of the cell fuel industry. Chart 6 illustrates that PDI impacts reach $3,273 million in year 2042. With the annual difference peaking in 2034 at $1,139 million, over the entire period the logistic growth path generates an additional $11,981 more than the constant growth case..

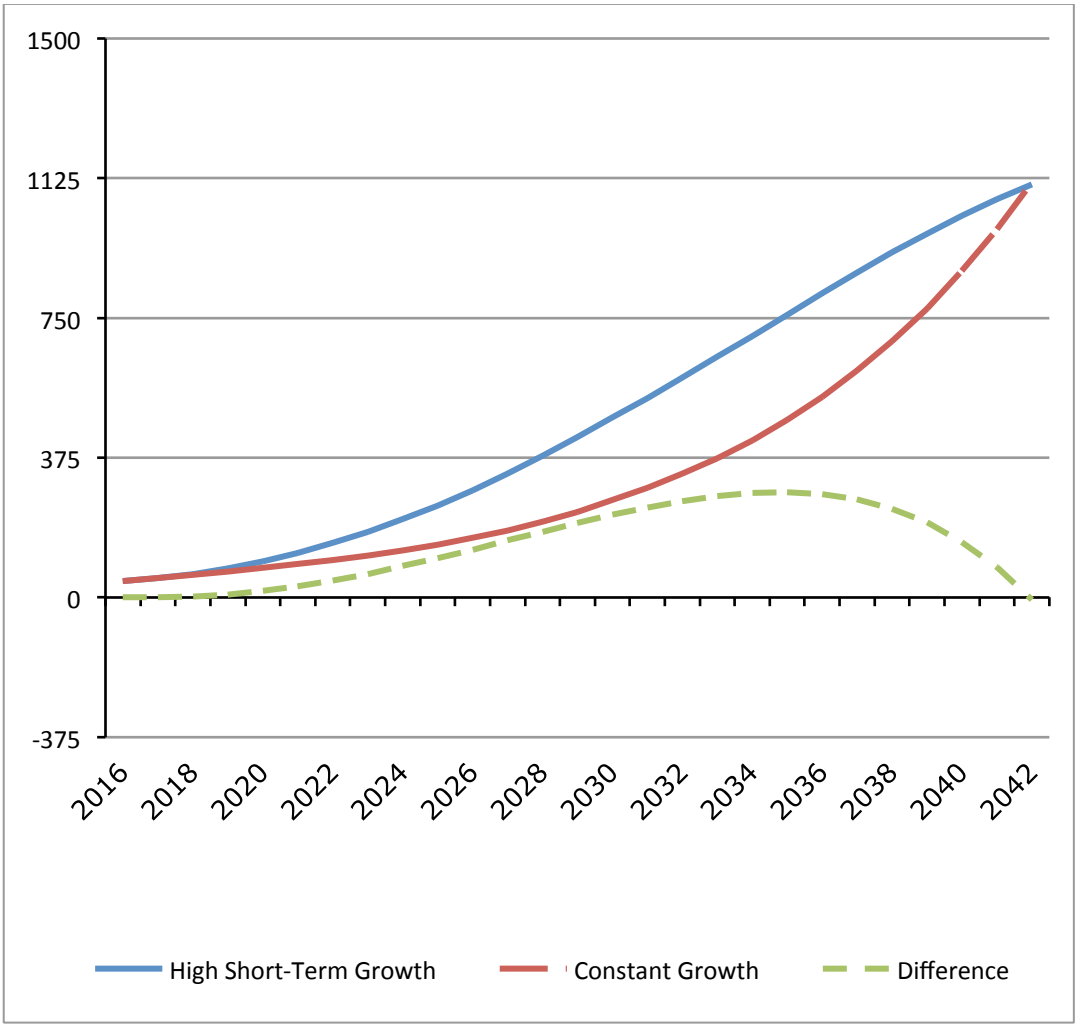
Chart 6: Incremental Personal Disposable Income 2016-2042 (Millions Current $)



Personal Income Taxes

Chart 7 shows the differences between PI and PDI as personal income taxes paid collectively to both federal and state government. Connecticut's direct share in these proceeds is about 23% of $13,174 million collected over the duration 2015-2042 in the logistic growth scenario. In 2029 the close proximity of the taxes paid in the constant growth case and the difference paid under the high growth scenario indicate that the personal federal and state income taxes under the high growth scenario came within $30 million of doubling those tax revenues to governments. Over the entire period, the constant growth scenario would generate $9,402 million in aggregate tax revenue; the high growth scenario $13,174 million, again with 23% accruing to the state. The difference in the personal income taxes collected between the two growth paths is $3,772 million, with Connecticut's share projected at $868 million.

Chart 7: Incremental Personal Taxes 2016-2042 (Millions Current $)



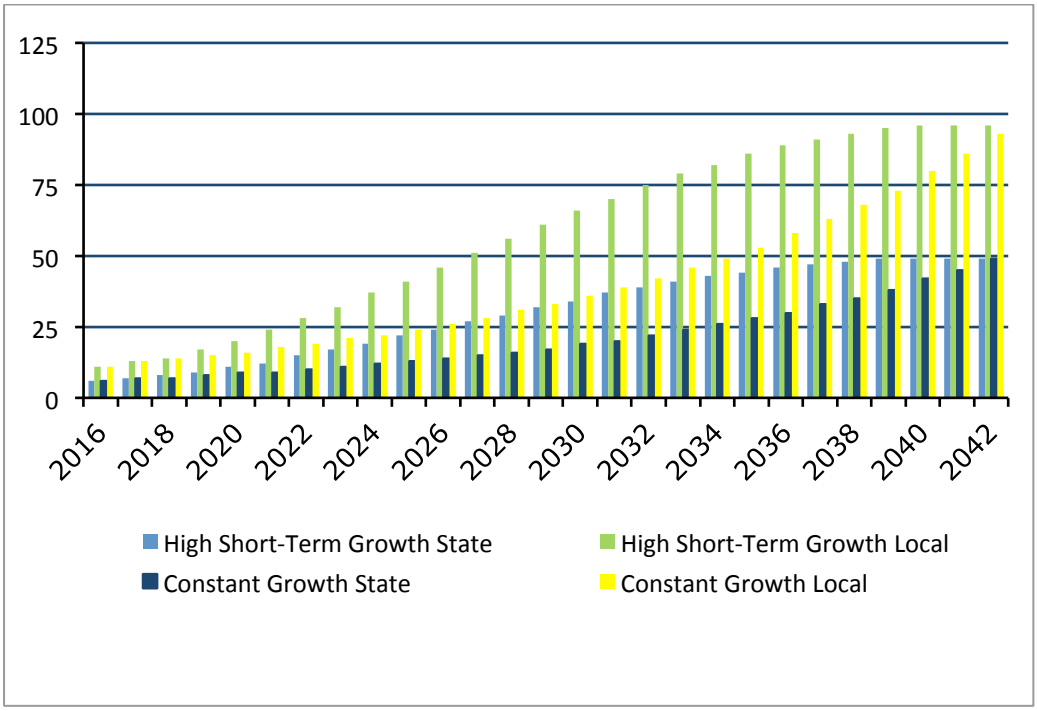
Fiscal Impacts

There are, of course, fiscal impacts beyond the flow of personal income taxes. The REMI results point to state sales taxes increasing $1,426 million over the period under the high short-term growth scenario, by $999 million under the constant growth scenario. Property taxes, licenses, and other fees generate additional government revenues.

Governments also incur expenses to provide services to the larger population. At this juncture, it is sufficient to illustrate that growth in the fuel cell industry generates incremental personal income taxes much more needed to offset additional government expenditures. REMI projects incremental expenses for local and state governments on the same basis as they appear in the national and state accounts in constant (2009) dollars Chart 8 shows.

Chart 8: Incremental Government Expenditures 2016-2042

(Millions 2009$)



The chart illustrates that impacts on government expenditures are higher for local than state governments and with the larger impacts on population in the high growth scenario than the constant growth scenario. The cumulated differences between the growth paths amount to $248 million at the state level and $488 million among local governments. But even under high short-term growth scenario, these increased cost of public services are quite modest at $2,378 million 2015-2042 relative to the large increase tax revenues the growth generates.

Conclusions: *Seize the Day!*

The expected short-term rapid growth path generates far superior macro-economic impacts compared to even quite robust steady growth – above 9.9% – even when after 25 years of growth from 2017 the two growth paths reach the same point. The analysis underlines how sustaining Connecticut's leading role and market share in the industry, regardless of the growth path the industry takes over the next three decades, delivers significant new employment, strengthens population growth, and is on net beneficial to government revenues. If the fuel cell industry's growth follows the anticipated logistic growth path, with rapid early expansion, retaining Connecticut's position delivers even more in jobs, income, and public revenue. In a state struggling to generate significant growth in quality jobs, expansion in real output, and improved tax revenue, the fuel cell sector has the potential to deliver a powerful helping hand.

Table 1: Summary of Findings Aggregated 2015-2042

	Metric	High Short-Term Growth	Constant Growth	Difference in Growth Paths*
Employment	Number of jobs	243,933	169,614	74,319
Population	Number of people	319,607	210,300	109,310
Real Gross Domestic Products (RGDP)	Millions 2009$	53,574	37,550	16,024
Personal income	Millions current $	53,596	37,843	15,754
Personal disposable income	Millions current $	40,422	28,441	11,981
Personal income taxes	Millions current $	13,174	9,402	3,772
State personal income taxes	Millions current $	3,030	2,162	868
State sales taxes	Millions current $	1,045	1,035	10
State expenditure impacts	Millions 2009$	813	565	248
Local expenditure impacts	Millions 2009$	1,565	1,077	488

Note: Some discrepancies due to annual rounding.