Impacts of the Indian Point Energy Center on Property Values

Summary of finding

My analysis indicates that there is an unambiguous negative impact on the value of residential services and on house prices for residential property within 5 kilometers of IPEC. I find to a reasonable degree of scientific certainty that there is an adverse impact on property values resulting from IPEC's presence in the community. My analysis suggests that decommissioning of IPEC and reclamation of the site for alternative uses would generate a recovery in property values that could add more than $1 billion dollars to the value of residential property, increasing its value by approximately 27%. This would increase the wealth of many individuals residing in the community and generate significant impacts on surrounding land use.

Introduction

My objective in this analysis is to determine whether there is a significant impact on property values that can, using a scientifically valid method, be attributed to the presence of the Indian Point Energy Center. Detecting such an impact requires careful analysis because the presence of the Center results in changes in the local economy and community that could potentially lower as well as increase property values. These arise because of the potential localized effect and disamenity associated with having the nuclear power plant and onsite storage of waste materials as well as the payment of significant taxes to local authorities which may or may not have an impact on the property taxes that must be paid by local property owners.

Environmental disamenities and potential localized effects can have impacts on the value of many different types of property. These impacts are of particular importance for properties whose location is fixed relative to the potential localized effect or disamenity because they cannot be reduced through relocation so that the value of the property must bear the full weight of the disamenity. The values of these properties are determined in the marketplace by the unfettered interplay of supply and demand, in which owners of property and those who wish to become owners entertain offers, make offers, and bargain until an agreement on the transfer price is reached. These prices, obtained when buyers and sellers are independent and negotiate without constraint or other intervening forces, constitute the best available measure of the value of the property. An owner will not relinquish ownership unless he or she is compensated for the loss of the benefits (present and future) that are associated with ownership. Similarly, a buyer will not agree to pay a sum that exceeds the anticipated value of the benefits associated with ownership. In this sense the prices, observed over many transactions, provide a reasonable measure of the value of the property.

While environmental disamenities and localized effects can and do affect many different types of properties, my focus in this report is on *real property* since the location of such properties is part of the legal definition of the property and is fixed relative to the disamenity. The use of market prices to measure the impact of a particular disamenity or localized effect is not always possible because the sales of some types of property takes place infrequently or because when such sales do take place the agreed transaction prices are not recorded or available as a public record. Detailed analysis is possible for residential property. In most communities residential property is the most frequently traded form of real property, and the system of real property registration records these sales and the associated price and sales date.

Residential property is a durable good that provides its owner with important benefits. These include housing services, providing shelter for occupants and their personal belongings. Housing services can either be consumed directly by the owner or rented to others by the owner. A second benefit for the owner is the asset value of the property and its potential as a store of value and source of capital gains. The values of these two benefits are closely related. The value of residential property as an asset is the present value of the stream of housing services less maintenance expenses and taxes over the expected life of the property. Using simple discounting, this relationship is summarized mathematically in the following expression:

$$price = \sum_{t=0}^{T} \frac{r_t - x_t - m_t}{(1+i)^t} \tag{1}$$

Where

price	=	The market price or value of the real property
T	=	The expected maximum life of the property (could be effectively infinite)
t	=	An index for the time period (year) where a value of 0 indicates the present and higher values represent the number of years in the future
i	=	The interest rate, cost of capital, or discount factor representing the cost of delaying receipt of revenues or benefits by one year
r_t	=	The value of the housing services supplied (amount for which the property could be rented) during period t
x_t	=	The value of tax payments (including property tax payments) during period t
m_t	=	The value of required maintenance expenditures during period t

This relationship between the price or market value of the residential property and the values of the residential services, property taxes and other variables is well-understood by economists, has been empirically tested and validated in hundreds of studies and is therefore widely accepted scientifically.

It is generally convenient to simplify this model to assume that with proper maintenance residential property can last effectively forever, that the value of housing services, associated property taxes, and maintenance expenditures begin from fixed base values of *r*, *x*, and *m* respectively, and grow at a constant rate of $(1 + i - \lambda)$. In this case the expression for the price of housing becomes:

$$price = (r - x - m) \cdot \sum_{t=0}^{\infty} \frac{(1 + i - \lambda)^t}{(1 + i)^t} \tag{2}$$

which simplifies to:

$$price = (r - x - m) \cdot \frac{(1 + i)}{\lambda} \tag{3}$$

To understand this expression, note that the first term $(r - x - m)$ is the value of housing services received for one period minus the cost of property taxes and the cost of maintenance. This term will generally be positive if the house is occupied or rented. If the term were to be negative, it would mean that the value of the housing services provided was not sufficient to cover taxes and maintenance so that the property would either be abandoned or converted to alternative uses. If we think of *r* as the market rent of the property for one year, the term in parentheses would be the net income (rent minus taxes and maintenance) to the landlord.

The relationship implies in particular that if buyers and sellers in the marketplace become aware of a change that will reduce the value of the housing services supplied by a property during some time period (a decline in *r*) this will tend to reduce the current price of housing. Similarly, when the market becomes aware of a change that will reduce required property taxes (a decline in *x*) this will increase property values. A change in the marketplace that generates both impacts (but leaves maintenance costs, housing durability and interest rates unchanged) will generate an impact whose sign and magnitude depends on the value of the harm arising due to the increased localized effect or disamenity relative to the value of the reduced taxes.

Generally the value of housing services received, maintenance expenses and property taxes will vary from house to house. If we have extensive and detailed data on the characteristics of each property and its surrounding neighborhood, it is possible to use statistical analysis to determine the separate contributions of the various characteristics and neighborhood qualities on the value of housing services and therefore on the price of housing.

If interest is focused on the impact of a single significant change in the community whose location and timing can be determined unambiguously, then a more straightforward approach is to analyze the impact on housing as an asset whose rate of return is (or might be) affected by the change. This approach can focus how the rate of rate of return to holding an individual residential property changes with the arrival of information about the significant change. The approach is similar in spirit to "event studies" that are widely applied to the values of stocks and other financial assets to determine the impact of changes in factors that affect the behavior of firms.

The rate of return ρ to the owner of a residential property during time period *j* is simply the percentage increase in the value of the property during the time period:

$$\rho = \frac{price_{j+1} - price_j}{price_j} \tag{4}$$

Assuming there is no change in the base value of housing services, taxes or maintenance expenditures, this simplifies to:

$$\rho = \frac{\lambda}{1 + i} \tag{5}$$

The situation is more complex in the case being analyzed in the region around the Indian Point Energy Center (IPEC). As stated above, the objective of my analysis is to determine the impact, if any, on property values (and hence on land use and development patterns) that are the result of the presence of IPEC. To determine an analytic approach suited for this analysis, we must adapt the approach presented to allow for possible change in the value of housing services and in the value of property tax payments that takes place when IPEC commences operations in the community. This will provide a framework within which to understand the empirical analysis presented in the next section.

Suppose we have a community where some change occurs in time period *j* that might affect both the value of housing services provided by residential property and also the taxes that must be paid on those properties. It is reasonable to assume that the change that takes place has no impact on the maintenance costs required, the mortgage interest or discount rate, and the rate of inflation. In the context of the model presented in equation (2) this means that the values of *m, i* and λ remain fixed. Then at time period *j* the base value of housing services changes from *r* to $\hat{r}$ and the base value of property tax payments changes from *x* to $\hat{x}$. While the direction and magnitude of this change can only be determined by analysis of the data, if the value of housing services is reduced then we expect that $r > \hat{r}$. Similarly, if the required property taxes are reduced by the change in the community then we expect that $x > \hat{x}$.

If we observe the sales price of each house in every year, then we would expect to observe a change in the housing price that would take place during time period *j*. At the beginning of this time period price would be determined according to equation (3) and by the end of the time period buyers and sellers in the community would become aware of the new values of housing services and of required property taxes, so that the price would be:

$$price_{j+1} = (\hat{r} - \hat{x} - m) \cdot \frac{(1 + i)}{\lambda} \tag{6}$$

The rate of return ρ to the owner of this asset (residential property) held during this period would be:

$$\rho = \frac{price_{j+1} - price_j}{price_j} = \frac{(\hat{r} - \hat{x} - m) \cdot \frac{(1+i)}{\lambda} - (r - x - m) \cdot \frac{(1+i)}{\lambda}}{(r - x - m) \cdot \frac{(1+i)}{\lambda}} \tag{7}$$

This simplifies to:

$$\rho = \frac{(\hat{r} - \hat{x}) - (r - x)}{(r - x - m)} \tag{8}$$

We can rearrange this expression to give the new value of housing services as a function of the rate of return:

$$\hat{r} = \rho\,(r - x - m) + (r - x) + \hat{x} \tag{9}$$

Or the new value of housing services *net* of the new level of property taxes:

$$\hat{r} - \hat{x} = \rho\,(r - x - m) + (r - x) \tag{10}$$

As noted above, the term $(r - x - m)$ is positive. Then equations (9) and (10) have several important implications that can be summarized as follows:

1. The value of housing services received after the change in the community is a positive linear function of the rate of return on residential property as an asset held during the period the change occurs.
2. The value of housing services net of taxes after the change in the community is a positive linear function of the rate of return on residential property as an asset held during the period the change occurs.
3. If the rate of return on residential property as an asset is lower during the period when the change in the community occurs than during other time periods, then the value of housing services has been reduced by the change **and** the value of housing services net of required property tax payments has also declined.
4. If the rate of return on residential property as an asset is lower during the period when the change in the community occurs than during other time periods, then the value (price) of residential property will have declined.

Now that we have a framework in which to understand and interpret changes in the rate of return on residential property, we can proceed to examine and analyze actual data from residential property markets surrounding IPEC.

Analysis

In order to provide the most precise answer to the questions addressed in this analysis, it was necessary to obtain data from actual residential property markets in and around IPEC. From the New York Office of Real Property Services (ORPS) and published announcements of real estate transactions dates and prices, data were obtained providing address, sales date and sales price for properties in Peekskill, Cortlandt and Buchanan that were sold during the period May 1999 through June 2009. A small number of other properties sold outside this time period were also identified using ORPS data sources. This provided an initial sample of approximately 1900 residential properties. A researcher under my supervision then visited the assessor's offices for the towns of Peekskill and Cortlandt (which does property assessment for Buchanan) and obtained photograph copies of the property record files for each of these sample properties.

Working from the photograph records of assessor's data files, the New York Attorney General's office then entered most of the information contained in these records including every legible recorded sale price and sales date for each of the properties. I supervised this process, and was in regular contact with office undertaking the data entry. I excluded recorded sales or transfers that were not "arm's length" (either because they were transfers between family members, transfers that took place at symbolic or zero prices, transfers that took place within 60 days of the previous transfer, or transfers that were identified by assessor's records as not arm's length) because they might fail to represent the market price of the property that would be reached by unconstrained negotiation between a willing buyer and willing seller. There were also a small number of observations that I excluded because they were unusual and unrepresentative in other ways (miscoded sales dates, unusual commercial properties converted to residential use, etc.)

I then geocoded these data to determine precise latitude and longitude, and Geographic Information System software was used to measure the linear distance of each property from the IPEC site. Analysis was limited to properties that are located within 5 kilometers of IPEC. This is a very conservative estimate of the possible extent of IPEC property value impacts. During the Three Mile Island event, for example, children, pregnant women and nursing mothers who were within 8 kilometers of the plant were evacuated. The NRC requires emergency planning zones around nuclear plants that designate an area where there would be possible exposure to a radiation plume in the event of a nuclear accident. This zone typically extends about 16 kilometers. As will be seen below, statistical relationships were clearly significant within the 5 kilometer zone. The locations of the residential properties in the sample are shown as blue dots in Figure 1 below. Also shown is the location of IPEC with a bold black **+** and the 5 kilometer boundary is shown in red.

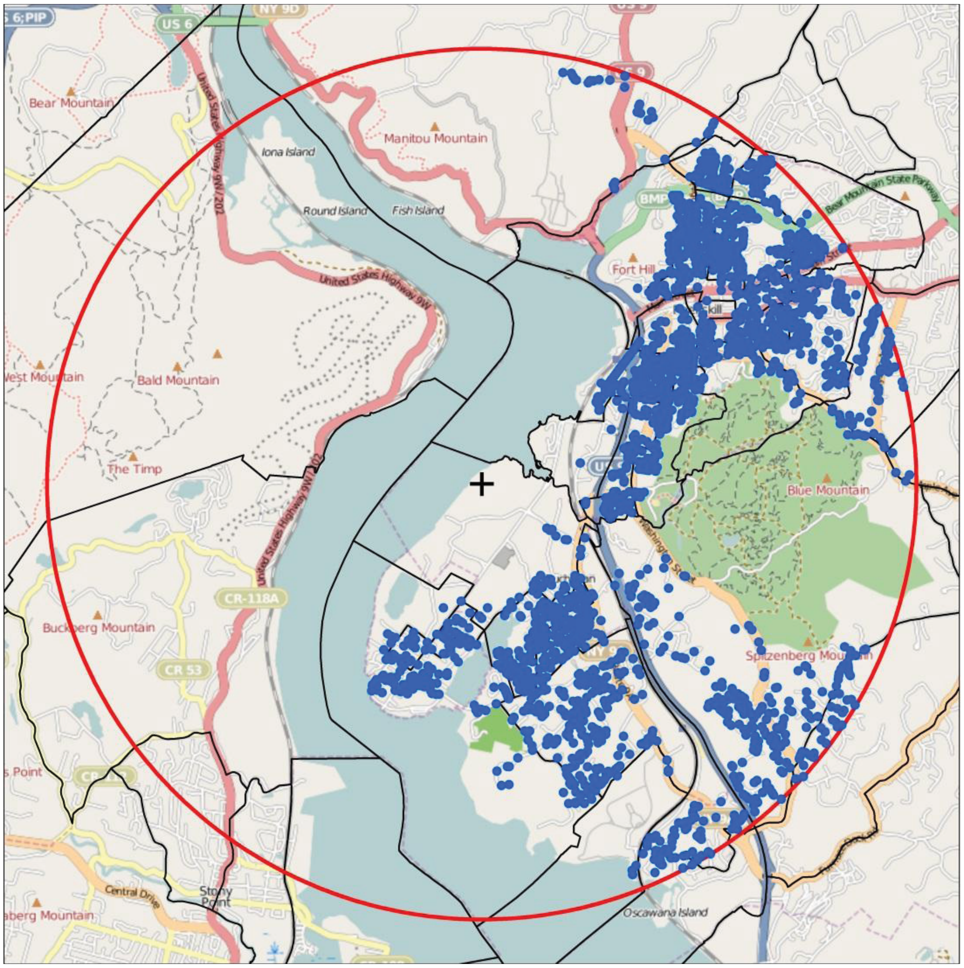

Figure 1: IPEC region showing 5 km boundary and location of sample properties

Next, I reorganized the data to provide one observation for each repeat sale; that is for each successive pair of arm's length transactions. In addition to distance from IPEC, each observation in the repeat sales data included both sales prices and both sales dates so that the nominal rate of return could be calculated for each holding period. For each repeat sale observation I used the two sales dates t_1 and t_0 and the two prices P_{t_1} and P_{t_0} to calculate the continuous discounting, rate of return using the formula:

$$\rho = \left(\frac{1}{t_1 - t_0}\right) \ln\left(\frac{P_{t_1}}{P_{t_0}}\right) \tag{11}$$

There were some observations that appeared to represent "extreme" rates of return – exceeding 100% per annum or less than -100% per annum. Because of my concern that these observations might be unrepresentative of the broader market, I excluded them from the analysis that produced the final estimates[1].

[1] Inclusion of these observations did not alter the sign nor the statistical significance of the estimated relationship, but did result in somewhat larger estimated property value impacts.

In order to identify the impact of the presence of IPEC in the community, I constructed an indicator variable that takes the value 1 if the sale took place after 1976 and the previous sale took place before 1974. Since these are the dates when IPEC units 3 and 2 (respectively) were constructed, this indicator provides a way of identifying the residential property asset ownership periods that would have been directly affected by the arrival of IPEC. For ownership periods that begin and end prior to 1974, the property would have been either not affected by IPEC or affected primarily by the presence of the smaller unit 1, which was shut down in 1974 and had all fuel removed by 1976. For sales that begin and end after 1976, the impact of contemporary IPEC operations would have been known to buyers and, if there was an impact on the value of residential services received or on property taxes due would have been factored into the amounts that buyers were willing to pay.

In terms of the analytical framework presented above, the transition from r to $\hat{r}$ and from x to $\hat{x}$ has already occurred and been factored into the market price of residential property for all ownership periods that take place after 1976. For ownership periods that begin and end prior to 1974, the change (if any) has yet to occur. Those ownership spells that begin before 1974 and terminate after 1976 constitute the portion of the sample that has received the "treatment" of the impact of the presence of IPEC on the local property markets. The ownership spells that are entirely prior to 1974 or after 1976 constitute the control group whose rate of return is the base against which the return experienced by the treatment group is measured.

These calculations provided a data set suitable for analysis containing information on sales date, previous sales date, sales price, previous sales price, the distance from IPEC plant, rate of return during the time period between the sales date and previous sales date, and the indicator variable that determines whether the repeat sale of the residential property is in the treatment or control group. Descriptive statistics for these data are provided in Table 1 below.

Variable	Observations	Mean	Std.Dev	Min	Max
Sale year	1554	1997.8	10.0	1959.2	2009.3
Prior sale year	1554	1989.6	13.3	1945.4	2008.2
Ownership period	1554	8.190	8.702	0.203	59.127
Sale price	1554	215551	163128.4	223.5	2354000
Previous price	1554	165532	431574.5	100	1.50E+07
Rho	1554	0.0920	0.1983	-0.9985	0.9847
IPEC sale indicator	1511	0.109	0.31	0	1
Distance (KM)	1554	3.50	0.89	1.22	4.99
Distance (meters)	1554	3503.50	891.10	1216.04	4994.76

Table 1: Descriptive statistics for sample observations

As shown in Table 1, the earliest sales in the sample take place in mid-1945, and the latest sales take place in mid-2009. On average, the duration of ownership periods is 8.19 years. Properties are located as close as 1216 meters from the IPEC facility and an average distance of just over 3500 meters. The average sales price is just over $215 thousand and the average prior sales price is over $165 thousand. The average nominal rate of return on properties in the sample is just over 9%. About 10% of observed repeat sales are in the treatment group. There are at least 1554 observed repeat sales that have data on one of the relevant variables. In the actual analysis there were 1511 observed repeat sales containing data on all required variables. These involved 507 different residential properties. Using these data I estimated the impact of being in the treatment group on the annual return during the ownership period. Estimation was done using OLS regression with clustered standard errors based on individual properties. Table 2 below presents the estimates.

		Observations	=	1511
		F(2,506)	=	9.07
		Prob>F	=	0.0001
Nominal Return	**Coefficient**	**Std. Error**	**t-statistic**	**P>|t|**
Sale in treatment group	-0.02926	0.00842	-3.48	0.001
IPEC distance KM	-0.01808	0.00560	-3.23	0.001
Constant	0.15855	0.01961	8.09	0

Table 2: OLS estimates of impacts of IPEC on returns to residential property

In the context of equations (9) and (10) above, these estimates provide a central finding of this report:

> The presence of IPEC in the local housing market caused a statistically significant reduction in the nominal rate of return to owning residential property in the region around IPEC. This reduction is estimated to be just under 3% per annum. This demonstrates, to a reasonable degree of scientific certainty, that IPEC reduced the value of residential housing services provided by properties within 5 kilometers of the IPEC facility, and that the reduced value of residential services was not compensated for by reduced required property tax payments on residential property.

While this analysis answers an important central question, it is reasonable to ask what the total impact on combined property values might be, providing a monetary value of the impact. While it is known from the analysis presented above that the combined impact will be a diminution in property values, to answer this question some additional information is required:

- What date should be used to evaluate the total property value diminution?

- What is the total value of residential property within the 5 kilometer boundary?
- What was the total value of residential property within the 5 kilometer boundary in 1974-76 (when the IPEC impact would have been felt)?

To answer these questions I begin by combining data from the Federal Housing Finance Administration house price index data and the BLS data on prices (used for constructing the CPI and other price indices) to construct a price index for the region that will allow estimation of total residential property values at different times. While this house price index will be only approximate for properties within the 5 kilometer boundary, it is based on the best data that are available. Figure 2 below shows the price index for residential property normalized so that July 1983 = 100.

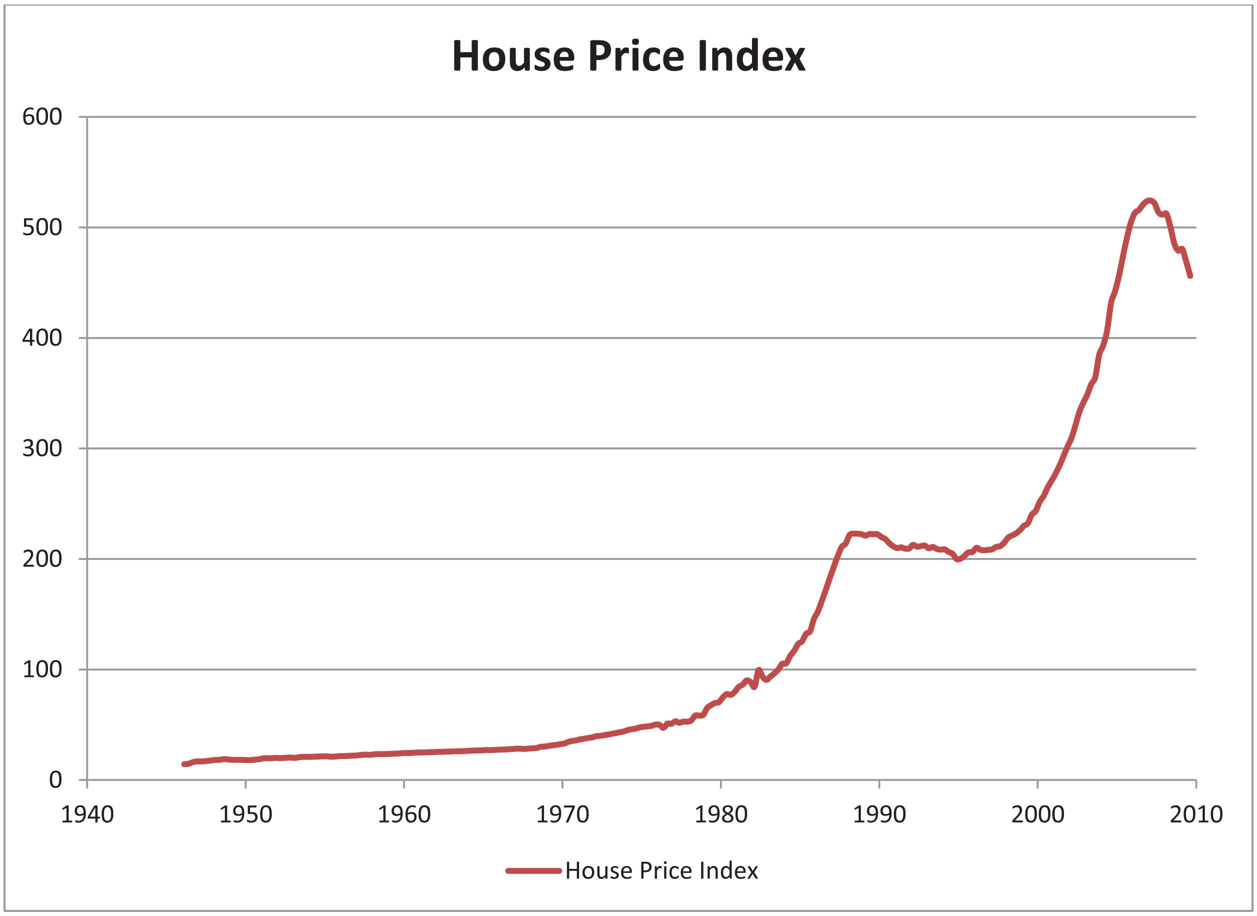

Figure 2: House Price Index for Buchanan, Peekskill and Cortlandt housing markets

Using this house price index it will be possible to use Census data to estimate total rental and owner-occupied property values using 2000 data, to translate these into 1976 values and associated impacts, and then to translate these into total values and impacts as of January 2011.

Before presenting the estimated values, it is worth noting that the estimates presented so far suggest that if IPEC were to be completely removed, there would be a period of above-normal returns to residential property owners resulting in substantial property value appreciation. This increase in property values would affect all residential property in place at the time that the IPEC "treatment" is removed. I have not endeavored to predict when that will occur nor how many residential properties will be in existence at that time. Instead, I have taken an approach that presents a reasonable and conservative compromise.

As a first step, I use 2000 census data to estimate the total value of residential property within 5 kilometers of IPEC. I consider all census block groups whose center lies with the 5 kilometer boundary. Census surveys provide owner estimates of the market value of owner-occupied properties and of the values of monthly contract rent. I capitalize rents at an annual rate of 5% to estimate the value of rental property and sum the estimated rental property value and owner-occupied property values to get a total for residential property in the block group.

Second, I use the house price index to calculate what the value of these properties would have been at the end of 1976. Using these values and the estimated reduction in the nominal return to home ownership, I calculate the total reduction in property values as of December 1976, conservatively estimating that these reduced returns were experienced for an ownership period that is equal to the sample mean duration of ownership[2]. This is done using the formula:

$$Loss = Price_{1976} \cdot \left(1 - e^{-\delta_\rho T}\right) \tag{12}$$

Where:

$Loss$	=	Estimated loss in property value as of December 1976
$Price_{1976}$	=	Total property value as of December 1976
$-\delta_\rho$	=	The reduction in the nominal rate of return on residential property
T	=	The average amount of time residential property is held

This provides a conservative estimate of the reduction in property value attributable to IPEC being present in the community.

Once the magnitude of property value diminution is calculated at December 1976 prices, I then use the house price index to translate these values to contemporary prices and present an estimated loss in residential property values as of January 2011. Table 3 below summarizes my calculations.

[2] In fact, properties subject to the IPEC treatment were owned for longer than the sample mean ownership period. Using the longer ownership period as the duration of reduced annual returns to ownership would generate larger property value impacts.

Description	Value
Value in 1976 of residential property within 5 km of IPEC facility	$449,625,380
Total loss in value of residential property in 1976	-$121,737,345
Total value in 2000 of owner-occupied and renter-occupied residential property within 5 km of IPEC facility (from census)	$2,227,926,067
Total value of affected residential property in January 2011	$3,952,218,345
Total loss in residential property values as of January 2011	-$1,070,074,312
Percentage loss in residential property values	-27.08%

Table 3: Calculations of property value impacts attributable to IPEC

Concluding remarks

My analysis indicates that there is an unambiguous negative impact on the value of residential services and on house prices for residential property within 5 kilometers of IPEC. I have been cautious and used an approach that, if anything, tends to understate the impacts. Despite these cautions, I find to a reasonable degree of scientific certainty that there is an adverse impact on property values resulting from IPEC's presence in the community. Because this impact is associated with the arrival of IPEC, it is scientifically plausible that the impact would dissipate after removal of IPEC and the decommissioning and reclamation of the site for alternative uses. My analysis suggests that the recovery in property values could add more than $1 billion dollars to the value of residential property, increasing its value by more than 27%. This would increase the wealth of many individuals residing in the community and others with a strong interest in the welfare of the community. The impact on land use within this 5 kilometer zone would be significant.

These results are based on actual data collected from the property market in the communities surrounding the IPEC location. The data are easily checked and the analytic approach taken is scientifically sound so that the results can be replicated and regarded as reliable. Nevertheless it is of interest to ask how these results compare to other studies of the impacts of nuclear power plants on property values. The results reported above are somewhat higher than some published studies but are of a similar order of magnitude. For example, Prest[3] [2009] used a different statistical methodology to investigate the impacts on residential property values of the Pilgrim Nuclear Power Station operating near Plymouth, Massachusetts. He finds

[3] Brian Prest, *Measuring the Externalities of Nuclear Power: A Hedonic Study*, unpublished thesis, Williams College, 2009.

significant property value impacts that extend further than the 5 kilometers analyzed in this report. He finds reductions in property values that range between 10% and 20% for properties located within the first 5 kilometers of the power plant. In a similar vein, Folland and Hough[4] [2000] examine the impact on residential property values of the announcement and installation of a nuclear power plant. They find reductions in property values exceeding 10%, again over a larger range than the 5 kilometer limit used in the analysis presented here. It is clear that there are several studies that have been published in peer-reviewed scientific journals with findings that are broadly consistent with those presented above, further increasing the confidence that can be associated with these results.

A 27% change in land values would certainly result in “significant” changes in land use. To help understand the potential impact of such a change in prices some comparisons might be helpful. From the beginning of 2007 through the first quarter of 2011, house prices in the US fell by approximately 16%. A few large markets experienced greater change than this, but many experienced less. This level of change in house prices has generated profound impacts on urban development around the country, and will have impacts on land use that are likely to persist for at least a decade, perhaps longer. The change in house prices associated with the presence of IPEC is even larger than experienced in most US cities during the “great recession” and the consequence of IPEC’s continued presence for local land use can be expected to be at least as large as those experienced during the recent collapse of the housing market.

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[4]Folland, Sherman and Hough, Robbin. “On the External Effects of Nuclear Power: Further Evidence” *Journal of Regional Science* 40 (2000): 735-53.