

1 Q. Please summarize your educational and professional
2 qualifications.

3 A. I hold a Ph.D. and a Masters Degree in economics from
4 Washington University in St. Louis, MO, and a Bachelor's of
5 Science Degree in economics from the University of Utah in Salt
6 Lake City, UT. Since 1976, I have conducted research, written,
7 lectured, and taught on topics such as microeconomic theory,
8 urban economics, land use regulation, housing markets, and
9 environmental economics. In my profession, I have worked
10 extensively with population data, including Census Bureau data,
11 and am knowledgeable in population calculation and modeling.
12 For example, in 2003, I received funding from the World Bank and
13 the National Science Foundation to study urban expansion in
14 cities around the world. Population is a critical input in
15 creating models to predict urban sprawl, and so, I worked with
16 data from the Census of the US and 55 other countries around the
17 world to create accurate population estimates for that study. I
18 have also worked with population data in my research on the
19 impacts of terrorism on urban form and structure. My education
20 and experience are described in my curriculum vita ("CV"), which
21 is attached to my testimony as Exh. NYS000208. A list of my
22 publications is also included in my CV.

*Pre-filed Written
Testimony of Dr. Stephen Sheppard, Ph.D.
Contention NYS-16/16A/16B*

1 Q. I show you what has been marked as Exh. NYS000209. Do
2 you recognize that document?

3 A. Yes. It is a copy of the report that I prepared for
4 the State of New York in this proceeding. The report reflects
5 my analysis and opinions.

6 Q. What is the purpose of your testimony?

7 A. The purpose of my testimony is to provide my views on
8 the State's Contention 16B¹, which asserts that Entergy and the
9 NRC Staff have underestimated the 2035 population within 50
10 miles of Indian Point likely to be exposed to radiation during a
11 severe accident. Neither Entergy nor the NRC Staff considered
12 census undercount or the commuter population, which led to the
13 underestimation. These omissions are significant because
14 population is a key input in the severe accident mitigation
15 alternatives ("SAMA") analysis conducted by Entergy. A lower
16 population estimate could lead to an underestimation of the

¹ The Atomic Safety and Licensing Board (ASLB) admitted NYS-16 in ASLBP No. 07-858-03-LR-BD01, Memorandum and Order (Memorandum And Order Ruling on Petitions to Intervene and Requests for Hearing) (July 31, 2008). On June 16, 2009, the ASLB admitted and consolidated NYS Contention 16A. See Ruling on New York State's New and Amended Contentions (June 16, 2009). On June 30, 2010, the Board admitted amended Contention NYS-16B (Ruling on the Admissibility of New York's New and Amended Contentions 12B, 16B, 35, and 36) (July 6, 2011) and consolidated it with 16/16A.

In Contention 16, the State also challenged Entergy's air dispersion model as not accurately predicting the geographic dispersion of radionuclides released in a severe accident but it has chosen not to pursue that aspect of the contention.

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1 benefit obtained from implementing a SAMA, thus potentially
2 excluding certain mitigation alternatives from full
3 consideration.

4 Q. Have you reviewed materials in preparation for your
5 testimony?

6 A. Yes.

7 Q. What is the source of those materials?

8 A. Many are documents prepared by government agencies,
9 peer reviewed articles, or documents prepared by Entergy or its
10 consultants.

11 Q. I show you Exhibits NYS000211 through NYS000218. Do
12 you recognize these documents?

13 A. Yes. These are true and accurate copies of the
14 documents that I referred to, used and/or relied upon in
15 preparing my report and this testimony. In some cases, where
16 the document was extremely long and only a small portion is
17 relevant to my testimony, an excerpt of the document is
18 provided. If it is only an excerpt, that is noted on the first
19 page of the Exhibit.

20 Q. How do these documents relate to the work that you do
21 as an expert in forming opinions such as those contained in this
22 testimony?

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1 A. These documents represent the type of information that
2 persons within my field of expertise reasonably rely upon in
3 forming opinions of the type offered in this testimony.

4 Q. What materials have you reviewed in preparation for
5 your testimony?

6 A. The materials I have reviewed are listed in Exh.
7 NYS000219. I have reviewed the NYS-16B filings concerning
8 population calculations. I have also reviewed Entergy's and its
9 consultants' reports that concern population estimates, as well
10 as NRC's analysis of Entergy's population estimate, contained in
11 Appendix G of the Final Supplemental Environmental Impact
12 Statement ("FSEIS"). I am familiar with the body of scholarly
13 work that discusses the census undercount and I have reviewed
14 data from the 2000 Census.

15 Q. Have Entergy and the NRC Staff underestimated the 2035
16 population within 50 miles of Indian point that would be
17 affected by a severe accident?

18 A. In my professional judgment and as I describe in more
19 detail, below, and in my report, the population estimate, used
20 by Entergy in its 2007 SAMA analysis and 2009 SAMA reanalysis,
21 and approved by the NRC Staff in the FSEIS, is deficient in two
22 respects. First, it fails to account for census undercount,
23 which is the undercounting of a portion of the population by the

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1 U.S. Census Bureau. Second, it does not include in the
2 transient population those who live outside the 50 mile radius
3 of IPEC, but commute to workplaces within IPEC's 50 mile radius.

4 Q. What is the result of the two deficiencies you have
5 identified?

6 A. As a result of these two deficiencies, Entergy
7 underestimated the 2035 population within 50 miles of IPEC by
8 approximately 1.2 million persons or 6.38 percent.

9 Q. Have you reviewed Entergy's estimation of the current
10 population of the region within 50 miles of Indian Point?

11 A. Yes, Entergy's population estimate is contained in its
12 License Renewal Application, in Appendix E and Attachment E of
13 the Environmental Report, and I have reviewed those parts of
14 that document. I have also reviewed Entergy's consultant's
15 report, Exh. NYS000211, which provides a more detailed
16 discussion of Entergy's population estimate.

17 Q. What types of population does Entergy's estimate
18 include?

19 A. Entergy's estimate includes the permanent and
20 transient population. The transient population includes
21 business travelers and tourists traveling to or through each
22 county and staying temporarily within the county, but does not

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1 include those who live outside the 50 mile radius of IPEC and
2 travel to workplaces within the 50 mile radius ("commuters").

3 Q. Please explain how Entergy estimated the current
4 population?

5 A. First, Entergy determined which counties are, in whole
6 or in part, within 50 miles of IPEC. For those counties that are
7 not entirely within the 50 mile radius, Entergy determined the
8 percentage of land area in the county that is within the 50 mile
9 radius of IPEC. Then Entergy used population estimates from
10 state and local governments, based on 2000 Census data, to
11 determine the population of each county.

12 Next, Entergy made use of state and local estimates of
13 transient population to estimate the ratio of permanent to
14 transient population for each county in 2004. Transient
15 population is an average of person-visits per day.

16 To estimate the permanent population in each county within
17 50 miles of IPEC, Entergy assumed that the population in each
18 county is distributed evenly throughout the county, and
19 multiplied the permanent population of each county by the
20 percentage of the county that is located within the 50 mile
21 radius of IPEC.

22 This number was then multiplied by the ratio of permanent
23 to transient population, to estimate the current transient

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1 population in each county within 50 miles of IPEC. The
2 permanent and transient populations for each county were added
3 to get the total population within 50 miles of IPEC for each
4 county. Each county's population was added to get the current
5 total population within 50 miles of IPEC.

6 Q. How did Entergy project the current population to
7 2035?

8 A. Entergy obtained county level projections of the
9 permanent population from the New York Statistical Information
10 System from 2000 to 2030, the New Jersey Department of Labor and
11 Workforce Development from 2000 to 2025, the Connecticut Data
12 Center from 2000 to 2020, and the Pennsylvania Data Center from
13 2000 to 2020. These state-generated projections are based on
14 U.S. Census Bureau data. Entergy performed a regression analysis
15 of the state data to project the permanent population of each
16 county in 2035. Linear regression was used for all counties
17 except for New York, Westchester, and Rockland counties where
18 polynomial regression was used. Entergy has not given an
19 explanation with the details of how these regressions were made,
20 therefore, I was unable to check their accuracy.

21 The permanent 2035 population of each county was multiplied
22 by the percentage of the county within 50 miles of IPEC. The
23 2035 transient population in each county was calculated by

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1 multiplying the estimated 2035 permanent population within 50
2 miles of IPEC by the transient to permanent population ratio,
3 which was assumed to remain constant through 2035. The permanent
4 and transient populations were added together to get county
5 totals. Adding the county totals provided by Entergy, the total
6 estimated population within 50 miles of IPEC for 2035 is
7 19,229,875 persons.

8 Next, Entergy transferred the total population from source
9 areas (county) to target areas (spatial elements, i.e. wind
10 direction and buffer distance) by converting county population
11 to a density measure and multiplying this density by the area
12 that a county has in a given spatial element. This calculation
13 produced a total population of 19,228,712 persons, which was the
14 number used in the 2007 SAMA analysis and 2009 SAMA reanalysis.
15 This is 163 persons less than the total population before
16 conversion from county to spatial element. Entergy did not
17 provide data on the area that each county has in each spatial
18 element so it is impossible for me to determine how exactly this
19 discrepancy came about. However, I surmise that it is the
20 result of rounding decimal points (163 is .00085 percent of 19.2
21 million). For my calculations, I used the county (as opposed to
22 the spatial element) population estimate because Entergy's
23 report did not give enough information to determine census

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1 undercount and commuter populations by spatial element (I would
2 need to know the area that each county has in a given spatial
3 element and Entergy has not provided that data).

4 Q. Have you identified any deficiencies in Entergy's
5 estimation of either the current population or its projection to
6 2035?

7 A. Yes, neither the 2000 population estimation nor the 2035
8 population projection accounts for census undercount or includes
9 those who reside outside of the 50 mile radius of IPEC, but
10 commute to workplaces within the 50 mile radius.

11 Q. What effect do these deficiencies have on Entergy's
12 2035 population estimate?

13 A. These deficiencies cause the population to be
14 materially underestimated.

15 Q. Can you explain the concept of census undercount,
16 which you identify as one of the clear deficiencies in Entergy's
17 methodology?

18 A. Census undercount is the persistent undercount of
19 portions of the population by the U.S. Census Bureau in the
20 decennial census. In particular, minorities and the poor are
21 undercounted at higher rates than other populations. For
22 example, in the 1990 census there was an estimated undercount of
23 4 million people. Exh. NYS000213 at p. 1. In that census, 4.4

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1 percent of Blacks, 5 percent of Hispanics, 2.3 percent of Asians
2 and Pacific Islanders, and 4.5 percent of American Indians were
3 missed, compared to 0.7 percent of non-Hispanic whites. *Id.*

4 Census undercount has been acknowledged for some time by
5 the U.S. Census Bureau. The September 2001 Presidential Members
6 Final Report to Congress (Exh. NYS000213) recognized census
7 undercount and summarized many other publications that have
8 described the phenomenon.

9 Q. Can you describe how census undercount affects the
10 region within 50 miles of Indian Point?

11 A. Census undercount causes the census data relied on by
12 Entergy in forming its 2035 population estimate to give an
13 artificially low count of the population within 50 miles of IPEC
14 at risk in the event of a severe accident. Census undercount
15 consists of missing people who are actually resident at a
16 particular location. This can happen because they are not
17 counted or because their addresses are missed (for example, they
18 never get the census form or a follow up visit). The Census
19 Bureau makes an effort to have a complete set of addresses. New
20 York City, located approximately 24 miles from Indian Point, has
21 a large minority population that has been subject to census
22 undercount. Of the 4 million addresses added to the 1990 census
23 to account for census undercount, 280,000 were located in New

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1 York City alone. Exh. NYS000213 at p. 22. Even with a complete
2 set of addresses however, undercount could still occur because
3 people are trying to avoid being counted or don't understand
4 census instructions.

5 Q. Is it possible to estimate the effect of census
6 undercount?

7 A. Yes. The U.S. Census Monitoring Board report, Exh.
8 NYS000213, provides estimated undercount rates for the states in
9 the region surrounding IPEC that range from 0.52% to 4.49%.
10 Averaging the rates and rounding to the nearest percent gives 3%
11 as a reasonable average percentage undercount. Assuming no
12 undercount of the white population and applying this 3%
13 undercount rate to the 2000 census figures for non-white
14 population results in an overall estimated undercount of 1.11%
15 in the IPEC region, slightly less than the 1.18% undercount
16 estimated for the entire US.

17 In general, the growth rate of minority populations is
18 somewhat faster than the growth rate of the population as a
19 whole, but I conservatively assume that the growth rate from
20 2000 to 2035 for the uncounted minority population will be the
21 same as that for the population as a whole in each county.
22 Applying this growth rate and taking the share of land area in
23 each county that is within 50 miles of IPEC (equivalent to

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1 assuming that the undercounted population in each county is
2 uniformly distributed over the county) as the share of required
3 county adjustment provides the adjustment for census undercount
4 for each county.

5 Q. What is the effect of census undercount on Entergy's
6 population estimate?

7 A. Following the method outlined in the previous answer,
8 my calculations indicate that census undercount caused Entergy
9 to underestimate the 2035 population by 231,632 persons.

10 Q. In your opinion, is an estimate that takes census
11 undercount into consideration superior to an estimate that does
12 not?

13 A. Yes, in my professional opinion, an estimate that
14 takes census undercount into consideration is superior because
15 it is more accurate than an estimate that does not take it into
16 account, and provides a more accurate account of the total
17 population within a given area.

18 Q. You explained that another clear deficiency of
19 Entergy's population estimate was the failure to include
20 commuters. Can you explain how accounting for commuters affects
21 Entergy's population estimate?

22 A. The census data relied on by Entergy includes only the
23 number of permanent residents in the 50 mile radius of IPEC,

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1 which is why Entergy had to adjust the number to account for the
2 transient population. However, in accounting for the transient
3 population, Entergy counted only tourists and business
4 travelers, not commuters. Commuters should be included in the
5 transient population because they enter and remain within the 50
6 mile radius of IPEC on a daily basis, and are therefore just as
7 at risk in the event of a severe accident as are permanent
8 residents, tourists, and business travelers. When commuters are
9 included, the population within the 50 mile radius of IPEC
10 increases substantially.

11 Q. Is it possible to precisely estimate the number of
12 commuters to the region within 50 miles of Indian Point?

13 A. Yes, it is possible to estimate the number of
14 commuters using Census Bureau data on county-to-county commuter
15 flows from 2000, Exh. NYS000215.

16 Q. How would the Census Bureau data be used to calculate
17 the commuter population for the 50 mile radius of IPEC?

18 A. For each county that is 100 percent within the 50 mile
19 radius of IPEC: (1) take 100 percent of the average daily
20 commuter flows into that county that come from counties that are
21 completely outside of the 50 mile boundary; and (2) take 100-S
22 percent of the average daily commuter flows into that county

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1 that come from counties that have S percent of their area within
2 the 50 mile boundary.

3 For each county that is partially within the 50 mile
4 radius, where P percent is the percentage of land area in the
5 county located within 50 miles of IPEC: (1) take P percent of
6 the average daily commuter flows into that county that come from
7 counties that are completely outside the 50 mile radius; and (2)
8 take P times (100-S) percent of the average daily commuter flows
9 into that county that come from counties that have S percent of
10 their area within the 50 mile boundary.

11 These calculations assume that employment locations are
12 distributed evenly over the entire land area of each county.
13 This procedure estimates the 2000 commuter population into that
14 portion of each county that is within 50 miles of IPEC.

15 To get the 2035 commuter population, take the county
16 population growth rates from 2000 to 2035 used in Entergy's SAMA
17 report as a conservative estimate of growth in county
18 employment, and apply those growth rates to total commuter
19 population for each county.

20 Q. How many commuters will enter the region on an average
21 day in 2035?

1 A. Following the procedure outlined above, my
2 calculations estimate that 995,778 commuters will enter the
3 region on an average day in 2035.

4 Q. If census undercount and commuters are taken into
5 account, what will be the 2035 population in the counties
6 surrounding Indian Point?

7 A. Accounting for census undercount and including
8 commuters, the 2035 population within a 50 mile radius of IPEC
9 will be 20,456,285 persons.

10 Q. How does this estimate compare to Entergy's estimate?

11 A. Entergy's 2035 population estimate by county (as
12 opposed to spatial element) was 19,228,875 persons. This is a
13 difference of 1,227,410 persons or 6.38 percent. It is also a
14 difference of 6.38 percent compared to the spatial element
15 population estimate of 19,228,712 persons, used by Entergy in
16 the 2009 SAMA analysis and 2009 SAMA reanalysis. The 163 person
17 discrepancy does not affect the percentage because 163 is only
18 .00085 percent of 19.2 million.

19 Q. Have you reviewed Staff's evaluation of Entergy's
20 estimate?

21 A. Yes, I have reviewed NRC Staff's evaluation contained
22 in the 2010 FSEIS Appendix G on pages G-24 and G-25, Exh.
23 NYS00133I.

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1 Q. What did Staff conclude?

2 A. Staff concluded that "Entergy's population data and
3 projected population growth analysis provide reasonable (and
4 slightly conservative) population values for its SAMA analysis."

5 Q. Did Staff address Entergy's failure to consider census
6 undercount or its exclusion of commuters from its population
7 estimate?

8 A. No, Staff did not address these issues.

9 Q. In your opinion, is a population estimate and
10 projection that does not factor in census undercount and that
11 excludes commuters a reasonable one?

12 A. In my professional opinion, a population estimate or
13 projection that does not account for census undercount or that
14 excludes commuters is deficient. These deficiencies cause the
15 population estimate to be inaccurate. Underestimating the 2035
16 population by approximately 1.2 million persons is not a
17 reasonable estimate.

18 Q. Does this conclude your testimony?

19 A. Yes.

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1 UNITED STATES

2 NUCLEAR REGULATORY COMMISSION

3 BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

4 -----x

5 In re: Docket Nos. 50-247-LR; 50-286-LR
6 License Renewal Application Submitted by ASLBP No. 07-858-03-LR-BD01
7 Entergy Nuclear Indian Point 2, LLC, DPR-26, DPR-64
8 Entergy Nuclear Indian Point 3, LLC, and
9 Entergy Nuclear Operations, Inc. December 16, 2011

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11 **DECLARATION OF STEPHEN C. SHEPPARD**

12 I, Stephen Sheppard, do hereby declare under penalty of
13 perjury that my statements in the foregoing testimony and my
14 statement of professional qualifications are true and correct to
15 the best of my knowledge and belief.

16 Executed in Accord with 10 C.F.R. § 2.304(d)



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