

# Dynamic Model of Net-Zero Neighborhood

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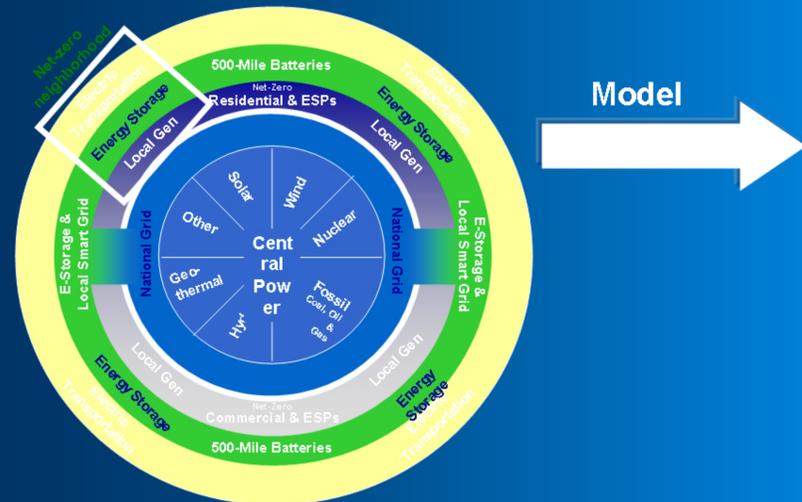
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[https://info.ornl.gov/sites/rams09/b\\_davis/Pages/default.aspx](https://info.ornl.gov/sites/rams09/b_davis/Pages/default.aspx)

Currently, the United States energy management system is incapable of meeting the needs and demands of the world's growing population. Managing the current energy and future energy needs is essential for securing energy independence for the United States. The current energy management system is out-dated and inefficient for the growing U.S. and world needs and demands. The Net-Zero Neighborhood Plan (NZN) is a comprehensive plan to support correcting this deficiency. The overall goal of NZN is to create local generation using renewable energy; provide energy storage near consumption; electrify transportation as an integral part of energy storage; and create new jobs based in local energy service providers (ESP). It will be accomplished by substantially removing the residential and commercial (R&C) from the energy grid and transportation from the gasoline grid; residential and commercial would become independent energy generators. Jobs will be created within the local community—the local ESP's. Advanced solar, battery, and wind technologies are essential to this plan. A national research and development focus is needed for these technologies to be brought up to an efficient, cost effective, and readily available level for local consumers. A model was created using Stella simulation software to evaluate the effectiveness of the Net-Zero Neighborhood Plan on a local level. An urban area roughly the size and population of metropolitan Knoxville, Tennessee, was used in this simulation. Results show that the Net-Zero Neighborhood Plan reduces CO<sub>2</sub> emissions and results in a reduction in gasoline consumption.

## Net-Zero Neighborhood



- NZN = Local Storage + Local Generation + Electrify Transportation
- NZN integrates seamlessly with other energy generation plans and the national grid

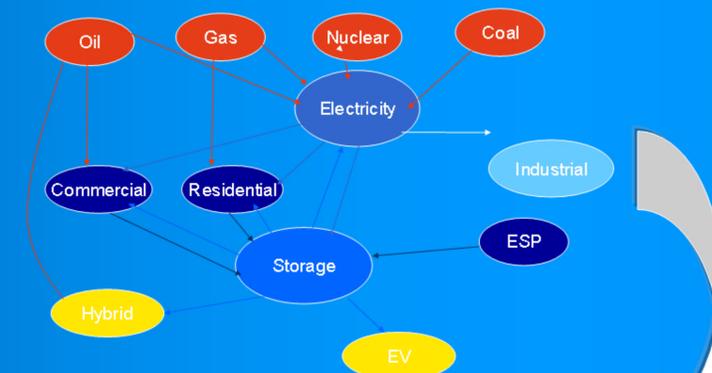
Figure 1. Net-Zero Neighborhood problem formulation.

## Research Objectives / Hypothesis

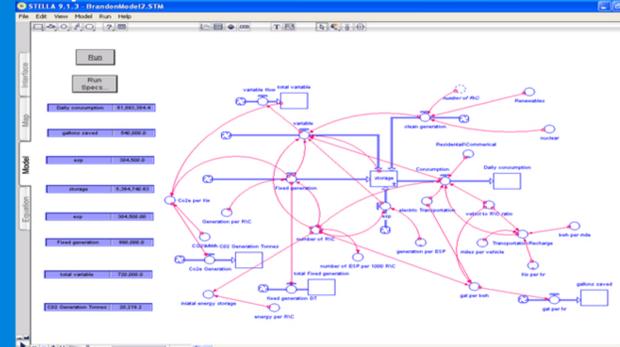
- Model for NZN Plan
- Determine effectiveness of NZN for reducing CO<sub>2</sub> equivalent (CO<sub>2</sub>e) emissions and reducing oil imports

## Methods

- Create an energy flows model
- Model as an initial value problem  $dE_k = f_i dt$  and solve using Euler's Method;  $E_k$  is energy,  $f_i$  is generation and consumption flows, and  $t$  is time



## Computer Simulation



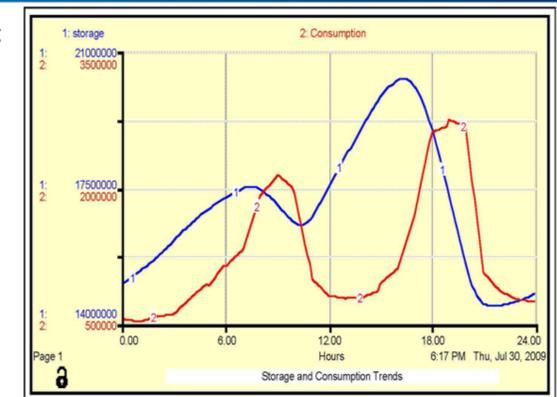
## Approach

- Model residential and commercial (R&C) energy flows for an average day in an area approximate size of metropolitan Knoxville, Tennessee
- Use open reports locate and apply data and models for energy generation, energy consumption, and CO<sub>2</sub>e emission using dynamic systems software, Stella
- Compare a 2010 and a 2030 case

## Results

Net-Zero-Neighborhood Simulation, R&C only:  
Metro like Knoxville: 300,000 R&Cs

	2010	2030
NZN Generation	No	Yes = 50%
Other Clean Energy	No	Yes ~ 10 kWh/R&C
All Electric Vehicles	No	Yes = 50%
Fleet MPG	24.6	24.6
CO <sub>2</sub> e (electric gen), tonnes/d	16,200	5,200
CO <sub>2</sub> e (transportation), tonnes/d	10,500	5,200
Total CO <sub>2</sub> e, tonnes/d	26,700	~ 61% drop 10,400
Gallons of gasoline (gallons)	950,000	472,000
Total energy/day (GWh)	~ 27 GWh	~ 30 GWh



## Discussion of Results

- Local storage switches all energy generation forms, e.g., solar and wind, into base load capacity
- At 50% market penetration
  - NZN reduces CO<sub>2</sub>e emissions by more than 50%
  - NZN can reduce oil imports by as much as 50%

## Conclusions

- NZN effectively reduces U.S. CO<sub>2</sub>e emissions and oil imports and creates U.S. jobs in local Net-Zero Neighborhoods
- NZN supports national environmental sustainability goals and energy security goals

## Future Research

- Develop a more comprehensive model to include time zone, seasonal, and regional effects, and multiple years
- Investigate specific R&D options for 500-mile battery to electrify transportation and 50% efficient solar cells