Sightline INSTITUTE

Transfer of Development Rights

A tool for reducing climate-warming emissions

Estimates for King County, Washington

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Summary

For years, local governments have used Transfer of Development Rights (TDR) programs to help channel urban growth away from farmland, forests, and open space. But new evidence suggests that, when used carefully, TDR programs can also help local governments achieve meaningful reductions in local greenhouse gas emissions.

Sightline's analysis of King County's TDR program and a variety of public data sources suggests that ***a single TDR exchange could reduce climate-warming carbon dioxide emissions by about 270 metric tons over 30 years***, compared with development patterns that might otherwise occur. This is a significant reduction, representing half of the average emissions from one US resident for the same period.

However, not all TDR exchanges yield climate benefits. TDRs achieve their greatest potential for reducing GHGs when a rural or exurban landowner sells the right to build a single family home, and a developer in the urban core purchases the right to increase floor space for multi-unit housing. But when TDR exchanges simply swap the location of single family residences from one low-density exurb to another, they may do little or nothing to reduce GHG emissions. Each TDR transaction is unique, and only some of them show promise for reducing climate-warming emissions.

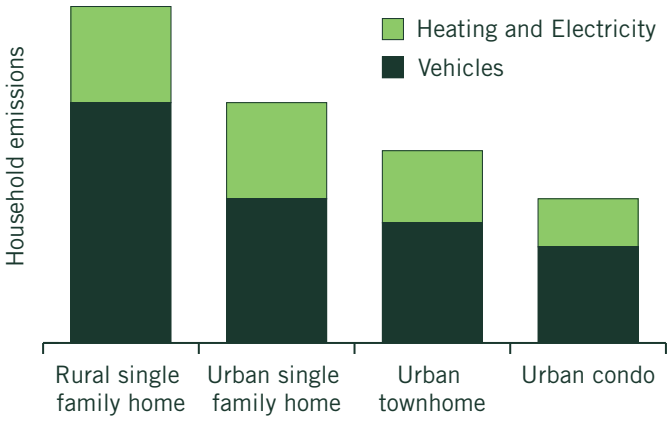
Introduction

County and municipal governments throughout North America employ a variety of strategies to limit uncontrolled, poorly planned development at the outskirts of metropolitan areas. These efforts take different forms, but share many of the same goals: preserving working farmland and forests; protecting ecologically sensitive areas at the urban fringe; channeling new development into vibrant city and town centers; and lowering the costs of providing roads, sewers, and other public services to a dispersed housing stock.

Transfer of Development Rights (TDR) programs offer communities a potent tool for managing growth. Under a TDR program, landowners in certain rural and exurban areas are given the option to sell the right to develop housing on their land. New development is thereafter prohibited on the property, either through zoning changes or through a legally binding easement. In turn, the program allows other landowners in areas where growth is encouraged to purchase those development rights, thereby increasing the amount of housing or commercial space permitted on their property. Such transfers provide broad benefits. Rural landowners receive fair compensation for their development rights. Purchasers of TDRs can see a financial return from their investment. And the local community channels new growth in accordance with its plans and objectives, by shifting development away from areas where local governments hope to discourage growth, and into areas where they hope to encourage it.

In recent years, growing concerns over global climate change have prompted many communities to look for tools to reduce local greenhouse gas (GHG) emissions. And as a growing body of academic research shows, local land use and housing patterns can significantly influence climate-warming emissions. In sprawling, low-density suburbs—where homes are widely separated from jobs, stores, and services—residents consume more gasoline for their daily needs than they do in more compact suburban and urban neighborhoods. Similarly, residents of large single family homes tend to consume more energy for heating, cooling, lighting and appliances than do residents of smaller dwellings or multifamily homes that share walls, ceilings, or floors with neighbors. (See Figure 1.)

Figure 1. The location and style of housing can have significant impacts on average household GHG emissions.



Note: data are illustrative only; actual values vary by climate, neighborhood, and other factors.

The connection between land use and GHG emissions offers an enticing possibility: if TDR programs can channel growth away from neighborhoods or housing types associated with high energy consumption, and into neighborhoods or housing types associated with low energy consumption, they may offer a viable strategy to help communities trim their long-term GHG emissions.

Residential Emissions: Transportation, Natural Gas, and Electricity

To estimate the potential for TDR programs to serve as tools to reduce local GHG emissions, Sightline constructed a spreadsheet model using data for King County, Washington, which has a mature and well-regarded TDR program.

For household transportation emissions, two recent modeling efforts—one undertaken by the research firm Lawrence Frank and Company, and the other by the Center for Neighborhood Technology in Chicago—provide estimates of neighborhood-level greenhouse gas emissions in the county. The two modeling efforts used different data sources and methods, but produced very similar spatial patterns of transportation emissions (see Figures 2 and 3).

Both models estimated that households in compact urban centers produced about one-third the transportation emissions as households at the metropolitan fringe—a pattern that conforms with the international literature on the relationship between land use and transportation emissions. For the purpose of analyzing the influence of TDR patterns on actual household emissions, we take the higher of the two model outputs as an upper-end estimate of transportation emissions from a particular block group, and the lower of the two as a lower-end estimate.

To help estimate emissions from energy consumption in people's homes, we obtained data from Puget Sound Energy (PSE)—the sole residential natural gas utility in King County, and the electricity provider to most of the County's homes—on household electricity and natural gas consumption, segmented by census block group throughout the county. This wealth of data offers important clues about household energy emissions from different King County neighborhoods. However, we could not obtain comparable data for the service territory of Seattle City Light, nor on the patterns of home heating with oil furnaces. Because of these data gaps, this report's conclusions about the effects of housing location on emissions from home heating and electricity consumption should be seen as tentative rather than definitive.

TDRs as Paired Transactions

TDR programs are typically described as facilitating the transfer of development rights from individual "sending" sites (where development is discouraged) to particular "receiving" sites (where development is encouraged).

But arguably, TDR programs have more complex effects on regional housing patterns. In the sending zone, the sale of development rights eliminates the risk of development on a particular piece of property. Yet those risks can be difficult to estimate over the long term, and may even be unknowable. In the receiving zone, however, the effects are far more predictable, since landowners who purchase development rights typically intend to exercise those rights promptly; otherwise, they would not have spent the money to purchase the rights.

Viewed through this lens then, a TDR transfer isn't a single exchange of development rights from a sending zone to a receiving zone. Instead it comprises two separate transactions. In the "sending" transaction, the sale of development rights reduces the odds of development from some indeterminate level to zero. In the "receiving" transaction, the purchase of development rights effectively increases the odds of development from zero to 100 percent. For the analysis, Sightline divided the sale and receipt of development rights into two separate transactions, estimating the GHG impacts of each.

Putting it All Together: Estimates of GHG Emissions for TDR Exchanges

Sightline applied the methods described above and in the methodology appendix to recent TDR transactions in King County, and reached the following conclusions.

When TDRs restrict exurban development, they typically reduce greenhouse gas emissions.

In recent years "sending" sites in the King County TDR program were uniformly in low-density areas where transportation emissions were significantly higher than the county average. When compared with the region-wide average, restricting development at these TDR sending sites reduced transportation-related GHG emissions by 53 metric tons per household over 30 years—with a high-end estimate of 62 metric tons per household over 30 years, and a low-end estimate of 45 metric tons per household. Similarly, TDR sending sites were associated with housing stock that uses slightly more natural gas than the county average, and that is serviced by a relatively carbon-intensive mix of electricity sources. We estimate that sending transactions are associated with a per household reduction of 24 metric tons of CO2 per household for electricity, and 5 metric tons for natural gas.

Purchases of TDRs in central Seattle significantly reduce GHG emissions.

Compared with the region-wide average, locating a new household in a compact urban neighborhood reduces household transportation emissions by 89 metric tons over 30 years, with a high-end estimate of 119 metric tons and a low-end estimate of 58 metric tons. In addition, when factoring in Seattle's low-carbon generation mix, emissions reductions for multifamily housing, and heat provided by Seattle Steam, we estimate further emissions reductions of 68 metric tons for electricity and 35 metric tons for natural gas.

Purchases of TDRs in low-density suburbs offer little or no benefits for GHG emissions.

The two transportation models obtained for this analysis agree that most of the lower-density suburban TDR receiving sites in King County were associated with slightly

higher household transportation emissions than the county-wide average. Similarly, creating additional single family housing in the PSE service territory yielded no obvious emissions savings in home electricity or natural gas compared with the county average.

Conclusion

TDR programs show significant potential for aiding local communities in reducing long-term greenhouse gas emissions—but only if TDR sites are carefully chosen. In King County, using TDRs to shift development from the metro-area outskirts to compact urban neighborhoods could reduce GHG emissions over 30 years by 272 metric tons per single family housing unit. These estimates may be conservative in some respects, but also embody significant uncertainty, particularly in accounting for electricity emissions. Based on this estimate, the Seattle-King County TDR agreement—which ran from 2001 to 2008, and relocated 70 development rights from the rural King County Cedar River watershed (the city's primary water supply) into the Denny Triangle in downtown Seattle—may have reduced regional GHG emissions by 19,000 tons over 30 years.

But not all TDR transfers show such potential. When a TDR receiving site is a single family home in a lower-density suburb far from the urban core, the TDR exchange may do little, if anything, to reduce GHG emissions.

Our analysis reinforces many previous findings that channeling growth into compact urban neighborhoods can be an effective strategy for reducing climate-warming emissions from new housing. Local governments looking for ways to moderate the global climate impacts of new development would do well to encourage compact, multifamily development near urban and town centers with ready access to transit, jobs, stores, and services.

Figure 2. Household transportation GHG emissions by census block group, western King County, as estimated by the Center for Neighborhood Technology.

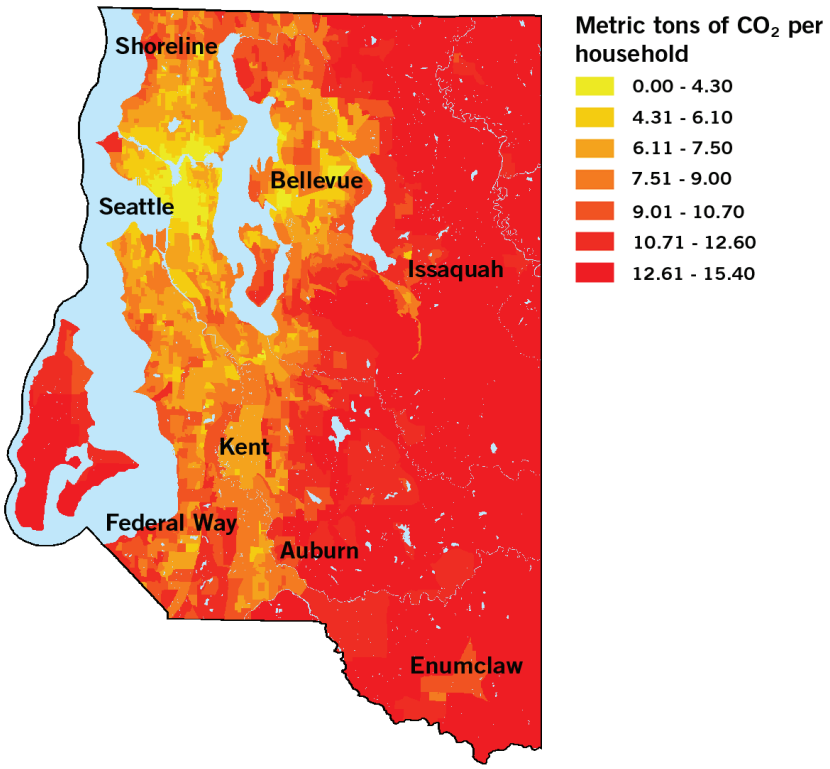
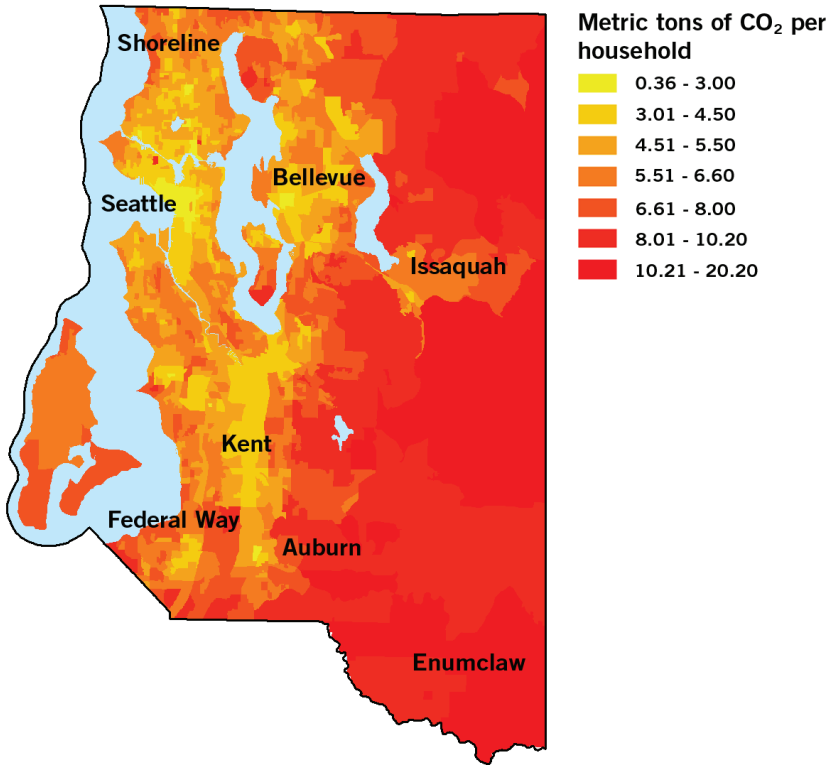


Figure 3. Household transportation GHG emissions by census block group, western King County, as estimated by Larry Frank and Co., 2008.



Methodology and Notes

Transportation Emissions

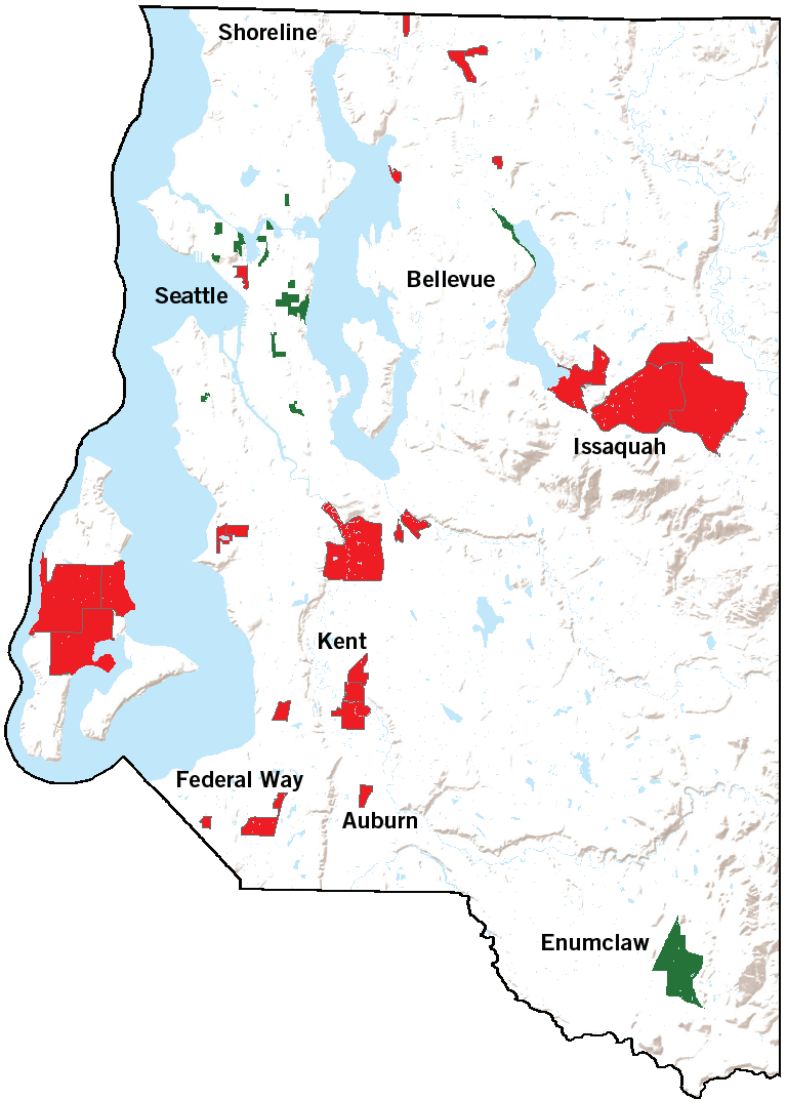
This report relies on estimates of transportation emissions from two recent modeling efforts. One of these was undertaken on behalf of King County by Lawrence Frank and Company (LFC),[1] a consulting firm led by University of British Columbia professor Larry Frank. This model used data from the Puget Sound Regional Council's 2006 Household Activity Survey, which collected data on household car and transit trips over a 48-hour period from more than 2,000 King County households.[2] The consultants correlated household travel data with other known characteristics of the respondents' neighborhoods, including residential density, demographics, travel times to employment centers, proximity to stores and other commercial establishments, and the level of transit service within the neighborhood. From these inputs, the consultants developed a model that allowed them to estimate household GHG emissions based on demographics, land use, and transportation data for each census block group throughout King County.

The second model was developed by the Center for Neighborhood Technology, a non-profit research institution based in Chicago, as part of a larger effort to estimate transportation emissions from neighborhoods in major metropolitan areas across the US. This model was developed using data on odometer readings for millions of vehicles within Massachusetts, which were correlated with widely-available data on neighborhood demographics and land use and transportation network characteristics. CNT ground-tested this model using odometer readings and land use data from the Chicago metro area, and then applied the model to estimate household transportation emissions in major metro areas throughout the US.

Despite their clear similarities in emissions patterns, there were at least three important differences between the two models. First, CNT's estimates of household transportation emissions were generally about 30 to 40 percent higher than LFC's estimates. The LFC models estimated that King County households overall produced an average of 5.6 metric tons of transportation-related GHG emissions per household per year, while the CNT models estimate an average of 7.8 metric tons. Recent work to develop a consumption-based inventory for the County suggests that household transportation emissions likely fall between the two estimates.[3]

Second, even after accounting for the discrepancy in average emissions rates, there were some significant differences in the household transportation emissions estimates for particular block groups (see Figure 3). Some of these differences may stem from the different data sources used for the two models. In particular, the LFC model accounted for travel times to a variety of regional employment centers–which may make the LFC model more sensitive to the specifics of local development patterns than the CNT model.

Figure 4. Block groups where LFC and CNT estimates differed most. (In red, block groups where CNT was particularly high compared with LFC; in green, block groups were where CNT was particularly low compared with LFC.)



Third, the models employed different treatments of household demographics. The LFC model outputs obtained by Sightline represented estimates of the actual household emissions from each census block group; that is, the GHG emissions mapped in Figure 2 reflect the income levels and household sizes that were actually found within that block group. The CNT model outputs, in contrast, purport to hold household demographics constant—showing not actual emissions, but the projected emissions of hypothetical, demographically identical households located in each block group.[4]

Electricity and Natural Gas Emissions

Although Puget Sound Energy has provided King County with a wealth of data on local electricity and natural gas use, interpreting the data creates significant complications for gauging the effects of TDR programs on residential emissions.

Missing data in Shoreline and Seattle.

Seattle City Light (SCL)—the second largest electricity provider in the county—does not release data on household electricity consumption within its service territory. As a result, household electricity consumption in Seattle and Shoreline, WA, along with portions of adjacent jurisdictions is simply unknown.

Missing data for home heating.

Some small share of King County households uses oil, other fossil fuels, or district heating (particularly Seattle Steam in downtown Seattle) for residential heating—meaning that data on residential electricity and natural gas by themselves provide an incomplete and uneven picture of household heating energy consumption in the county.

Uncertainty in electricity emissions rates.

Emissions rates for electric utilities vary from year to year, depending on factors such as hydropower production.[5] But perhaps more importantly, accounting for electricity emissions is the subject of considerable methodological debate. On the one hand, SCL sources most of its electricity from low-carbon sources (hydropower dams and nuclear power plants), whereas Puget Sound Energy gets much of its energy from coal and natural gas plants—suggesting that electricity consumption in SCL's service territory produces much lower emissions than in PSE's.[6] Yet on the other hand, overall emissions across the generation portfolio of the entire Northwest Power Pool may be only minimally affected by the choice of putting new housing in SCL's service territory. (After all, building new housing in SCL's service territory doesn't cause the region's dams, nuclear plants, or wind farms to produce more electricity.) The two very different methods of emissions accounting (averages for each utility vs. marginal emissions for the entire Northwest Power Pool) yield vastly different estimates for potential emissions reductions from housing location choices within King County. For this analysis, we develop high-end and low-end estimates of the potential emissions reductions due to different generation mixes with Seattle—but we recognize that emissions from electricity will remain uncertain and subject to debate.

Local climate variations.

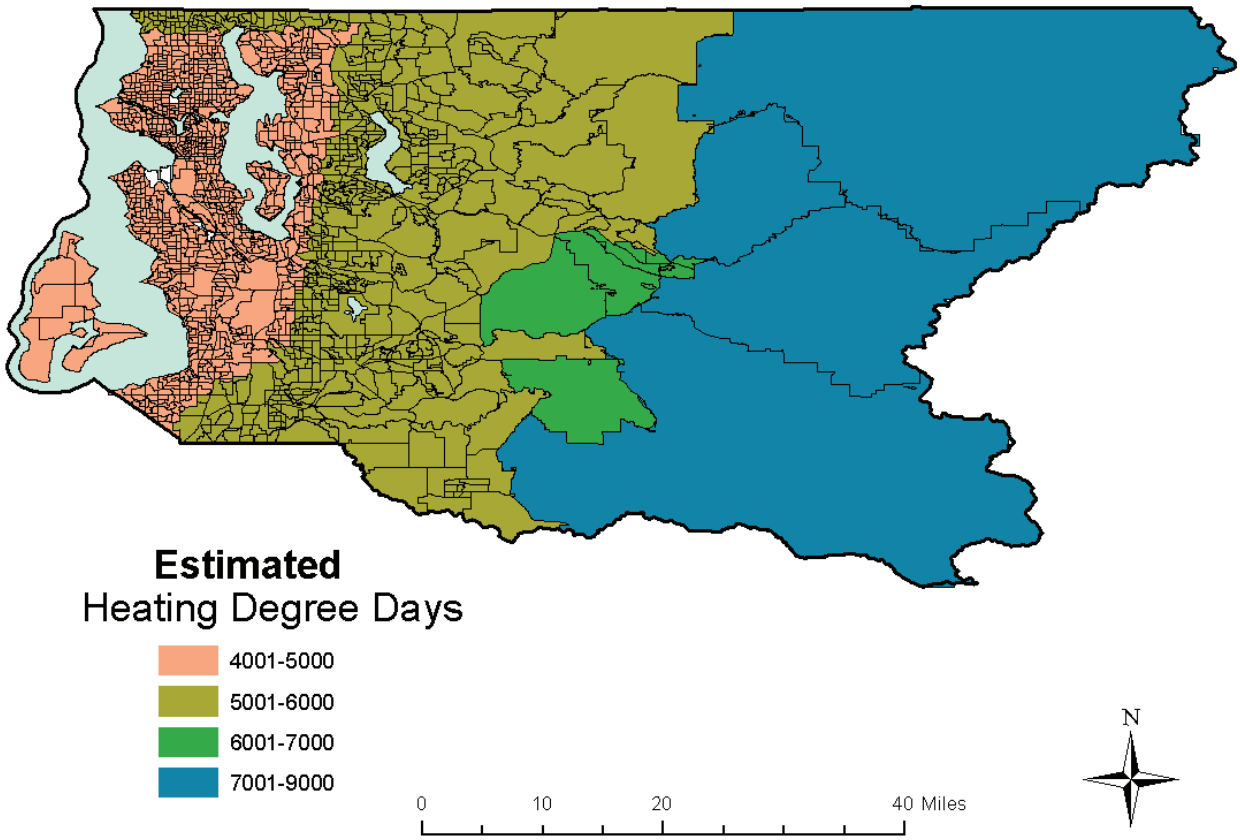
Energy consumption for heating and cooling likely depend on local climate conditions. And within King County, climate conditions vary by elevation and by proximity to water (see Figure 4). This suggests that an accurate account of the effect of new housing would need to factor in differences in local climate.

Need for more sophisticated models of home energy consumption.

Although PSE's data provides helpful clues about energy-related emissions in different parts of its service territory, an accurate assessment of the effect of the location of new housing on household emissions would require a more in-depth modeling effort—one that relates data on demographics, household size, income, new home square footage, and climate with estimates of household energy consumption.

Resolving these many complications is outside the scope of this report. This means that this report's conclusions about the effects of housing location on emissions for heating, cooling, and home appliances should be seen as tentative rather than definitive.

Figure 4. Heating Degree Days vary in different parts of King County. (Source: NOAA.)



Other Assumptions

Sightline's model also incorporates the following factors:

Two transactions.

For this analysis, Sightline divides a TDR exchange into a "sending" transaction and a "receiving" transaction, each with separate effects. In the sending transaction, we assign annual odds that a "sending" parcel would have been developed if development rights had not been sold.[7] We then assume that the TDR sale "pushes" development activity that might have occurred at some place in the sending zone to a hypothetical location that represents the county-wide average emissions profile for household transportation, natural gas, and electricity emissions. Likewise, we assume that the purchase of a TDR "pulls" development activity from the county-wide average to the profile of the receiving zone.

Time frame.

Housing location and style can affect energy consumption for many decades. Yet changes in technology and neighborhood amenities are unpredictable. To avoid overreach, Sightline only considers potential emissions changes during the first 30 years after TDR rights are sold.

Changes in vehicle fuel consumption.

The Washington State Office of Financial Management has published projections of the fuel efficiency of the vehicle fleet through 2027. For purposes of this analysis, Sightline adopts OFM's estimates through 2027, and assumes that vehicle efficiency will continue to improve modestly thereafter.[8]

Transportation behavior and the "self-selection" effect.

A substantial body of research suggests that compact neighborhoods tend to attract households that prefer to drive less, and walk, bike, and use transit more than the average household. This "self-selection" effect—rather than the influence of neighborhood design per se—may partially explain the lower emissions found in compact neighborhoods. To address this potential, Sightline's low-end estimate for transportation emissions includes a substantial discount of emissions savings, to account for potential "self-selection" bias in the transportation model results.

Square footage in single family homes.

The American Housing Survey shows that, when measured per capita, new single family homes contain the same square footage inside Seattle as in the Seattle suburbs.[9] Although the AHS data does not hold household income constant, Sightline conservatively assumed that, after holding family size and income constant, a new home for a single household would be of the same size no matter where in the metropolitan region it is constructed.[10]

Square footage in multifamily homes.

Some TDR exchanges give landowners in a receiving zone the right to build a fixed square footage (e.g. 2000 sf/TDR) of new floor area, which can be used for many different purposes—e.g., one large apartment, several smaller apartments, or even office space. The diversity of potential uses for this building space complicates any GHG analysis. As a simplifying assumption, Sightline follows published estimates that residential energy consumption is roughly proportional to floor space,[11] and that occupants of compact center cities use 9-10 percent less floor space per person than do occupants of lower density areas.[12]

Multifamily housing energy consumption.

Consistent with recent research, Sightline assumed that multiunit housing with 2-4 units in a single structure (typically duplexes or row houses) consumed about 4-5% less energy per household than single family homes. Multiunit housing with 5 or more

units per structure, in turn, was associated with a 17% reduction in household energy consumption.

Seattle Steam.

We assumed, based on data provided on the Seattle Steam website, that housing serviced by downtown Seattle's "district heat" utility produced about one-half as much CO2 per household for heating as home serviced by a natural gas utility.

Model sensitivities

Several assumptions and decisions have an outsized effect on any estimates of the potential effects of TDR transfers on GHG emissions:

Time frame.

Sightline assumes that over the long term, emissions from vehicles and electricity generation will decline—meaning that the GHG benefits of efficient locations and housing styles also decline over time. Nonetheless, most available data suggest that the year-to-year pace of decline will be slow. As a result, the total magnitude of GHG effects is highly dependent on the choice of the time horizon. Reducing the time horizon from 30 to 15 years roughly halves the emissions effects of TDR exchanges. Doubling the time frame to 60 years nearly doubles the net emissions effects.

Development odds.

The estimated odds that a sending site will be developed significantly influence estimates of long-term GHG emissions. Holding the time horizon constant at 30 years, doubling the estimated odds that a location will be developed within 20 years roughly doubles the expected GHG effects associated with the TDR "sending" transaction.

Electricity accounting.

The choice of how to account for emissions related to electricity generation has a substantial effect on household emissions estimates, and accounts for the large majority of the uncertainty in emissions estimates for TDR transfers. If we assume that electricity provided by Seattle City Light is essentially emissions-free, while electricity provided by Puget Sound Energy produces roughly 1 pound of CO2 per kWh, the potential effects of TDR exchanges on electricity emissions appear to be every bit as significant as the effects on transportation emissions. But if we assume that any new housing unit in King County has roughly the same impact on the Northwest's overall fossil fuel generation, then housing location is largely irrelevant to GHG calculations. Sightline's estimates take the middle road; our mid-point estimates represent the average of the two accounting methods. But we recognize that considerable uncertainty remains about the effects of housing location on electricity emissions.

Endnotes

1. Now doing business as Urban Design 4 Health, http://urbandesign4health.com.
2. Puget Sound Regional Council, "PSRC 2006 Household Activity Survey Analysis Report," Appendix A: Survey Methods, http://www.psrc.org/assets/1455/AppA_methods_2006.pdf.
3. Note that CNT's estimates were more closely aligned with other published estimates of average household transportation GHGs than were LFC's.
4. Note that LFC's model could also be used to project hypothetical emissions from demographically identical households; but such an exercise was outside the scope of this project.
5. Variable emissions rates from US Environmental Protection Agency, eGRID website. See e.g., "eGRID2010 Version 1.1, "Year 2007 Summary Tables," created May 2011, http://www.epa.gov/cleanenergy/documents/egridzips/eGRID2010V1_1_year07_SummaryTables.pdf.
6. In fact, Seattle City Light works diligently to reduce its emissions by purchasing low-carbon electricity, promoting conservation, and purchasing emissions "offsets" for the small portion of fossil-fuel powered electricity that it does purchase.
7. For this analysis, we assume that the odds are that a given parcel would be developed within 20 years of the sale of development rights. We believe that this may be a conservative assumption, given that managers of TDR programs often focus on land that is under high development pressure.
8. Note that these estimates do not reflect the effects of the most recent revisions to federal CAFE standards, announced in late July 2011.
9. US Census Bureau, "American Housing Survey for the Seattle Metropolitan Area: 2009," Table 2-3, http://www.census.gov/hhes/www/housing/ahs/2009Seattle/seattle09.html.
10. This estimate is conservative, since some evidence suggests that, holding household income and size constant, housing close to urban centers contains fewer square feet per resident than housing farther from the urban core.
11. Jonathan Norman, Heather MacLean, and Christopher Kennedy, "Comparing High and Low Residential Density: Life Cycle Analysis of Energy Use and Greenhouse Gas Emissions," Journal of Urban Planning and Development, March 2006, http://bit.ly/qMJvOC.
12. Edward Glaeser and Matthew Kahn, "Sprawl and Urban Growth," National Bureau of Economic Research, May 2003, http://people.missouristate.edu/davidmitchell/Urban/Sprawl%20and%20Urban%20Growth.pdf.

Sightline Institute is a not-for-profit research and communication center—a think tank—based in Seattle. Sightline's mission is to make the Northwest a global model of sustainability—strong communities, a green economy, and a healthy environment.