Measuring **MOBILITY POTENTIAL**

NREL Researchers Develop New Metric that Quantifies Mobility Energy Productivity

Advances in technology are fueling a new era of transportation transformation, with the potential to shake up a system that has remained virtually unchanged for decades. Congestion and other mobility challenges associated with rising urban populations, such as air pollution and affordability, are spawning ever-evolving mobility technologies to connect people to goods, services, and employment—all of which define a high quality of life. Because transportation is evolving so rapidly, it is also expected that tens of billions of dollars in urban infrastructure investments and modernization upgrades will be part of capital improvements in coming years.

New ways of thinking about mobility are being spurred on by questions such as: How does an infrastructure investment impact the mobility of a place or a region? In what way does new and emerging mobility technology influence a community's overall mobility? Would businesses choose a different location to improve their operations or customer experience if they could evaluate the variety of opportunities that can be accessed using different modes in that area? How does mobility impact a person's quality of life?

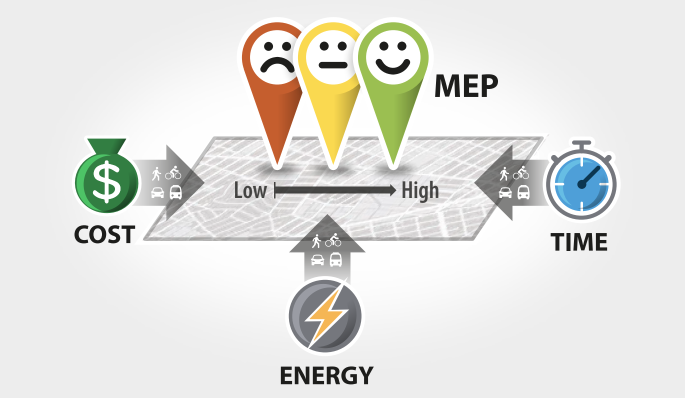
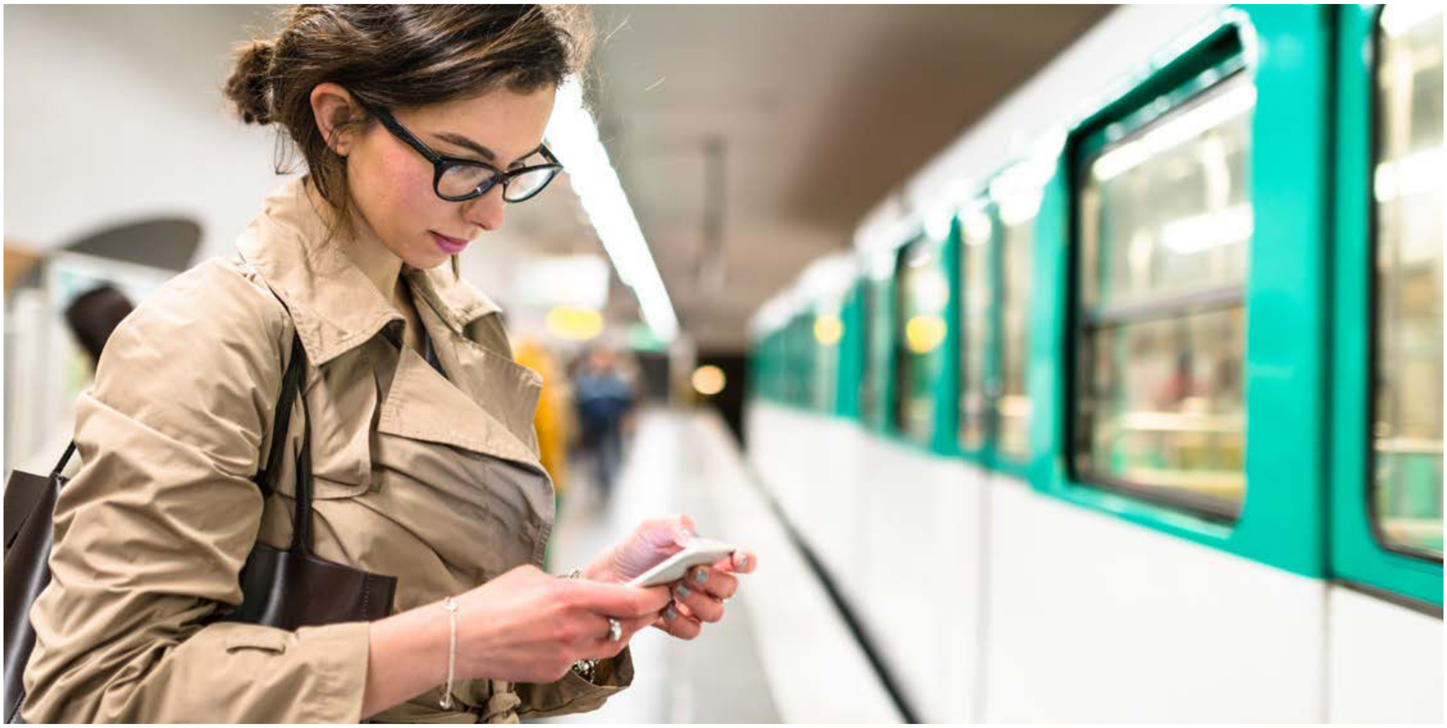


Figure 1. MEP metric representation

With support from the U.S. Department of Energy's (DOE) Energy Efficient Mobility Systems (EEMS) Program, an interdisciplinary team at the National Renewable Energy Laboratory (NREL) is developing the Mobility Energy Productivity (MEP) metric to address this challenge (as shown in Figure 1). The intent of the MEP metric is primarily to track changes in mobility within a single city, location, or place over time. The metric can measure current levels of mobility at a specific location, and then test how various technological advancements, services (e.g. scooters, ride hailing, automated vehicles) and infrastructure



investments (e.g. bike lanes, mixed-used development) may impact the mobility of that location over time. A location with high mobility offers multiple transportation options to access a diverse number of opportunities while optimizing for time, cost, and energy consumption.

The MEP metric will aid DOE's EEMS program in communicating the impact of emerging mobility choices. NREL intends the metric to serve as the unifying lens to assess the impact of cutting-edge research, advanced transportation, and vehicle technologies within DOE, as well as across a broader mobility space.

MEP Metric Expands Upon Existing Measures of Mobility

While measurements of accessibility are not new, the MEP metric significantly expands upon familiar metrics such as walk, bike, and transit scores. These current measures allow individuals to separately assess whether an area is walkable, bike-friendly, or well-served by public transit services based on the distances that can be traveled in various amounts of time using these modes[1]. However, these measures are proprietary, only address a single mode, and often lack detailed information about overall performance, trip costs, and energy consumption.

Beyond simply location, distance, and energy, the MEP metric also considers the total number of opportunities accessible from a given location within a certain time frame. For example, how many employment opportunities, health care facilities, grocery stores, restaurants, parks, and entertainment destinations exist within twenty minutes of a location using different modes. The resulting metric provides a robust assessment of mobility options provided at a given location, regardless of whether travelers posses their own mode of personal transportation or use a bus, train, transportation network company (TNC) (e.g., Uber, Lyft, etc.), bikeshare, or carshare.

The MEP metric is open source, non-proprietary, and adaptable to include new modes of transport as they emerge—like connected and autonomous vehicles and shared transportation services—by characterizing new modes through travel time, affordability, and energy consumption.

Methodology

The MEP metric combines mobility, energy, and affordability components with geospatial analysis, providing both a visual map and numeric metric to quantify the richness of a mobility system at a given location. Using third-party travel data or outputs from regional travel demand models along with land use data

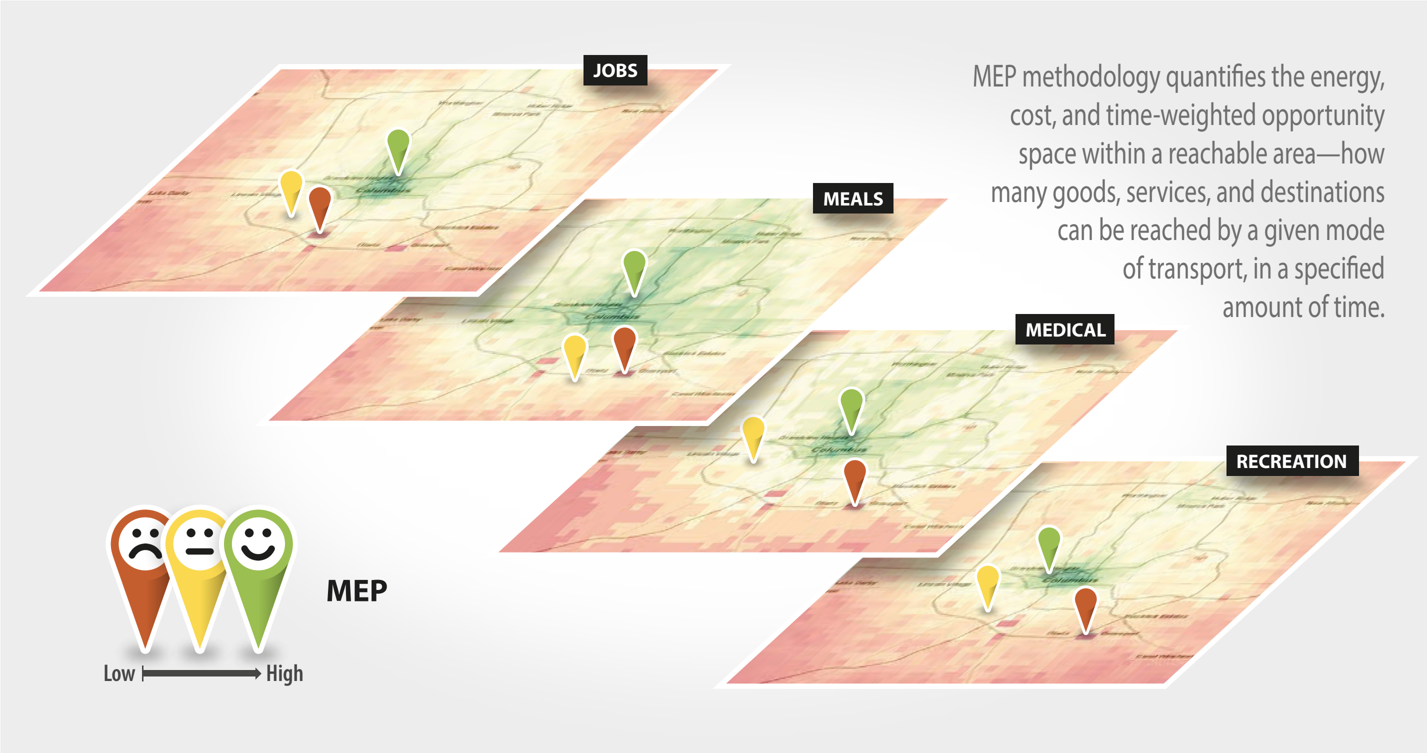


Figure 2. Energy weighted mobility metric by activity for a sample Midwestern city.

from cities, metropolitan planning organizations, or commercial entities, maps are built using geospatial analysis techniques. These maps of a region show what can be accessed within a given time frame, using a selected mode of travel. For example, how far an individual can travel within 15-, 30-, 45-, and 60-minutes from home by walking, biking, driving, or public transit, and what can be accessed within that time-mode boundary (defined as the opportunity space).

This opportunity space is weighted by time, energy, and cost, meaning high-cost travel affects the score negatively, while energy efficiency improves it. This is calculated using data from literature including the national household travel survey[2] and energy studies[3], culminating in a numeric MEP metric. Fundamentally, the basis of the MEP metric is the proximity and convenience of access to a variety of goods, services, and destinations reachable by various forms of mobility. Therefore, a location that provides the ability to access many opportunities by a variety of modes, within a short amount of time, low energy, and the least amount of cost, will have a high numeric MEP score.

Applications

The MEP metric will give transportation researchers and city planners a metric to assess mobility, energy, and quality-of-life outcomes of new technology on existing road systems, airport infrastructure, curb-fronts, parking capacities, and overall urban architecture. This information can be used to help them prioritize and inform investment and policy decisions. Additionally, a community can use the MEP metric to track progress toward mobility goals at certain locations and among specific population groups over time.

For example, if weighing a decision between investing funds to add an additional lane on a busy roadway or providing subsidies for transit trips to and from the central business district, the city could run both scenarios through a regional travel demand model. The outputs of the travel demand model provide inputs to the MEP methodology and provides a visualization showing how each of these decisions would affect the MEP of the region.

As part of the EEMS program's Systems and Modeling for Accelerated Research in Transportation (SMART) Mobility Laboratory Consortium research effort, the MEP metric was first applied to a sample Midwest city to provide a comprehensive assessment of the energy productivity of mobility provided to residents of the city. Figure 2 depicts the MEP metric by activity across four travel modes (walking, biking, driving, and TNC) and four activity types (work, medical, meal, and recreation). Using the methodology, the city would be able to track how MEP metrics are impacted as the vehicle market evolves to encompass more electrified vehicles or as new modes of transport such as automated shuttles emerge.

The MEP framework is being applied to the outputs of state-of-the-art mobility systems models that are at the core of DOE's EEMS Program research. SMART Mobility researchers have developed a complete end-to-end modeling workflow that captures a multitude of factors. These include human activity and behavior, fueling infrastructure, land-use patterns, market penetration of various vehicle technologies, and mobility services. Other factors include technology performance and linking multiple scales — from individual vehicles and travelers, to traffic flow in corridors and networks, to city/regional-scale mobility systems—in order to explore future mobility scenarios. The trade-offs between energy consumption, travel time, and affordability are being evaluated across a variety of potential scenarios for multiple locations through the MEP metric. This helps to identify the most critical research opportunities and inform DOE's mobility research priorities.

The MEP metric can also be used by a business faced with the decision of where to locate a new headquarters identify the most and least accessible locations within a city in order to determine an optimal location for both employees and customers. Similarly, individuals may one day use the measure to determine the best place to purchase a home based upon the cost and convenience of reaching fundamental needs like groceries, health care, employment, and other desired destinations.

Conclusion

New mobility choices will have critical impacts and implications for future planning and decision making for transportation, energy use, and infrastructure. Communities of the future will need to move beyond single-mode metrics like walk, bike, and transit-specific scores to measure the quality of multiple or varied options available to their citizens. With new data streams for mobility becoming increasingly available, the MEP metric will allow communities to layer many facets of mobility into a single overarching metric. Furthermore, it will allow communities to disaggregate the metric to isolate the impacts of certain mobility options at specific locations or among certain sub-populations and track progress over time.

The MEP metric offers a new and innovative approach to characterize, measure, and inform the movement of people within a given location or region. The ability to quantify mobility using the MEP metric has the potential to create more livable communities that offer transportation choices that are affordable, accessible, create economic opportunities, and lead to a higher quality of life for citizens.

NREL continues to expand upon the measure and has plans to include additional cost elements and travel modes in the near future. The team is also developing a MEP metric for freight that captures additional parameters specific to goods movement.

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[1] "Walk Score Methodology," Walk Score, accessed July 6, 2018, *https://www.walkscore.com/methodology.shtml*.

[2] "National Household Travel Survey," U.S. Department of Transportation Federal Highway Administration, accessed July 19, 2018, *https://nhts.ornl.gov/*.

[3] David Banister, "Sustainable Transport and Public Policy," *KIM, TJ Transportation Engineering and Planning*, Oxford: Eolss, 2 (Spring 2009): 192-214.