The Mobility Energy Productivity (MEP) Metric

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MOTIVATION

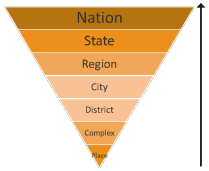
- What is mobility?
- How do you quantify mobility?
- No 'open' and practical method to quantify mobility
- Existing transportation performance metrics measure utilization or efficiency of road network
- Can we increase energy use if we connect people better?
- Productivity = mobility benefits/costs

Mobility: The quality of a network or system to connect people to goods, services, and employment that define a high quality of life.

The Energy Efficient Mobility Systems (EEMS) Program will identify and support technologies and innovations that encourage a maximum-mobility, minimum-energy future.

PROPERTIES OF THE MEP METRIC

- Reflects efficiency of accessing a variety of goods, services, and employment
- Can be applied to any mode (car, walk, bike, transportation network company [TNC], etc.) and across modes
- Determined by
  - Travel time and travel time reliability to destinations
  - Energy and monetary cost of travel
- Spatially scalable (applied to a home, district, city, or employer)
- Can compare
  - Two locations (Chicago vs. Topeka, Kansas)
  - Two planning strategies (roadway extension vs. transit expansion)
  - Two technologies (electric vehicle penetration vs. automated vehicle penetration)
- Can be disaggregated by geography, mode, trip type, and population sub-group



A metric that is easy to scale spatially, as different contexts might require computation at different scales

DATA SPECTRUM DRIVING THE METRIC

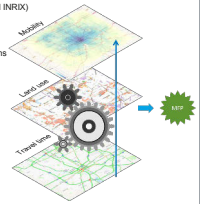
Travel Time and Isochrone
- Third-party isochrone application program interfaces (e.g., HERE)
- GPS trajectory data (TomTom and INRIX)
- Travel demand models

Land Use Data
- Metropolitan planning organizations

Energy Efficiency Measures
- Transportation Energy Data Book
- Other energy intensity studies

Travel Demand Data
- National Household Travel Survey (NHTS)

Cost Measures
- Capital and operational costs
- Value of time

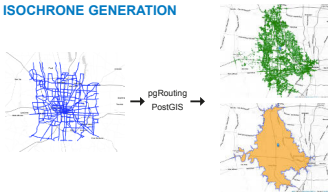


BASIC DATA ELEMENTS OF THE MEP METRIC

- Quantify the number of opportunities that people can reach within a certain travel-time threshold via different transportation modes
- The opportunities measure is weighted by the energy efficiency, affordability (cost), and time efficiency of different transportation modes

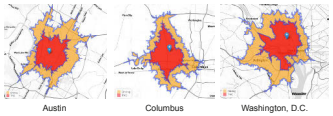
- Average the energy-weighted mobility values across all activities by frequency of trip purpose
- The opportunities measure is further weighted by the travel cost of each mode

ISOCHRONE GENERATION



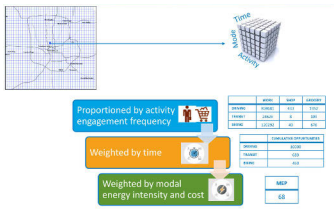
TNC ISOCHRONES

- 10 minutes of driving versus 10 minute TNC ride
- TNC waiting time is 3 minutes



Austin Columbus Washington, D.C.

WEIGHTING MECHANISM FOR THE METRIC



MEP METRIC

The MEP metric is calculated by weighting the cumulative opportunities using a negative exponential function applied on the modal weighting factor.

$$o_{ikt} = \sum_j o_{ijkt} \cdot \frac{N^*}{N_j} \cdot \frac{f_j}{\sum_j f_j}$$

$$\text{MEP}_i = \sum_k \sum_t (o_{ikt} - o_{ik(t-10)}) \cdot e^{U_{ikt}}$$

where $U_{ikt} = \alpha e_k + \beta t + \sigma c_k$

e_k – energy intensity of mode k

c_k – cost of mode k

α, β, σ – weighting parameters

t – travel time

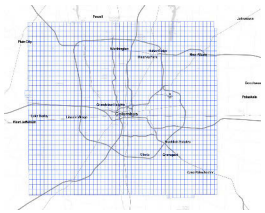
MODAL WEIGHTS FOR ENERGY AND OPERATING COSTS

Mode	Energy Intensity (kwh/passenger-mile)	Capital and Operational Cost (dollar/passenger-mile)
Driving	0.90	0.48
Transit	0.65	0.85
Bike	0	0
Walk	0	0
TNC	1.8	1.54
Paratransit	4.13	2.25

$\beta = -0.08, \alpha = -0.5, \sigma = -0.5$

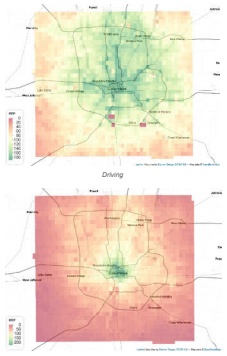
References:
- Federal Transit Administration, "National Transit Summary and Trends," 2015
- Oak Ridge National Laboratory, "Transportation Energy Data Book," 2018
- American Automobile Association, "Your Driving Costs," 2018
- ALG, "The Road to 2030," 2016

GEOGRAPHIC AREA FOR ANALYSIS



- Metropolitan area of Columbus, Ohio
- Divided into 1,830 1 km by 1 km pixels
- Mobility is evaluated at the centroid of each cell block
- 1 km chosen for balance between homogeneity of data and complexity of calculations
- Actual scale can be traffic analysis zone (TAZ) → block group → address, driven by data availability and analysis needs
- The MEP metric computed for each pixel is aggregated to the city level using population or employment density-weighted summation

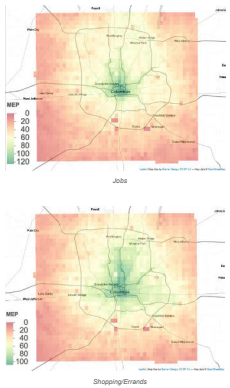
MEP MAPS BY MODE – COLUMBUS



Driving

Transit, Biking, and Walking Combined

MEP MAPS BY ACTIVITY – COLUMBUS



Jobs

Shopping/Errands

ILLUSTRATIVE SCENARIO ANALYSIS

Baseline

Population-Density-Weighted Metric: 162

Increase in Vehicle Efficiency

If MPG of cars is increased by 200% (MPG of cars increased from 25 in the baseline to 75 in the scenario)

Population-Density-Weighted Metric: 204 (26% increase from baseline)

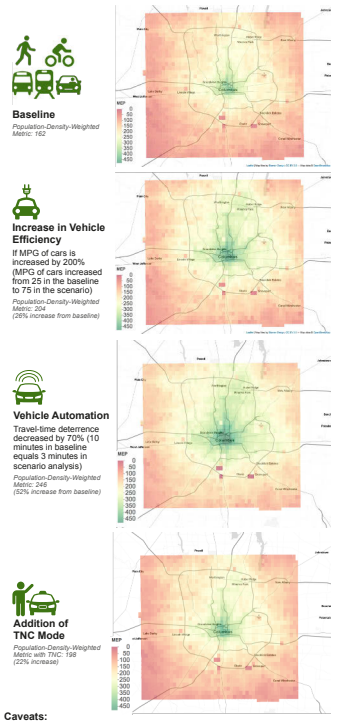
Vehicle Automation

Travel-time deterrence decreased by 70% (10 minutes in baseline equals 3 minutes in scenario analysis)

Population-Density-Weighted Metric: 246 (52% increase from baseline)

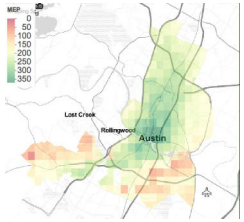
Addition of TNC Mode

Population-Density-Weighted Metric with TNC: 198 (22% increase)

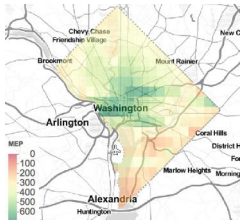


Caveats:
- In the scenario analyses presented above, assumptions were made to show first-order-effects improvements in MEP scores due to technological advancements or transportation investments
- Coupling the MEP calculations with agent-based travel microsimulation models can fully capture such effects—not only primary impacts such as energy intensity, but also impacts of adoption rates, induced (or reduced) congestion, and other secondary and tertiary impacts that can arise from these scenarios

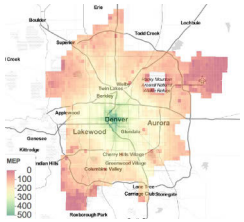
MEP FOR VARIOUS CITIES



Austin, Texas: 233



Washington, D.C.: 427



Denver, Colorado: 216

NEXT STEPS

- Incorporate mode-activity realism into the computation of the metric (to address unrealistic scenarios like walking 40 minutes to access a grocery store)
- Obtain relevant data from publicly available sources such as the National Household Travel Survey
- Integrate with regional travel demand models to assess alternative future scenarios
- Calculate MEP for the 50 largest metropolitan areas in the United States

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