

# The economics of networks: The challenges of rural networkification

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# Why is this hard?

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- What is rural?
- How far behind are rural areas?
- We electrified rural America in the 1930s!
- What are the options and trade-offs?
- Adoption, not just construction

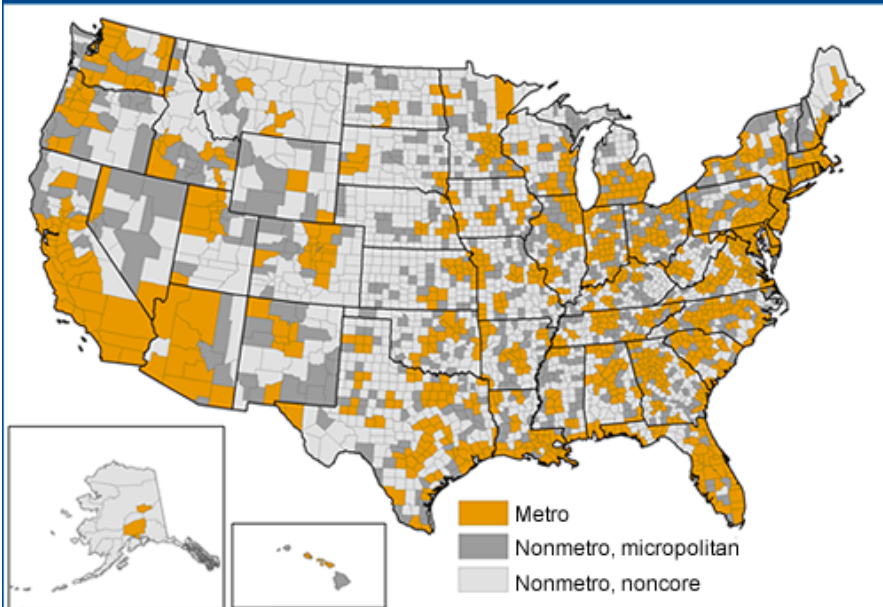
# What is rural?

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- Census:
  - Urban = Urbanized Areas (UAs) of 50,000 or more people
    - OR Urban Clusters (UCs) of **2,500 to 50,000** people.
    - core of population density of 1000 people/mi<sup>2</sup>
      - all of NJ: 1210 / mi<sup>2</sup>
  - Rural = everywhere else
- OMB:
  - Metropolitan Statistical Areas (MSAs):  $\geq$  one urbanized area of  $\geq$  50,000 population, plus adjacent territory that has a high degree of social and economic integration with the core as measured by commuting ties.
  - Micropolitan Statistical Areas:  $\geq$  one urban cluster of at least 10,000 but less than 50,000 population, plus adjacent territory that has a high degree of social and economic integration.
- USDA
  - based on counties

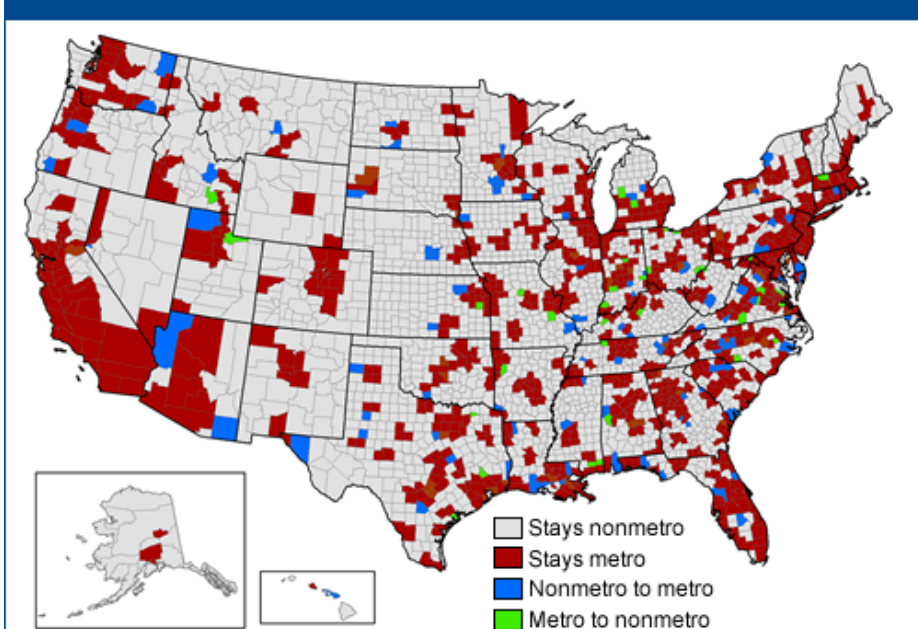
# Rural areas (USDA)

Metro, nonmetro micropolitan, and nonmetro noncore counties, 2013



Source: USDA, Economic Research Service using data from the U.S. Census Bureau.

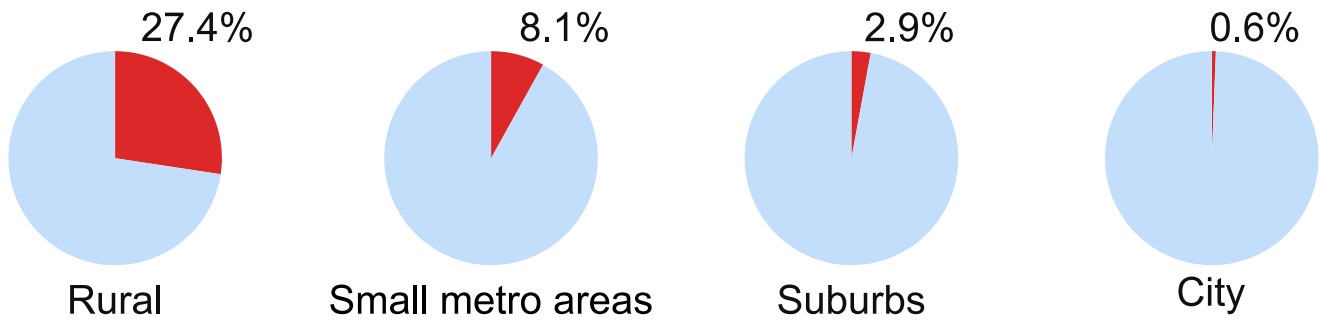
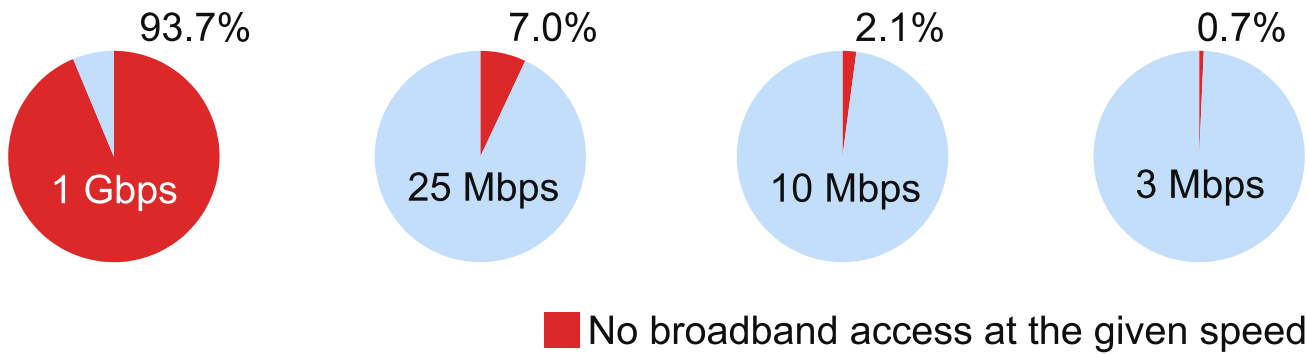
Counties changing metro status, 2003-2013



Source: USDA, Economic Research Service using data from the U.S. Census Bureau.

# Broadband access by speed & geography

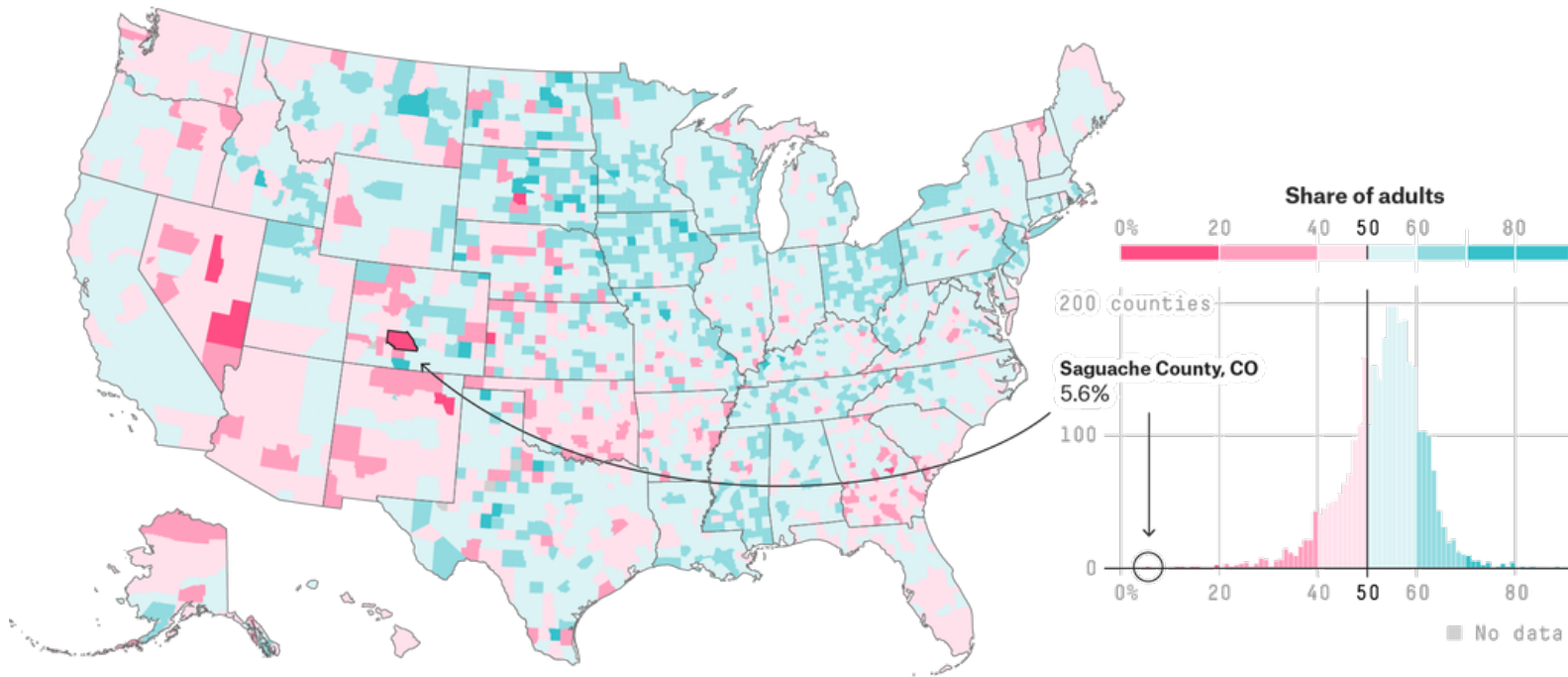
BROOKINGS



15% of US population

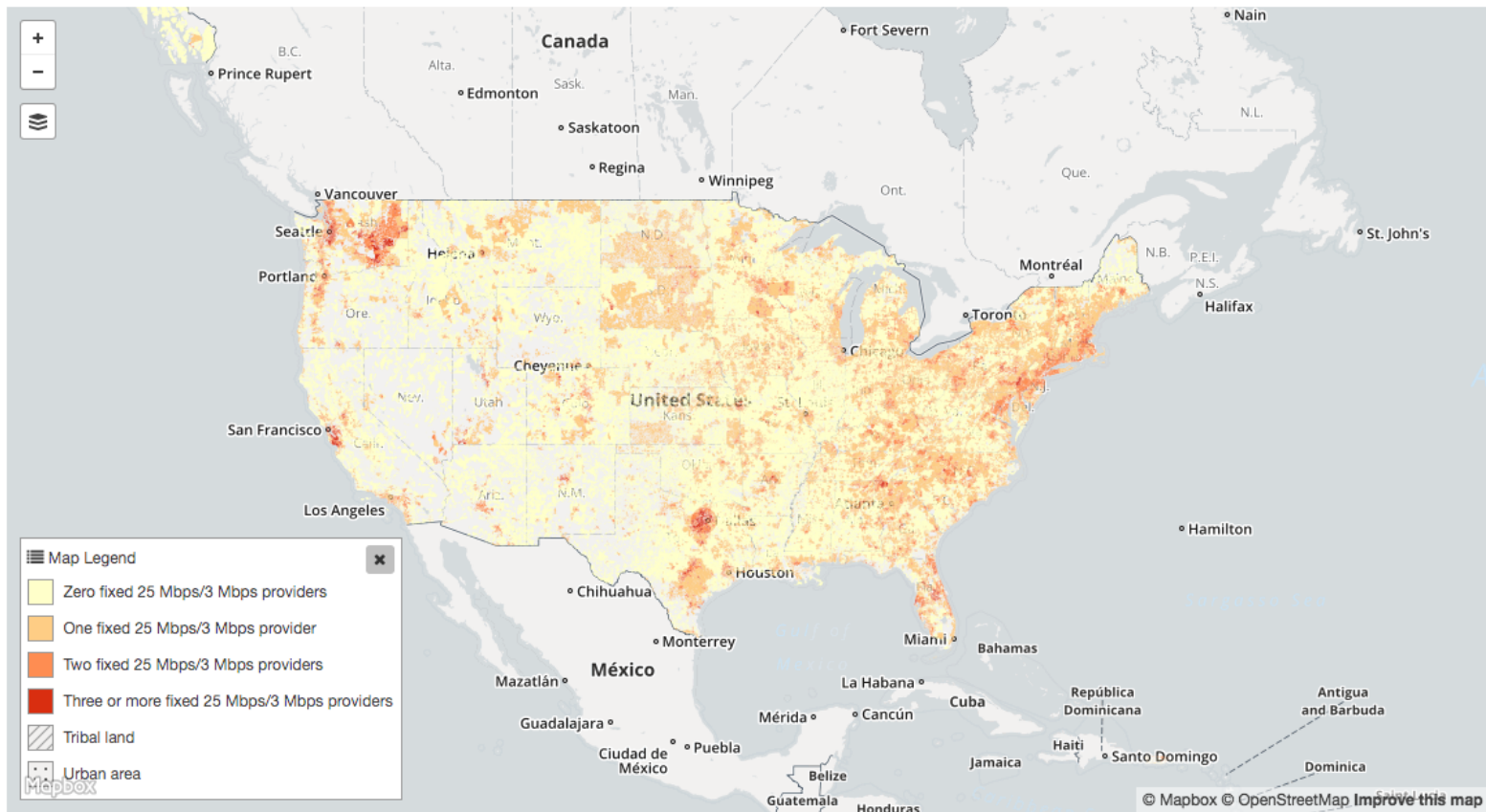
No broadband access at 25 Mbps

# Rural broadband US



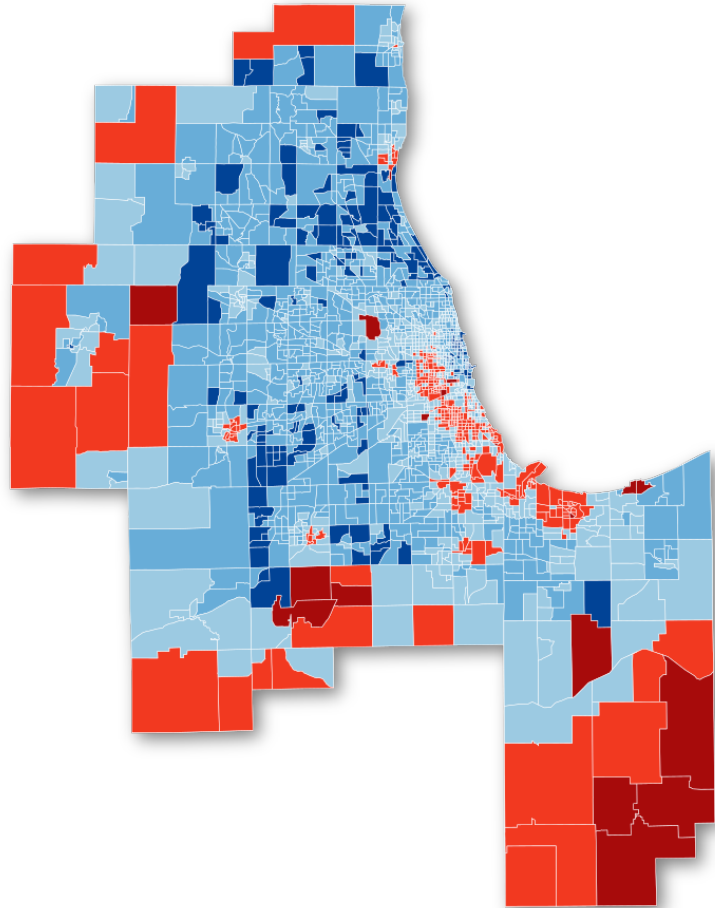
County shares are estimated using data from a 1 percent sample of 240 million voting-age Americans provided by Catalist, an election data firm. Internet connections faster than dial-up include those via DSL, cable, fiber-optic, satellite, etc.

# Number of 25/3 Mb/s providers



# Aside: urban areas, too

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Chicago metro area



# Rural electrification

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- Early 1920s, between 2 and 3% (likely less)
  - 1921: DC had 98.2%, MA 97.8%
- “In 1935, only 10.9% of American farms (744,000) enjoyed central station power, compared with Germany and Japan at 90%, France between 90 and 95%, and New Zealand at 60%.”
- “In 1940, just four and a half years after Roosevelt signed Executive Order No. 7037 (followed by 1936 “Rural Electrification Act”), 25% of American farms had been electrified.”
- 1950: 90% had been electrified nationally
- Today: 850 distribution coops serving 14 M homes

# Rural electrification

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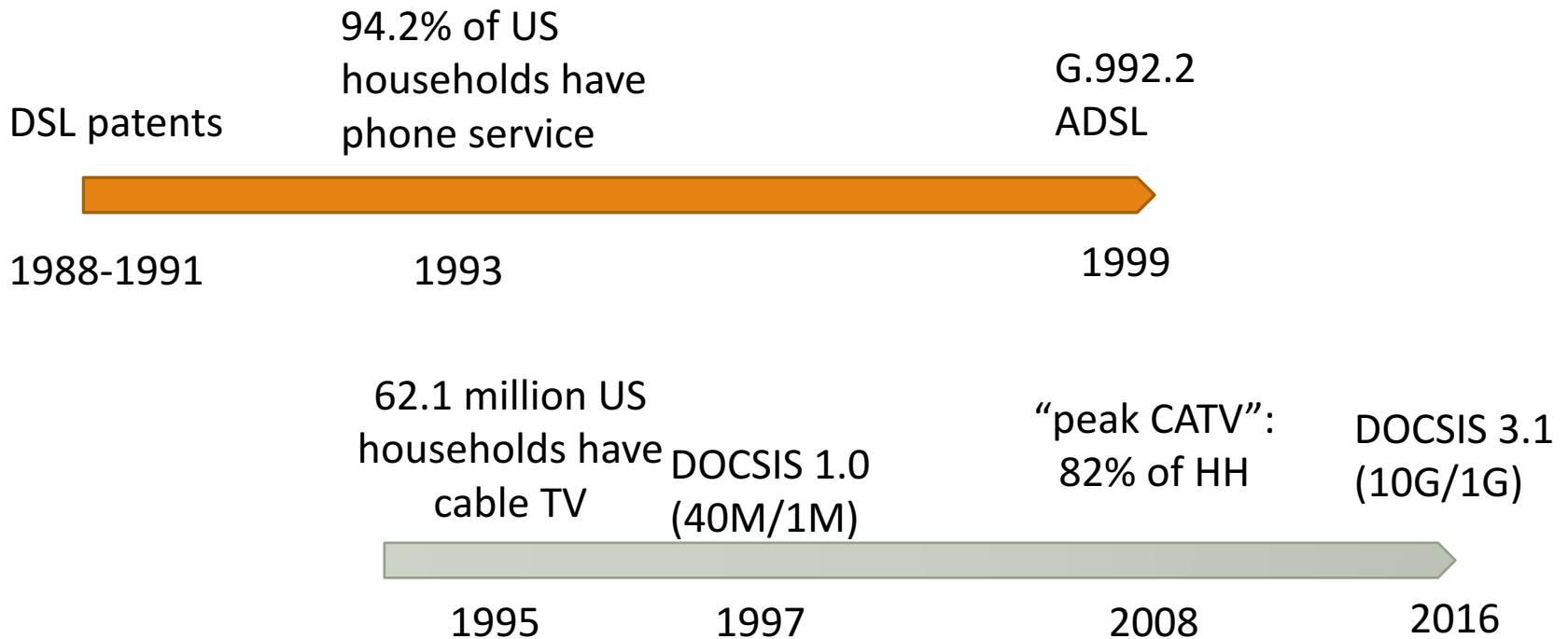
- “In 1935, Morris Llewellyn Cooke, a mechanical engineer who had devised efficient rural distribution systems for power companies in New York and Pennsylvania, had written a report that detailed a plan for electrifying the nation's rural regions. Appointed by Roosevelt as the REA's first administrator, Cooke applied an engineer's approach to the problem, instituting what was known at the time as "scientific management" — essentially systems engineering. Rural electrification became one of the most successful government programs ever enacted. Within 2 years it helped bring electricity to some 1.5 million farms through 350 rural cooperatives in 45 of the 48 states. By 1939 the cost of a mile of rural line had dropped from \$2,000 to \$600. Almost half of all farms were wired by 1942 and virtually all of them by the 1950s.”
- Cost of aerial **fiber** installation: \$14k/mile material, \$39k/mile installation (Singer, 2017)



\$10,958 in  
2017

# Accidental broadband

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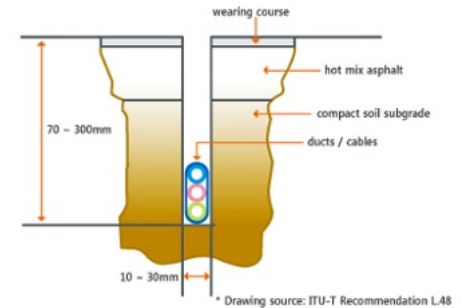
# Trade-offs across the world?

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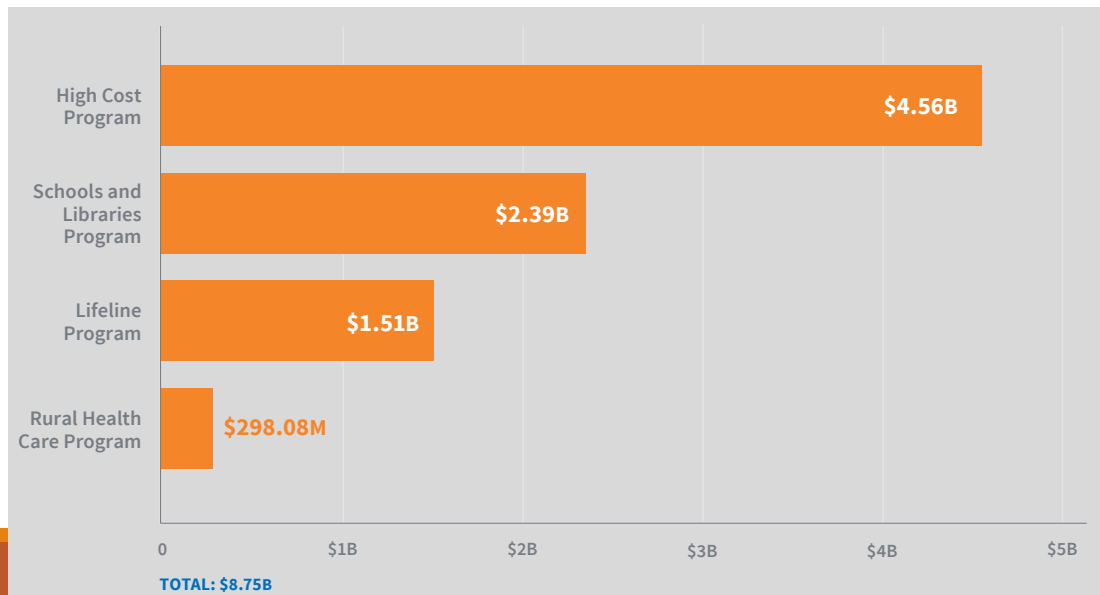
- If new deployment, predicted return on investment
  - with unbundling: what is the wholesale price going to be?
  - no magic algorithm --- margin squeeze
- Allow infrastructure owner to provide services?
- Impact on consumer surplus
- US: pole attachment problems
  - if incumbents are pole owners

# Policy levers for rural broadband

- Decrease cost of serving
  - “dig once” – bury conduit or fiber during street (or other utility) repair & construction
  - pole attachment: make-ready, rates, shot clocks, ...
- Provide funding
  - US: Universal Service Fund



microtrenching

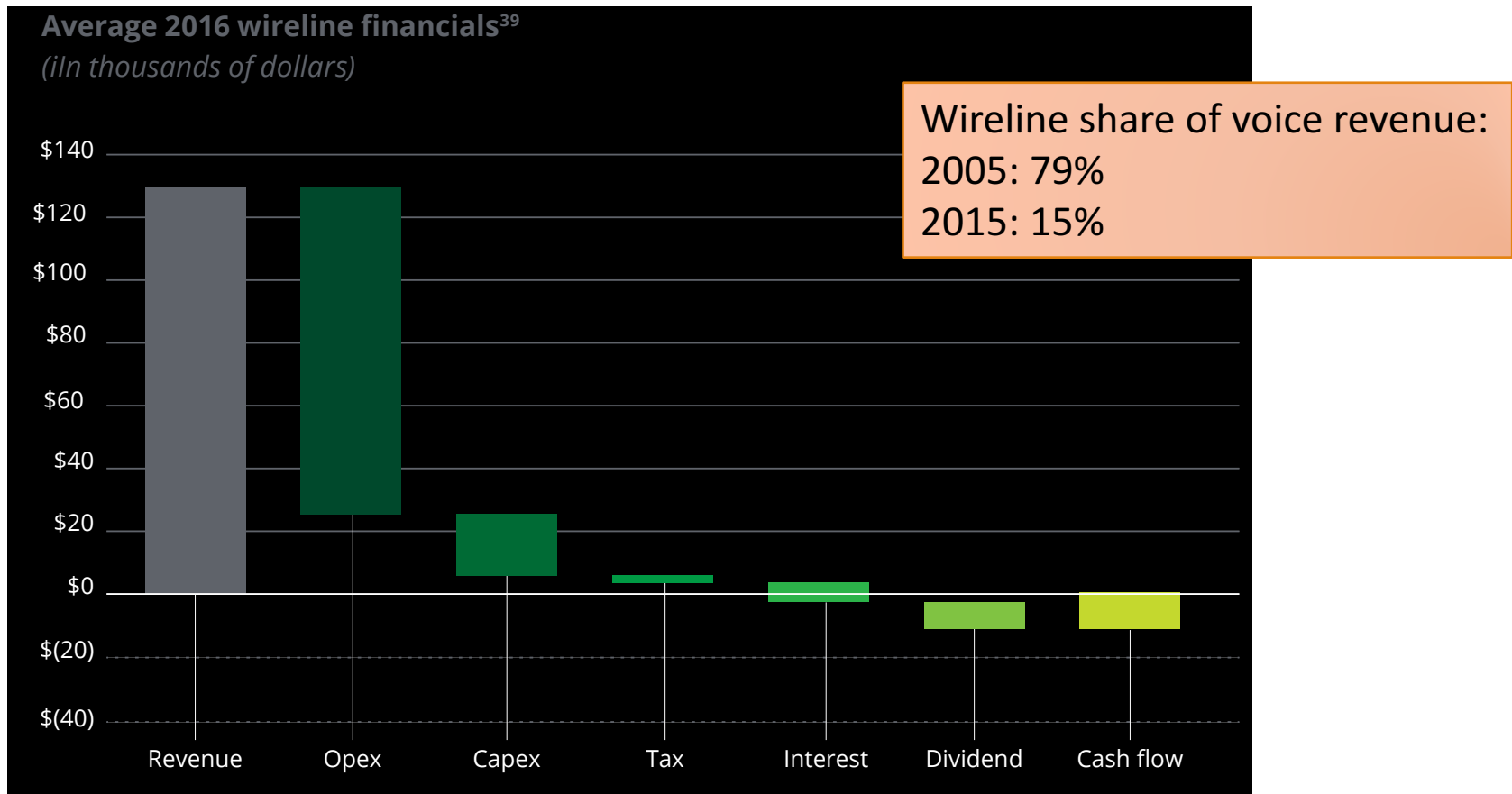


# Challenges for rural broadband

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- Who is going to build out?
  - some incumbent local exchange carriers (ILECs) are not interested
  - municipalities may be prohibited by state laws
    - or hurdle is extremely high
  - rural electric cooperatives – serve 14M homes in US (out of ~110M)
    - average, 5.8 electric meters per mile
- Who is going to pay for broadband?
  - government support: pay once (build out) or pay forever?
  - pay for middle mile or last mile or subsidize use?
- Are non-landline approaches scalable?
  - TV whitespaces
  - satellite – NGS like OneWeb (600 satellites)
    - currently, about 500k residential satellite subscribers

# Rural wireline ILECs lack resources

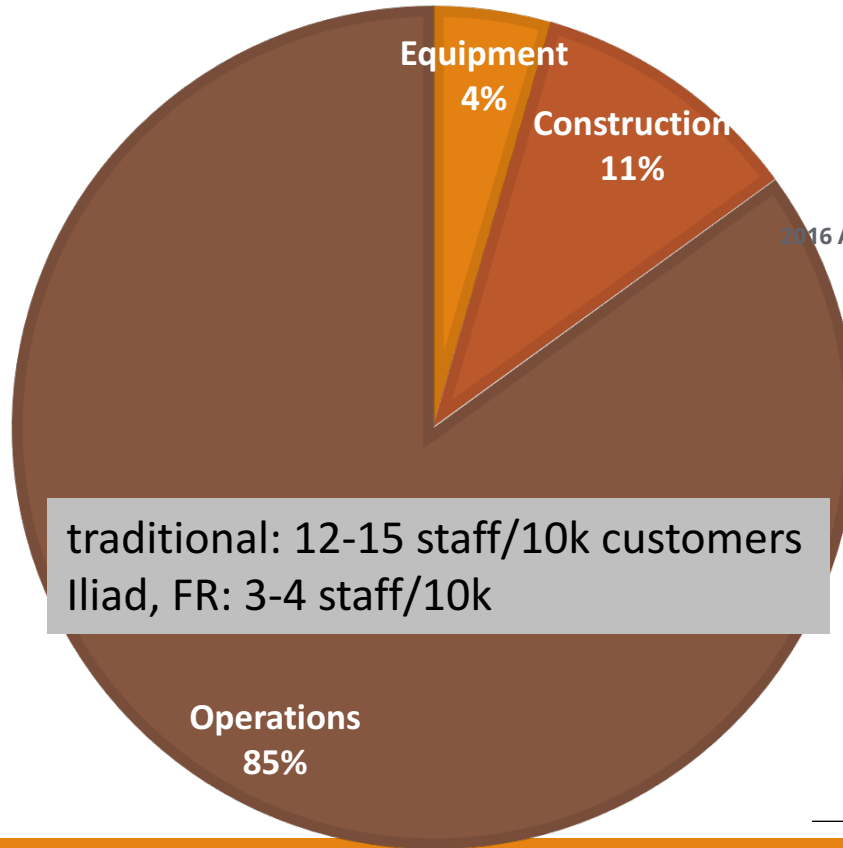


# Network economics, (over)simplified

% OF REVENUE

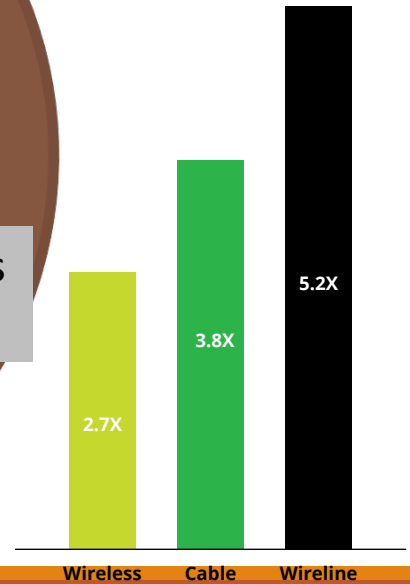


■ Equipment ■ Construction ■ Operations ■



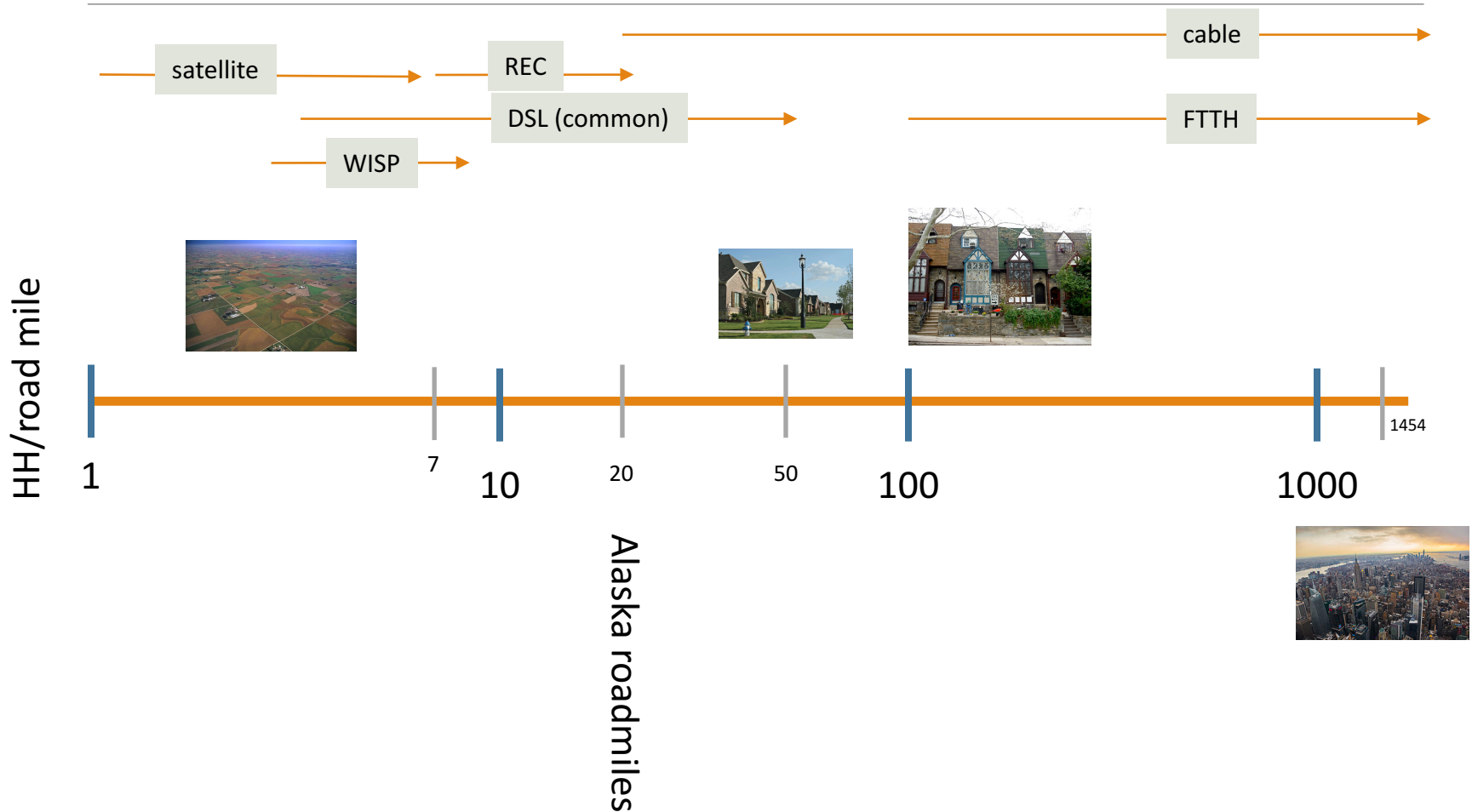
traditional: 12-15 staff/10k customers  
Iliad, FR: 3-4 staff/10k

2016 Average OPEX to CAPEX ratios<sup>44</sup>





# Density determines network choices



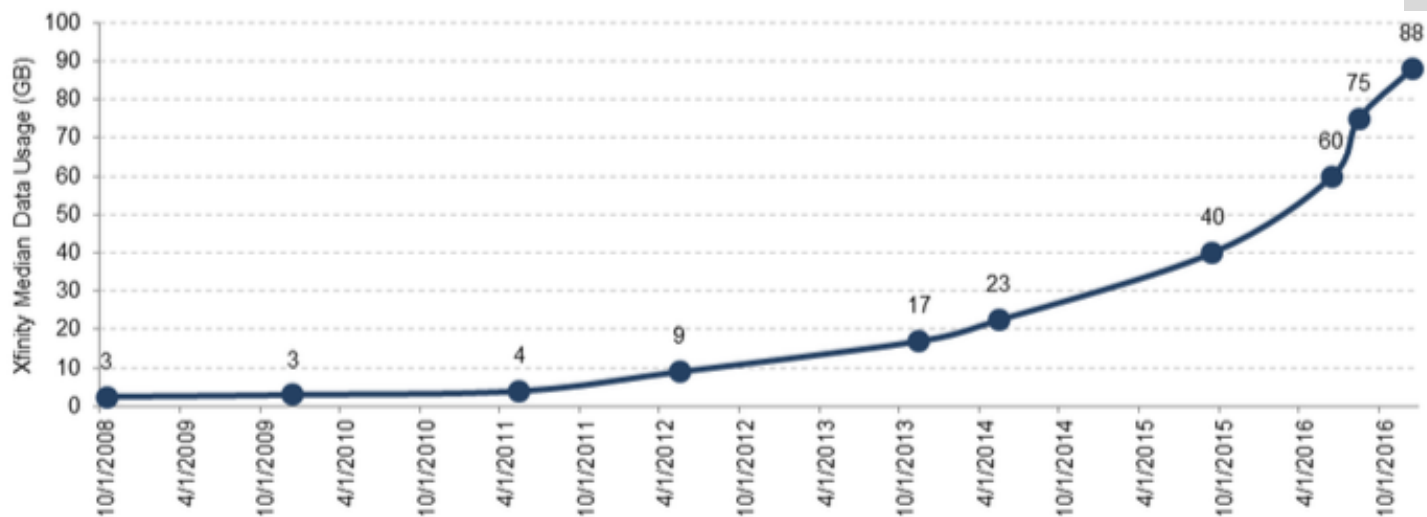
# Rural deployment options

Technology	Capacity in rural areas (typical)	Advantage	Disadvantage
DSL	< 5 Mb/s	mostly deployed	speed increase requires active components deep in network
4G LTE	~ 5 Mb/s	existing deployment, MF II	limited capacity (current avg.: 2.1 GB/month)
5G (3.5 GHz, not mmWave)	depends on deployment model	saves fiber drop	spectrum OpEx
satellite (current geo)	12 Mb/s nominal	no incremental deployment cost	expensive, capacity-limited, latency
HFC (“cable”)	25-100 Mb/s	low upgrade cost to 1 Gb/s+	85% of households
FTTH & FTTC	100 Mb/s – 1 Gb/s	20 year life time passive outside plant	cost to deploy

# Problem likely capacity, not speed

## Exhibit 13

### Comcast: Median Bandwidth Usage per Household per Month, 2008 to 2016



June 2017: 100 GB

Source: Comcast's website, MoffettNathanson estimates and analysis

# Rural options may be restricted

NO EXCEPTIONS —

## 8,500 Verizon customers disconnected because of “substantial” data use

Roaming data use makes customers unprofitable, so Verizon will cut them off.

JON BRODKIN - 9/15/2017, 12:40 PM

Xede

BY VIASAT

**CLASSIC 15**

**15 GB**

PRIORITY DATA

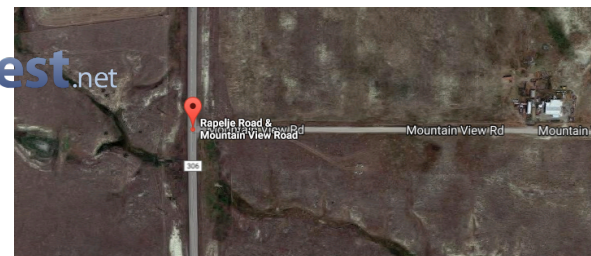
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Big Timber, MT

Late Night Free Zone

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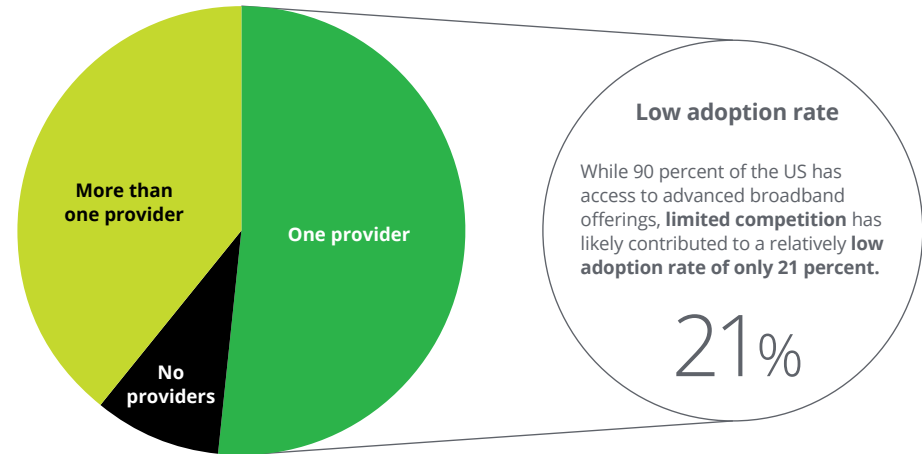
**\$79.99** /mo



	Download	Upload	Price
	768 Kbps Download	768 Kbps Upload	\$29.95 Monthly
	1.5 Mbps Download	1.5 Mbps Upload	\$39.95 Monthly
	3.0 Mbps Download	1.5 Mbps Upload	\$49.00 Monthly
	5.0 Mbps Download	2.0 Mbps Upload	\$59.00 Monthly
	7.0 Mbps Download	3.0 Mbps Upload	\$69.00 Monthly

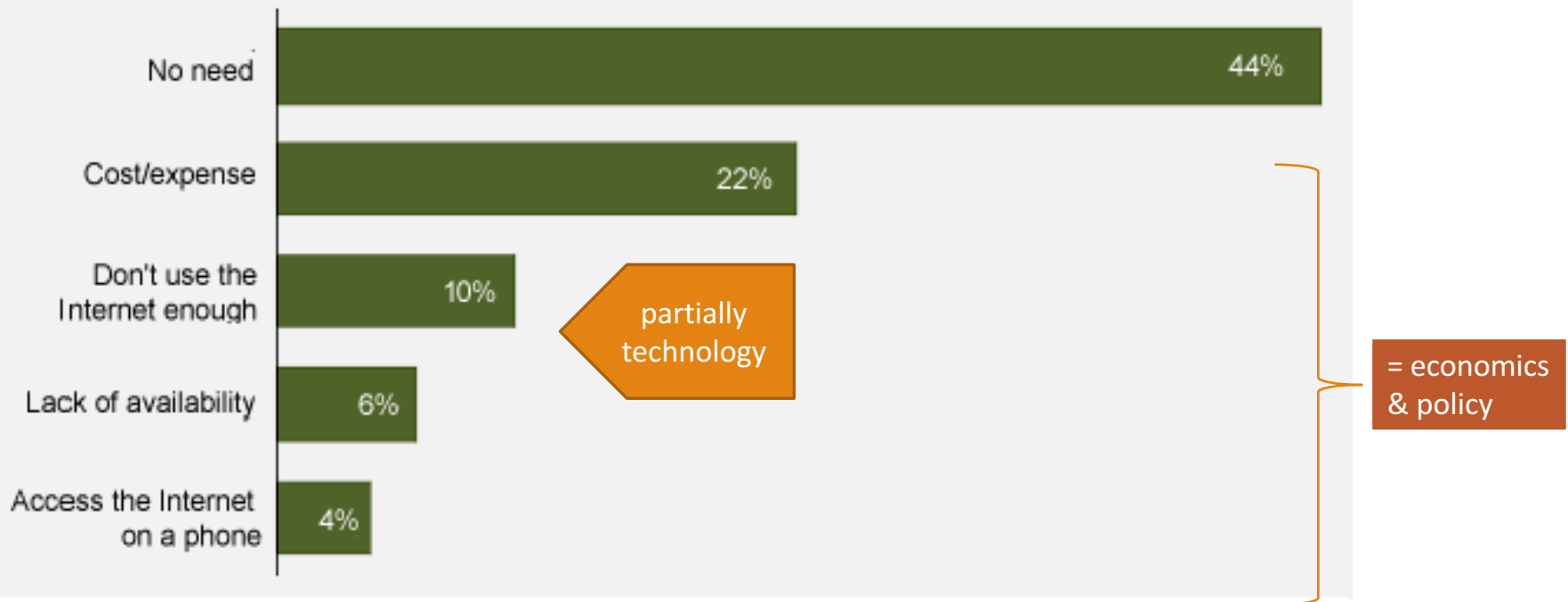
# Broadband adoption

- Used to be simple binary: “are you on the Internet?”
- Now:
  - low-speed landline Internet
  - mobile Internet
  - high-speed Internet
- What capabilities matter?
  - Facebook and Whatsapp access?
  - ability to fill out job form? → mobile apps
  - content creation → tethering ok?



# Reason for non-adoption

Table 2: Top Reasons for not Subscribing to an Internet Service at Home\*



\* Asked of those who do not currently get an Internet service at home and do not plan to subscribe in the next six months

# Conclusions

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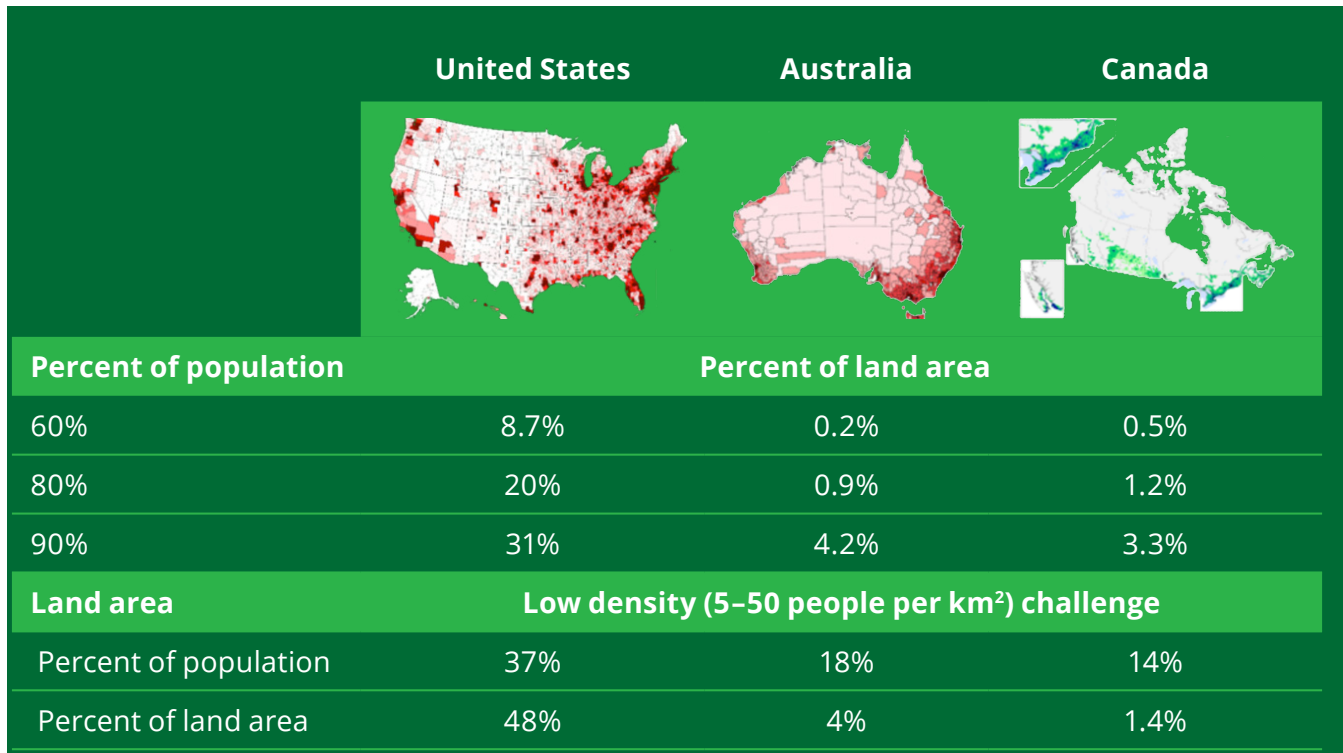
- We managed to electrify rural farms in a decade, but have been working on broadband for two already
- We have not made much progress in getting networks deployed cheaper and faster
  - and operate them more efficiently
  - consider these as broader-impact research opportunities...
- Adoption is probably harder than for electricity
- Many of the problems are incentive or non-incentive problems
  - we know how to solve them, but levers are missing
  - or are politically not feasible
  - or some actors have an active interest in things not happening

# Lower population density, easier broadband

32.45/km<sup>2</sup>

2.91/km<sup>2</sup>

3.49/km<sup>2</sup>

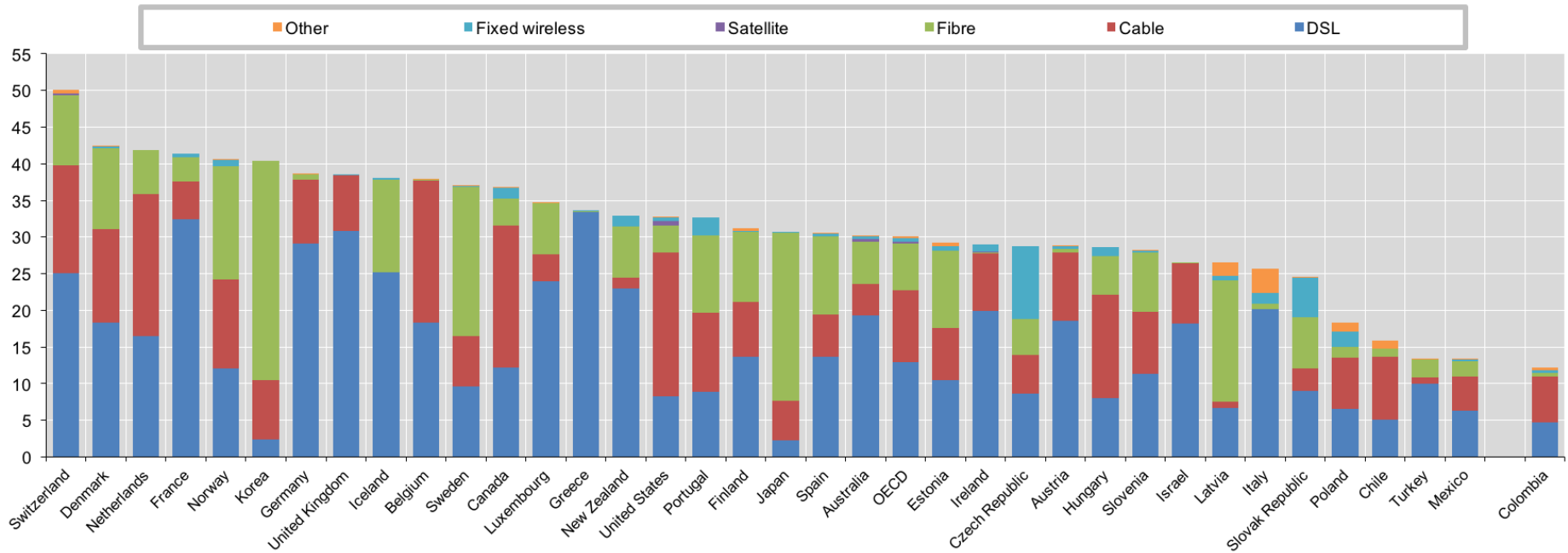


Deloitte, 2017



# OECD overview

1.2.1. OECD Fixed broadband subscriptions per 100 inhabitants, by technology, December 2016



# Metrics: not Gb/s or b/s/Hz, but \$/GB and \$/year

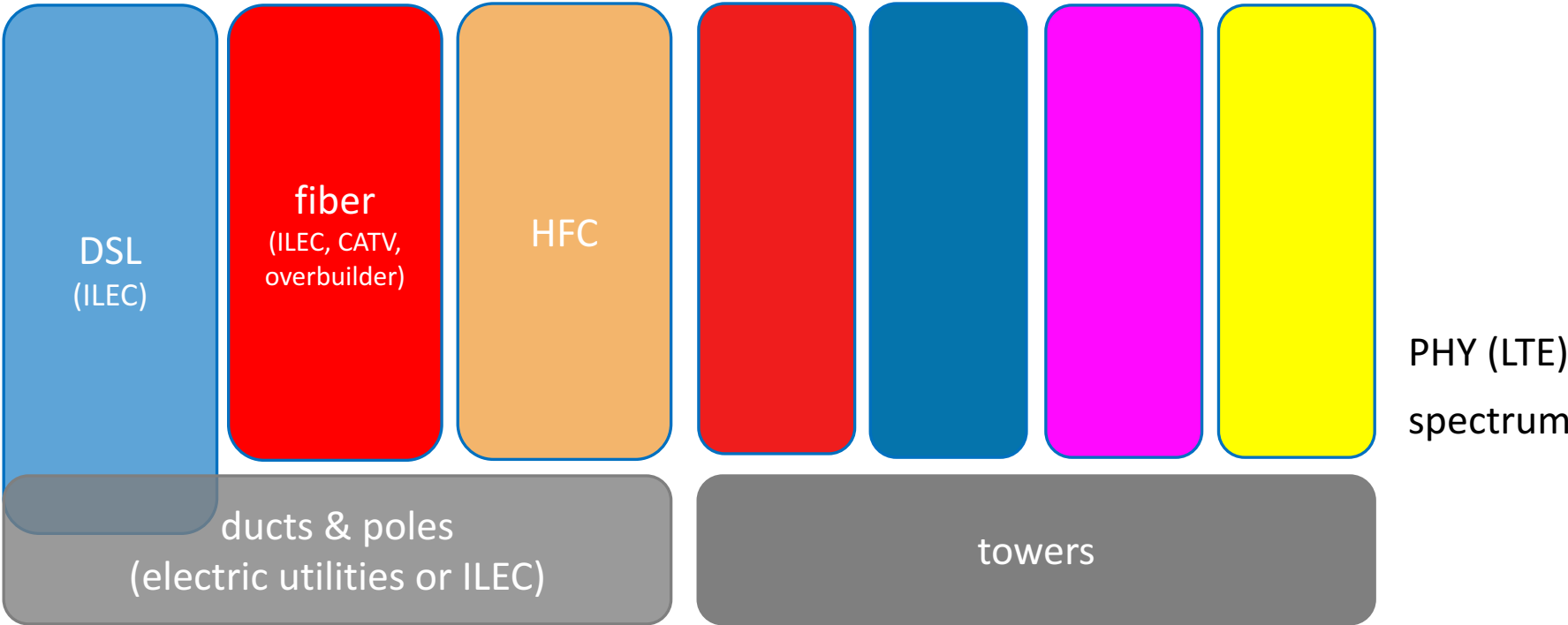
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- Consumer market: **\$/GB delivered**
  - little willingness to pay for speed above 10 Mb/s for now
  - unless \$/GB  $\rightarrow$  0, 1 Gb/s just threatens wallet
- NB-IoT: **\$/device + \$/year cost**
  - compete with \$0 incremental cost BT/Zigbee/WiFi or LPWAN
  - include amortized
  - typically,  $\ll$  \$1/month
  - predictable coverage & international reach
  - alternative for one-way: ATSC 3.0 (50+ miles reach, no incremental cost)

sharing (incumbent + new entrant) vs. neutral third party

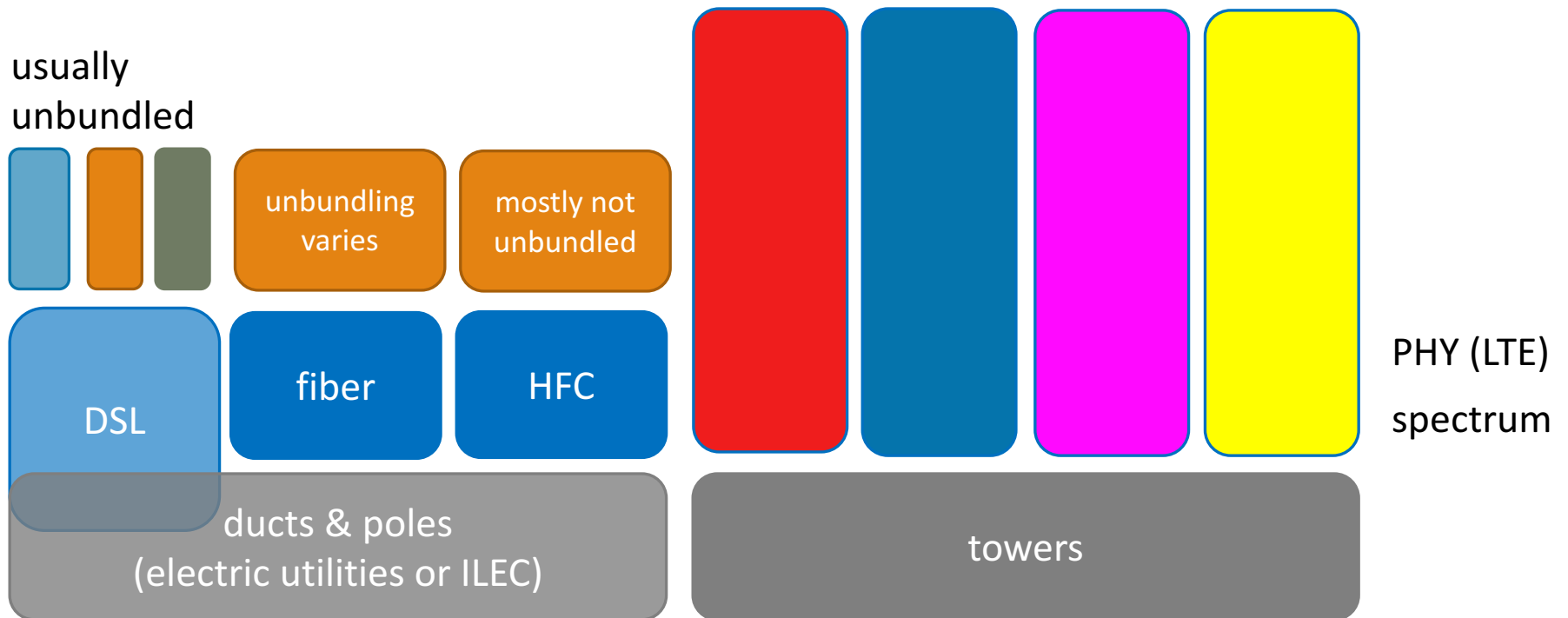
# Sharing models: US

+ WISP & satellite


















# Sharing models: Canada, Europe, Australia

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# Barriers to Internet adoption

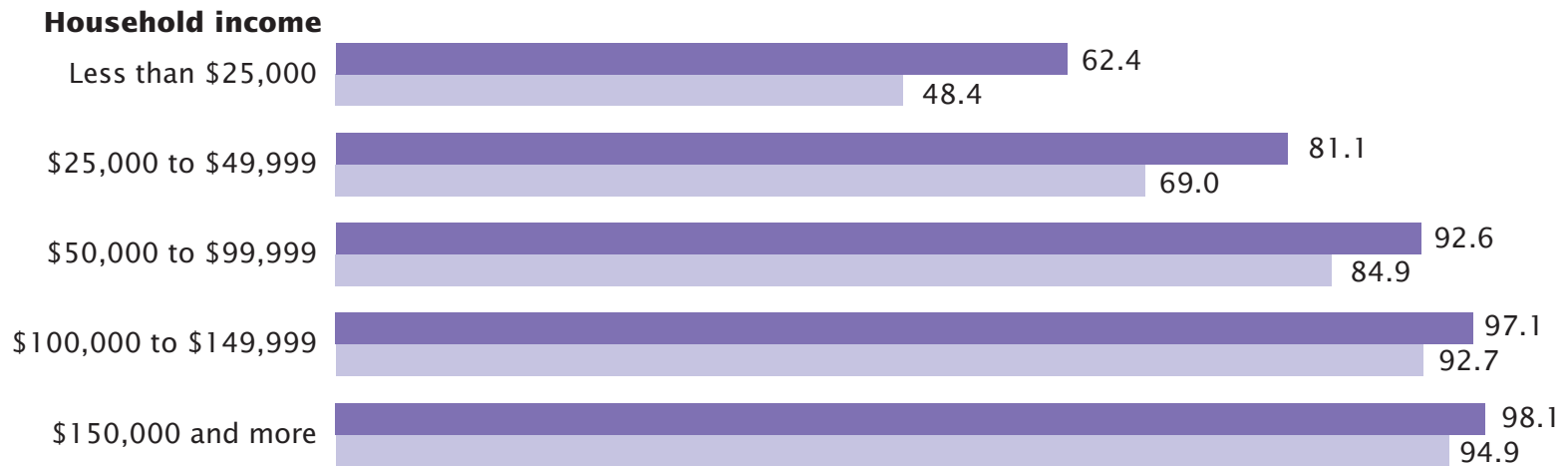
## Non-Internet users face four categories of barriers

	 <b>Incentives</b>	 <b>Low incomes and affordability</b>	 <b>User capability</b>	 <b>Infrastructure</b>
<b>Barriers directly affecting consumers</b>	 Lack of awareness of Internet or relevant use cases	 Low income or consumer purchasing power	 Lack of digital literacy	 Lack of mobile Internet coverage or network access
	 Lack of relevant (e.g., local, localized) content and services	 Total cost of ownership for device	 Lack of language literacy	 Lack of adjacent infrastructure (e.g., grid electricity)
	 Lack of cultural or social acceptance	 Cost of data plan  Consumer taxes and fees		
<b>Root causes</b> (e.g., providers, government/regulatory, industrial)	<ul style="list-style-type: none"> <li>High content and service provider costs and business model constraints</li> <li>Low awareness or interest from brands and advertisers</li> <li>Lack of a trusted logistics and payments system</li> <li>Low ease of doing business</li> <li>Limited Internet freedom and information security</li> </ul>	<ul style="list-style-type: none"> <li>Challenging national economic environment</li> <li>High device manufacturer costs and business model constraints</li> <li>High network operator costs and business model constraints</li> <li>High provider taxes and fees</li> <li>Unfavorable market structure</li> </ul>	<ul style="list-style-type: none"> <li>Under-resourced educational system</li> </ul>	<ul style="list-style-type: none"> <li>Limited access to international bandwidth</li> <li>Underdeveloped national core network, backhaul, and access infrastructure</li> <li>Limited spectrum availability</li> <li>National ICT strategy that doesn't effectively address issue of broadband access</li> <li>Under-resourced infrastructure development (e.g., FDI limits)</li> </ul>

SOURCE: Literature review; expert interviews; McKinsey analysis

# Internet usage by income

Computer ownership  
Internet use



Note: About 4.2 percent of all households reported household Internet use without a paid subscription. These households are not included in this figure.

Computer and Internet Use in the United States: 2013  
American Community Survey Reports