ELECTRIFYING ECONOMIES

ENERGY CONSUMPTION BENCHMARKS

BUILDING THE ENERGY LADDER

Effective, integrated electrification must start with an understanding of user needs. It is now widely understood that additional support for accessing appliances and building businesses must accompany the provision of electricity needs, while electricity that is unreliable or expensive is less effective at unlocking social and economic development. Many definitions of electrification focus on residential consumption or the number of connections, which are important, but by themselves insufficient. Instead, we focus on the services unlocked by rural electrification and the levels of electricity consumption these imply.

To provide benchmark levels of consumption for fully realized rural electrification, this study provides bottom-up calculations demonstrating the annual electricity consumption per person (kWh/person/year) for the first steps on the energy ladder: basic household consumption, community services, and productive uses of energy, like businesses and agricultural processing.

Over time, the increased income from productive uses of energy can help households move up to the next stage on the energy ladder. Demand will grow, as people use more home appliances, like refrigerators or electric cooking. We calculate a second benchmark level to envision what this future consumption might look like.

ESTIMATING ESSENTIAL DEMAND

This study builds an estimate of rural electricity needs, drawing on usage and performance levels of various appliances and activities. Taken together, these usages allow communities to reach a level of energy prosperity as they start to see the economic benefits of electrification.

The study draws on a number of data sources, referenced below, and extensive site visits by the authors. Calculations are based on the estimated unit consumption and adoption rate in a 500-household rural community with a population of 2,250 people. Figures are shown as annual consumption per person, including both residential and non-residential energy consumption in the community. To demonstrate the role of energy efficiency, the study estimates the consumption under both efficient and inefficient scenarios.

Appliances and activities are grouped into four categories, which progressively build an "energy ladder," as follows:

- **Basic household appliances are those which might be found in a large proportion of households**
- **Additional household appliances will only be found in a few, wealthy households**
- **Community services are institutional or shared loads, including health, education, and domestic water supplies**
- **Productive use appliances represent businesses and agricultural processing loads**

Collectively, the usage shown here represents the energy services that enable a community to achieve social and economic development goals. Although consumption is measured per person, three quarters of the demand at the first stage occurs outside the home.

Actual rural energy demand will vary by climate, agricultural activities, wealth, business environment, and many other factors. The benchmark figures shown here do not attempt to set out the desirable level of energy consumption for any specific community, or to define the exact set of appliances or businesses that would be appropriate. Instead, it seeks to give rule-of-thumb reference figures for the levels of energy demand that are consistent with development. These can help inform planning and goal setting for electrification programs.

It is important to emphasize the additional activities that must complement the provision of affordable and reliable power, to enable the growth of electricity consumption and associated benefits. These include: support for wiring houses, access to appropriate appliances, affordable finance, and business support. Importantly, the sector also requires integration of planning between power system providers—such as distribution utilities or minigrid developers—and the agencies responsible for building and operating shared loads—such as health clinics or schools.

Essential Demand for Productive Use: 200 kWh per Person

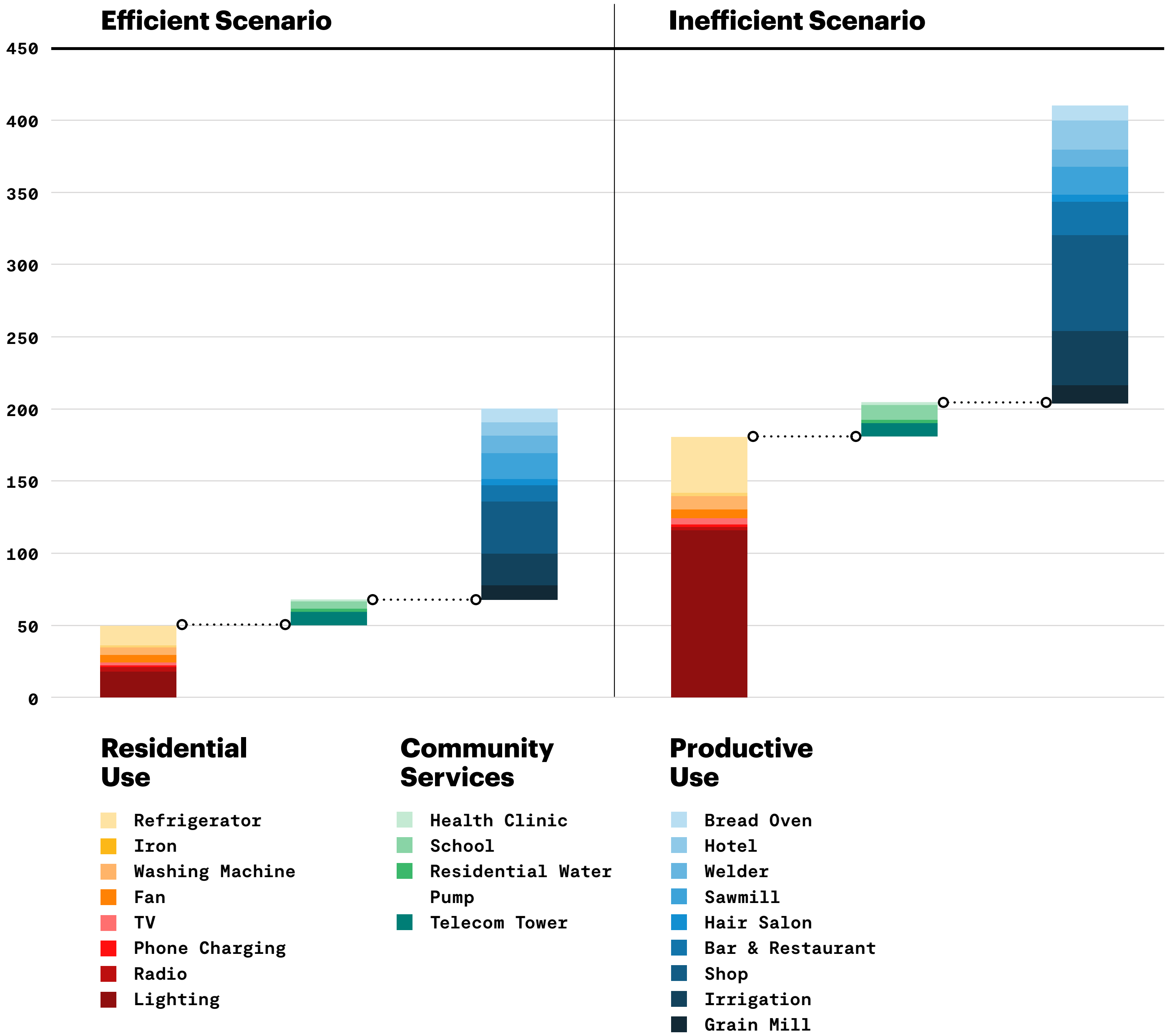
At this level, 50 kWh energy consumption per person provides basic services for households: extensive lighting, phone charging, radios, and TVs. Half of all households have refrigerators and fans, and a few of the wealthier households have appliances like washing machines or irons.

Another 20 kWh per person powers health clinics, schools, and shared water supply.

The remaining 130 kWh (to reach a total of 200 kWh per person) unlocks productive uses of energy. Irrigation for crops and electrified grain milling increases agricultural productivity. Shops, hospitality businesses, welders, and sawmills produce employment and income. The community becomes wealthier by increasing its output and attracting investment.

The Energy Ladder

Efficient and Inefficient Scenarios for Energy Consumption at Household, Community, and Productive Use Levels



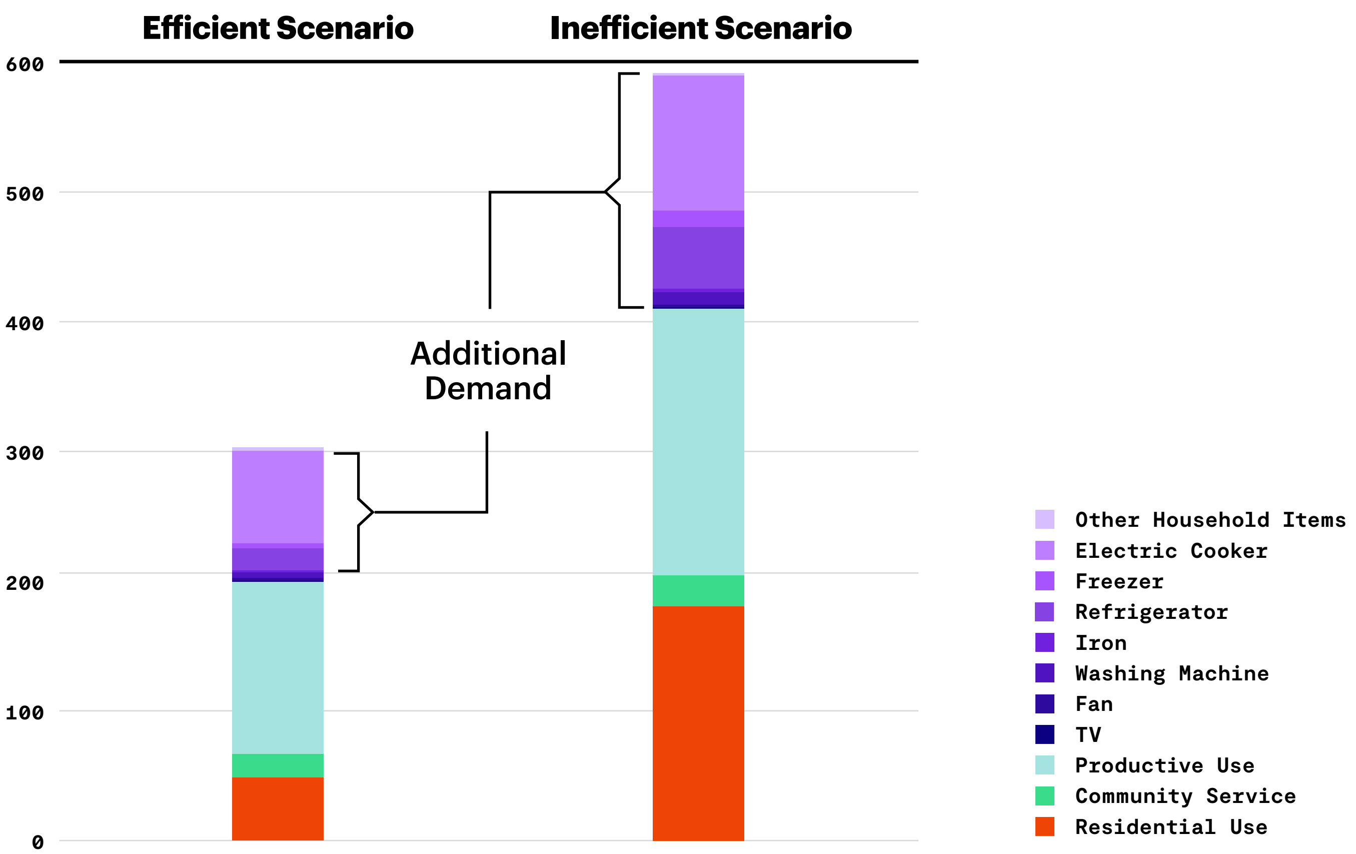
A Target for Rural Energy: 300 kWh per Person

At this level, wealthier households with higher ability to pay for power can use electric appliances to improve living standards and health, deploying an additional 100 kWh per person.

Replacing half of all cooking needs with electric cookstoves, induction hobs, and pressure cookers provides high-quality cooking solutions and drastically cuts indoor air pollution. Practically every house now has a refrigerator, while many own washing machines and some have separate freezers. Almost all households have TV and more than two thirds of them own fans. Uptake rates for irons and washing machines also double, reaching levels consistent with those in fully electrified, middle-income countries. Electronics such as internet routers and kitchen appliances account for further energy consumption.

The Energy Ladder

Efficient and Inefficient Scenarios for Essential Demand and Additional Household Use for Future Demand



APPLIANCE UPTAKE AND USAGE

Essential Demand (200 kWh per person per year)

Demand type	Appliance/ Activities	High efficiency unit consumption (Wh)	Low efficiency unit consumption (Wh)	Usage Time (Day Per Month)	Number of units per community	High efficiency annual consumption (kWh)	Low efficiency annual consumption (kWh)
Residential appliances	Lighting	60	360	30	2000	43,200	259,200
	Radio	9	9	30	1800	5,832	5,832
	Phone Charger	6	6	30	1687	3,644	3,644
	TV	34	68	30	400	4,896	9,792
	Fan	128	160	30	250	11,520	14,400
Residential appliances -advanced	Washing Machine	1,000	2,000	12	75	10,800	21,600
	Iron	300	600	30	25	2,700	5,400
	Fridge	400	1,200	30	200	28,800	86,400
	Freezer	1,000	3,000	30	0	0	0
	Electric Cooker	1,800	2,600	30	0	0	0
	Other Household Items	500	500	30	0	0	0
Community appliances and activities	Telecom Tower	60,480	60,480	30	1	21,773	21,773
	Water Pump (Domestic use)	675	1,000	30	15	3,645	5,400
	School	12,000	24,000	20	4	11,520	23,040
	Health Clinic	8,800	12,600	20	1	2,112	3,024
Productive appliances appliances and activities	Grain Mill	8,250	9,350	20	12	23,760	26,928
	Irrigation	3,000	4,800	30	50	54,000	86,400
	Shop	5,278	10,000	25	50	79,170	150,000
	Bar & Restaurant	14,890	28,000	30	5	26,802	50,400
	Hair Salon	4,200	8,000	20	6	6,048	11,520
	Sawmill	82,800	92,000	20	2	39,744	44,160
	Welder	54,600	54,600	20	2	26,208	26,208
	Hotel	30,100	60,000	30	2	21,672	43,200
	Bread Oven	7800	8,580	25	10	23,400	25,740

APPLIANCE UPTAKE AND USAGE

Increased demand (300 kWh per person per year)

As this future vision mainly focuses on the consumption of large household appliances, the following chart lists only the updated items. Appliance or activities not in table below remain the same as in essential demand table above.

Demand type	Appliance/ Activities	High efficiency unit consumption (Wh)	Low efficiency unit consumption (Wh)	Usage Time (Day Per Month)	Number of units per community	High efficiency annual consumption (kWh)	Low efficiency annual consumption (kWh)
Residential appliances	TV	34	68	30	450	5,508	11,016
	Fan	128	160	30	350	16,128	20,160
Residential appliances -advanced	Washing Machine	1,000	2,000	12	150	21,600	43,200
	Iron	300	600	30	50	5,400	10,800
	Fridge	400	1,200	30	200	28,800	86,400
	Freezer	1,000	3,000	30	25	9,000	27,000
	Electric Cooker	1,800	2,600	30	250	162,000	234,000
	Other Household Items	500	500	30	25	4,500	4,500

APPLIANCE DEMAND ASSUMPTIONS

Demand type	Appliance/ Activities	Key assumptions	References
Residential appliances	Lighting	Four 10W LEDs / 60W (800 lumens) incandescent bulbs in each household with 6 hours usage per day.	1, 2
	Radio	80% of population own 3W radios, with 3 hours daily usage.	3, 4, 5
	Phone Charger	75% of population own 2W cellphone chargers, with 3 hours daily charging.	3, 6
	TV	80% of households own 17W LED TV / 34W inefficient TV with 2 hours usage per day.	2, 3, 5, 7, 8, 9
		Additional demand (300 kWh benchmark): 90% of households will own a TV.	
	Fan	50% of households own 16W fan / 20W inefficient fan with 8 hours usage per day.	2, 3, 9, 10, 11
		Additional demand (300 kWh benchmark): 70% of households will own a fan.	
Residential appliances -advanced	Washing Machine	15% of household will own 500W / 1000W washing machine with 2 hours usage per day and 12 days per month.	2, 3, 12, 13
		Additional demand (300 kWh benchmark): 30% of households will own a washing machine.	
	Iron	5% of household will own 1000W / 2000W iron with 0.3 hours usage per day.	2, 3, 13
		Additional demand (300 kWh benchmark): 10% of households will own an iron.	
	Refrigerator	40% of household will own 0.4 kWh / 1.2 kWh daily consumption refrigerator.	2, 9, 14
		Additional demand (300 kWh benchmark): 90% of households will own a refrigerator.	
	Freezer	No freezers at essential demand phase.	2, 9, 14
		Additional demand (300 kWh benchmark): 5% of household will own 1 kWh / 3 kWh daily consumption freezer	
	Electric Cooker	No electric cooking at essential demand phase.	15, 16
		Additional demand (300 kWh benchmark): 40% of households will own 1000 W regular electric cooker with 2 hours usage per day, and 10% households will own 1000 W electric pressure cooker with 1 hour usage per day in efficient scenario; 50% of households own 1300 W regular electric cooker with 2 hours usage per day in inefficient scenario.	
	Other Household items	No additional loads at essential demand phase.	2
		Additional demand (300 kWh benchmark): Kitchen appliances and electronic devices, such as laptop computers or wifi routers, consume 0.5kWh per day.	

APPLIANCE DEMAND ASSUMPTIONS

Demand type	Appliance/ Activities	Key assumptions	References
Community appliances and activities	Telecom Tower	Telecom tower has medium range power demand in typical configurations, 2.52 kW.	17
	Water Pump (domestic use)	150 person per tap, 100 L per person per day, and the underground water is 10m deep. The motor–pump system efficiency ranges from 40%–60%. 135W / 200W water pump with 5 hours usage per day.	18, 19, 20
	School	12 kWh daily consumption, once the 50% energy efficiency potential has been fully realized.	20, 21, 22, 23
	Health Clinic	8.8 kWh daily consumption, once the 30% energy efficiency potential has been fully realized.	20, 24, 25, 26, 27, 28
Productive use appliances and activitties	Grain Mill	12 units of 750 W/850 W mills per 500-household community with 11 hours usage per day.	29, 30, 31
	Irrigation	1 ha farmed per household, of which 30% is high-value crops that are worth irrigating. Irrigation consumption per ha is approximately 1 kWh (research shows a range of 0.4-3 kWh/ha). 300W / 480W irrigation pump with 10 hours usage per day.	20, 32, 33
	Shop	5.3 kWh daily consumption, including: 2 lights, 1 small fan, 1 refrigerator, and 1 phone charger, after fully utilizing 50% energy saving potentials.	21
	Bar & Restaurant	14.9 kWh daily consumption, which includes: 5 lights, 2 small fans, 2 ceiling fan, 2 fridges, 1 speaker, and 1 TV, after fully utilizing 50% energy saving potentials.	21
	Hair Salon	4.2 kWh daily consumption which is the demand after fully utilizing 50% energy saving potentials.	21
	Sawmill	2 units of 11.5 kW / 10.35 kW sawmill machine per 500-household community with 8 hours usage per day.	29, 34, 35
	Welder	2 units of 9.1 kW welding machine per 500-household community with 6 hours usage per day.	35
	Hotel	14.9 kWh daily consumption which is the demand, built bottom-up with 10 lights, 10 small fans, 1 air conditioner, 2 refrigerators, and 5 TVs, after fully utilizing 50% energy saving potentials.	21
	Bread Oven	10 units of 1.3 kW/ 1.43 kW ovens per 500-household community with 6 hours usage per day.	36, 37

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ELECTRIFYING
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The Electrifying Economies project
demonstrates the role distributed energy will play in ending energy poverty and catalyzing a green and equitable recovery from the Covid-19 crisis. It draws on the latest data and research from around the world to show how distributed renewables can provide sustainable, affordable, and reliable power for all. The project provides information to support policy makers and investors in taking action today, to realize this potential.