

A Dialogue on Data Centers

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CONCERNED-CITIZEN: Good afternoon. Thank you all for agreeing to participate in this discussion about data centers. As you all know, there is now extraordinary pushback across the political spectrum against the construction of new data centers, particularly hyperscale data centers for AI. The public is concerned that building a large data center in their community will result in (1) *increased electricity costs* due to greater electricity demand and required upgrades to the electrical infrastructure, (2) *negative environmental impact* due to increased fossil-fuel consumption, increased release of heat into the atmosphere, and increased water consumption, (3) *negative land-use impact* due to the depletion of available agricultural, housing, and natural land; the reduction of adjacent land value; and required upgrades to local infrastructure, and (4) *other negative economic impacts on the local community* such as, increased housing costs due to the influx of construction workers.

I will introduce now the participants. HYPERSCALE is a proponent of *hyperscale data centers*, which are extremely large data centers usually located in rural communities that demand at least 100 MWs (megawatts) and up to several GWs (gigawatts) of electrical power and primarily provide digital services to the “cloud”, i.e., to remote users over the Internet. DISTRIBUTED is a proponent of *distributed data centers*, which are highly integrated networks of medium-size data centers that each demand about 10 MW of electrical power and provide digital services both remotely and locally. RURAL is an advocate for improving rural communities. And, finally, HEALTH-CARE is an advocate for improving health care particularly in rural communities.

Let’s start with the overarching question: Why do we need more data centers? Is it just for AI? HYPERSCALE, you go first.

HYPERSCALE: We do need data centers for AI, but that is not the whole story. We live now in the Information Age in which continued economic progress across the world depends on the availability of adequate digital services. AI is just one example of a technology that requires substantial digital services. It is what everyone is talking about today, but there will be many other new digital-service-hungry technologies that can improve our world — most of which are very likely waiting to be discovered.

CONCERNED-CITIZEN: DISTRIBUTED, what do you say?

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DISTRIBUTED: I fully agree with HYPERSCALE. Continuous growth in digital services is the key to the future. Of course, like so many things, the production of digital services can have both good and bad consequences, depending on how they are produced.

CONCERNED-CITIZEN: I think everyone will agree, RURAL and HEALTH-CARE included, that the world needs digital services and data centers to produce them. But why do we need hyperscale data centers?

HYPERSCALE: The answer is simple: Hyperscale data centers offer enormous economies of scale in electrical, cooling, network, and physical infrastructure; in computational efficiency; and in management.

DISTRIBUTED: Hyperscale data centers do indeed offer these economies of scale, but — as I hope this discussion will show — distributed data centers also offer other economies of scale as well as important benefits to society that hyperscale data centers don't provide. It is important to keep in mind that a distributed data center can roughly provide the same level of digital services as a hyperscale digital center. For example, a distributed data center composed of fifty 10-MW component data centers would be about equivalent to one 500 MW hyperscale data center.

CONCERNED-CITIZEN: So, HYPERSCALE and DISTRIBUTED, you agree that a hyperscale data center offers significant economies of scale. These increase the profit for the hyperscale data center company and reduce the cost for its users, but how do they benefit the community in which the data center is located?

RURAL: In particular, how do the economies of scale achieved by a hyperscale data center benefit a local community that is rural.

HYPERSCALE: A hyperscale data center benefits society in two ways. First, it raises the level of digital services available to society as a whole. Second, it lifts the local community's economy in a number of ways, e.g., by providing new jobs and increasing the tax base.

DISTRIBUTED: Yes, it may well be true that a hyperscale data center can lift up its local community in a number of ways, but this leaves behind all the other rural communities that don't have a hyperscale data center located within them. A distributed data center would benefit many rural communities. For example, a distributed data center could serve an entire state or province by having a component data center located in almost every county in the state or province.

Moreover, a hyperscale data center produces its digital services at a single location, while the digital services produced by a distributed data center are distributed across a network of component data centers. Thus distributed data centers are structurally better suited to withstand system-level threats such as hardware or software failures, security breaches, natural disasters, and terrorist attacks.

CONCERNED-CITIZEN: RURAL, HEALTH-CARE, and I have some specific concerns about hyperscale data centers that we would like HYPERSCALE to address. I will start first. To reduce the energy loss by electricity transmission and to address the climate crisis, can new hyperscale data centers be co-located with new or existing low-carbon energy sources?

HYPERSCALE: A new hyperscale data center requires a huge amount of new energy. Roughly speaking, the equivalent of a nuclear power plant

is needed to power a 1-GW data center. A hyperscale data center’s power demand will generally be too great to be supplied by local low-carbon energy sources. That is, a new hyperscale data center will very likely have to be powered by energy taken from the electrical grid or produced locally from fossil fuels like natural gas.

DISTRIBUTED: The first law of the distributed data center model is that the component data centers of a distributed data center are powered as much as possible by local, low-carbon energy sources such as wind, solar, hydro, biomass, geothermal, tidal, or nuclear. To maintain a constant supply of low-carbon energy each component data center must be able to store energy in some form that can be quickly converted into electricity. This all is quite feasible since the targeted electricity demand for a component data center is 10 MWs, much less than the electricity demand of a hyperscale data center. Powering these with local, low-carbon energy will minimize both their contribution to the climate crisis and the need to upgrade electrical infrastructure.

RURAL: It is well known that data centers produce two things: computation and heat. The great majority of data centers use cooling systems to move the heat from the data center servers to the atmosphere. This requires additional energy and further exacerbates the climate crisis. Why can’t a data center’s waste heat be extracted, stored, and in winter transported to heat the buildings in the community in which the data center is located?

HYPERSCALE: This certainly makes sense for data centers located in cold climates and is actually being employed in several northern European countries. A heat network works for small and medium-size data centers, but hyperscale data centers produce too much heat to make heat harvesting economically feasible, especially in less-populated rural communities.

DISTRIBUTED: The second law of the distributed data center model is that, in cold climates, each component data center is part of a local heat network in which heat is extracted from the data center and then either stored or transported over the heat network to where it is needed. This arrangement can significantly reduce the heating costs of the local community, thereby decreasing the global demand for fossil-fuel energy.

RURAL: Many rural communities have brownfield (environmentally compromised) land and abandoned or underused industrial buildings. Shouldn’t data centers be located as much as possible on this brownfield land and in these building?

HYPERSCALE: In theory, this is good idea. However, it is not economically feasible for hyperscale data centers since they require much more space than the brownfield land and abandoned or underused space that is usually found in a typical rural community.

DISTRIBUTED: A third law of the distributed data center model is that each component data center is located as much as possible on brownfield land or in abandoned or underused industrial buildings. This puts to use unproductive land and industrial buildings as well as possibly unused infrastructure that was originally developed to support this land and these buildings — instead of prime land that can be better used for agriculture, housing, and recreation.

RURAL: Rural communities need better digital services, especially In-

ternet services. Internet services and some other digital services must be provided locally

HEALTH-CARE: I must step in now to say that this is particularly true of hospitals that must maintain local data centers due to privacy and regulatory concerns. Rural hospitals also need much better Internet communication to support telemedicine and data storage to support medical imaging.

RURAL: So can hyperscale data centers supply these digital services directly to the communities in which they are located?

HYPERSCALE: Hyperscale data centers usually don't provide digital services directly to local communities. However, the local communities can access digital services from the hyperscale data centers over the Internet.

HEALTH-CARE: As I noted, accessing digital services strictly via the "cloud" is not a viable option for hospitals, particularly rural hospitals.

DISTRIBUTED: A fourth law of the distributed data center model is that each component data center provides designated digital services locally to the community in which the data center is located. Since the component data center and the hospital data center share similar energy and communication needs, there is an economy of scale to be gained when these two data centers are integrated with each other.

CONCERNED-CITIZEN: It appears that distributed data centers offer much more to rural communities and their hospitals than hyperscale data centers.

DISTRIBUTED: Yes, a distributed data center following the four laws above would obtain several economies of scale different from the economies of scale gained by a hyperscale data center. These would include constructing large numbers of (1) low-carbon energy sources, (2) community heat networks, and (3) medium-size data centers on brownfield land or in abandoned or underused industrial buildings, offering digital services locally, and integrated with the data bases of rural hospitals.

There is also an important fifth law of distributed data centers: Software is used to balance computation and energy use across the network of component data centers. This is done in two ways. First, computation jobs can be freely moved over the network from components with currently high computation demand or high energy costs to components with currently low computation demand and low energy costs. Thus the rate of computation performed can be maximized and the cost of performing the computation can be minimized by just moving computation jobs around the network.

Second, components with currently high electrical grid costs can convert stored energy to electricity and sell it to grid, and components with currently low electrical grid costs can buy electricity from the grid and store it locally. This enables (1) the distributed data center to minimize its electricity cost and (2) each component data center to act as if it were a "peaker plant" for the electrical grid, which would significantly increase the electricity supply that can be provided at peak demand.

In summary, a distributed data center largely offers the same digital services as a hyperscale data center, but a distributed data center — unlike a hyperscale data center — offers several major benefits to the local, usually rural, community.

CONCERNED-CITIZEN: Building distributed data centers instead of hy-

perscale data centers would clearly neutralize most of the public's concerns about building large data centers — i.e., increased electricity costs, negative environmental impact, negative land-use impact, and other negative economic impacts — by offering rural communities many more benefits than hyperscale data centers. So, HYPERSCALE, why are we building hyperscale instead of distributed data centers?

HYPERSCALE: Distributed data centers do indeed offer significant benefits that are not offered by hyperscale data centers. However, a distributed data center is much more complex. It involves a network of data centers instead of one large data center, the production of local, low-carbon energy, the construction and use of heat networks, the development of brown-field land and abandoned and underused industrial buildings, the integration with rural hospitals, and the balancing of computation and energy. These are significant additions to the hyperscale data center model that require a much wider partnership and greater government support than the current hyperscale data center model. This is why there are no fully implemented distributed data centers today.

DISTRIBUTED: What HYPERSCALE says is true. However, the need for wider partnership and greater government support doesn't mean we as a society should conclude that distributed data centers are too hard to build. Rather we should see building distributed data centers as a challenge whose difficulty is far outweighed by the benefits distributed data centers will offer to society and particularly rural communities. For the sake of rural communities, it is imperative that society step up and do the research and policy development necessary to create a blueprint for building distributed data centers as an alternative to hyperscale data centers!

RURAL and HEALTH-CARE together: Hear! Hear!

CONCERNED-CITIZEN: Thank all of you for this interesting and informative discussion. DISTRIBUTED has presented a very strong argument for building distributed data centers instead hyperscale data centers. Clearly, the private sector, rural communities, and government need to start working in concert to make distributed data centers an economically viable option for society.