Global Digital Economy Report 2025

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Acknowledgment

This comprehensive report is created through the efforts of seasoned subject matter experts of IDCA who have dedicated their time and expertise in hopes of bringing transparency and light for resourceful measures to the Digital Economies of the world:

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01 Executive Summary

The Digital Economy worldwide is taking inreasing shares of global GDP. Yet there is a broad range of development, and each nation must find its own way.

Executive Summary

The Digital Economy comprises about 15 percent of world GDP in nominal terms, according to the World Bank. This amounts to about $16 trillion of approximately $108 trillion in 2024. This report examines the foundation of the global Digital Economy and forecasts its trajectory of growth and development, along with shortfalls and necessities in 2025 and beyond.

The report's objective is to capture the essential use and trends of the digital infrastructure and related technology that's used to build Digital Economies throughout the world. Data and insights come from IDCA's worldwide research, and survey activities.

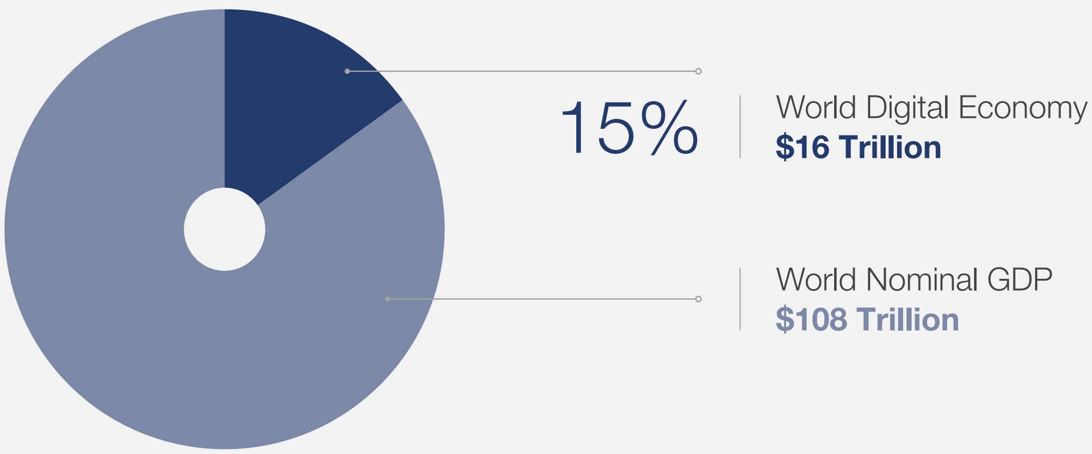
The report was prepared within the context of current world economic conditions. It renders evaluations on key technologies and issues of concern to the IDCA community, and offers critical recommendations. It identifies the key areas of digital infrastructure necessary to building viable Digital Economies, and outlines the present state and disparities of digital infrastructure in the world.

Ultimately this report generates the Global Digital Readiness Index of Nations and a ranking of the world's nations with respect to the state of their Digital Economy development. All nations have been evaluated against the vital ingredients of Digital Economies, and have been ranked based on their achievements in proportion to their global standing and resources available to them.

The ranking identifies whether a Digital Economy is in a Pre-, Early-Stage, Substantially Developed, or Highly Developed phase. A key to this analysis is that Digital Economies must be sustainable – a lack of sustainability impedes the path to a true Digital Economy.

FIGURE 1.

Percent of Digital Economy of Nominal World GDP



Source: World Bank, Forrester, IDCA

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Key Findings

Several key findings have emerged within IDCA's research into the Digital Economy worldwide. There is optimism among the findings, along with major areas of opportunity identified.

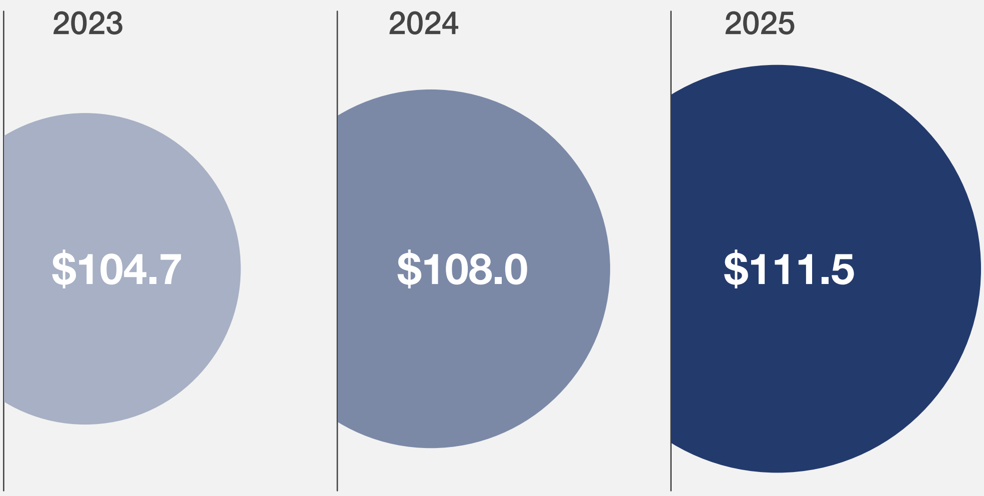
Key Findings

1. Economic Momentum

There is technological and economic momentum propelling the nations of the world as 2025 begins. World economic growth in 2024 is estimated at 3.2 percent, remarkably similar to 2023, and expected to continue to grow at that rate in 2025, according to the World Bank, IMF, OECD, and IDCA Research. Economic growth in Asia in 2024 was above 5 percent, according to consensus research, and is projected to continue at a higher pace than the world as a whole.

FIGURE 2.

Projected World Economic Growth



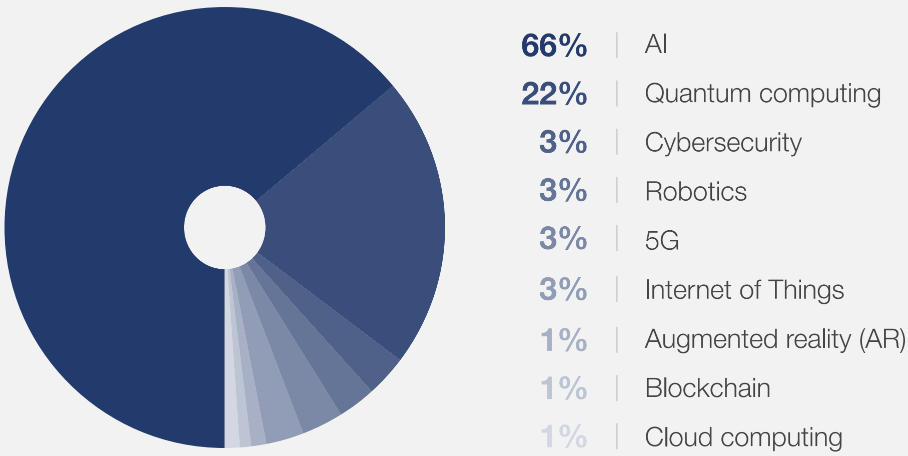
Source: World Bank, IMF, OECD, IDCA Research

2. AI's Prominence

AI's prominence become well-established in the world's tech industry in 2024, and is expected to continue in 2025 and beyond. IDCA conducted several polls and surveys among industry professionals and global leaders to measure their interest in game-changing technologies and their effect on the growth of Digital Economies. The results are shown in Figure 3:

FIGURE 3.

Game-changing Technologies for Digital Economies



Source: IDCA Research

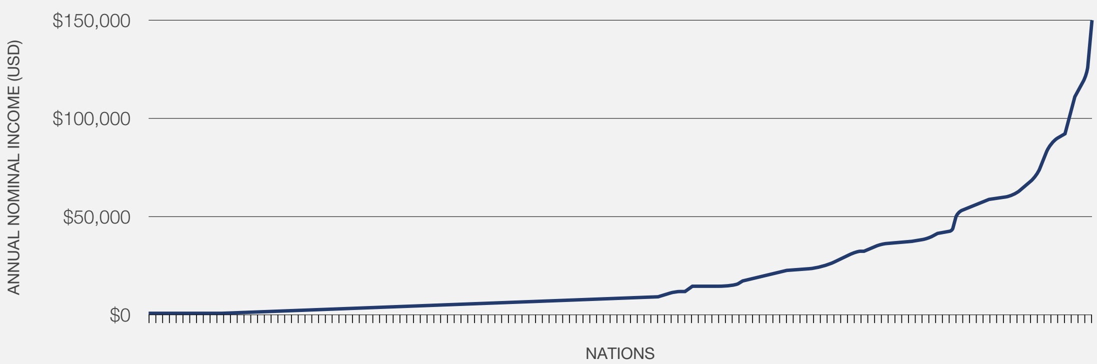
Follow-up interviews confirm that AI in all its modern guises consumes the thoughts and plans of enterprise IT and other large organizations throughout the world.

3. Economic and Technological Disparities

Gaping disparities remain in the world, starting with per capita income. On a nominal basis, income varies by about 50X between the lowest- and highest-income countries. The lowest 20 nations by income reach only 8 percent of the world average per-person income, while the highest 20 generate as much as 5X the world average.

FIGURE 4.

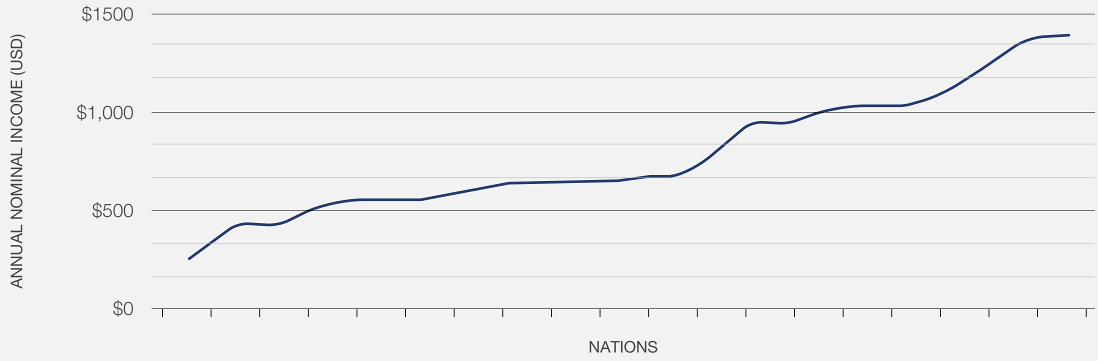
Nominal Income of Nations



Source: IDCA Research

FIGURE 5.

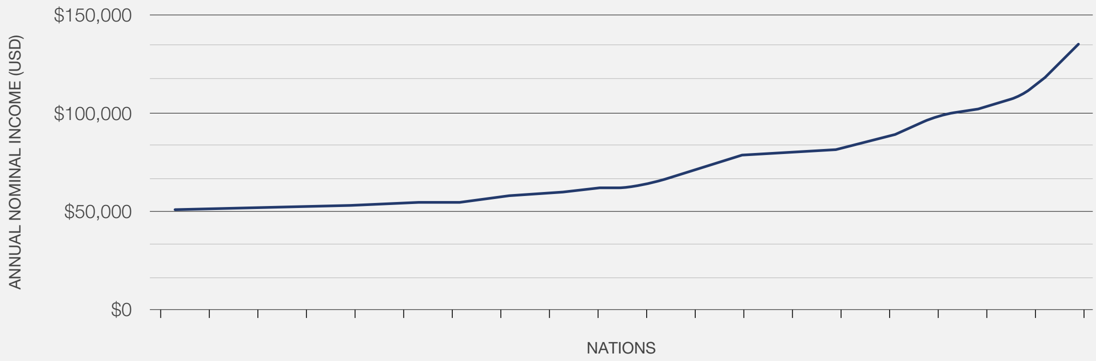
Nominal Income of Lowest 20 Nations



Source: IDCA Research

FIGURE 6.

Nominal Income of Highest 20 Nations



Source: IDCA Research

There are even larger disparities in all areas of digital infrastructure, including mobility, internet access, and bandwidth. This reality is especially true with the world's data center footprint, which varies by as much as 100,000X across the nations of the world.

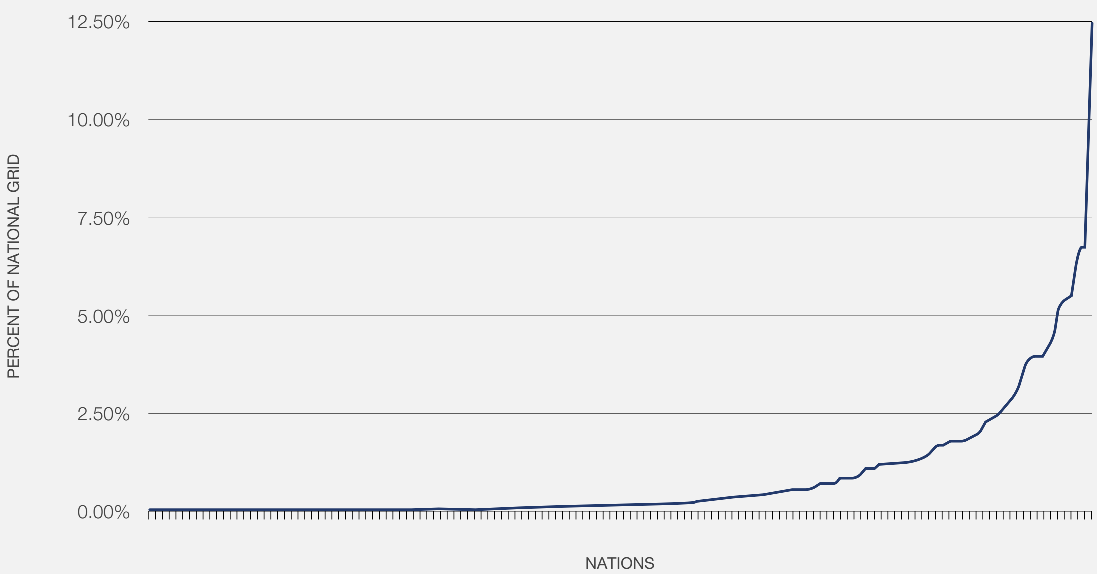
4. Electricity Disparities and Shortages

There is a disparity of as much as 100X in the strength of the world's electricity grids, at the same time that data centers and related digital infrastructure are consuming an increasing proportion of those grids. The world average is about 1.1 percent, according to IDCA Research. The US average has reached 2.8 percent.

At the high end, more extreme examples are raising political concerns and intensifying regulation, especially in Singapore and Ireland. At the low end, many developing nations have data center footprints that consume only 0.01 percent of their grids, yet these nations struggle to provide reliable power to their people for even modest living conditions. Developing new data centers in these environments will only make these situations more difficult.

FIGURE 7.

Data Center Consumption of Electricity Grids



Source: IDCA Research

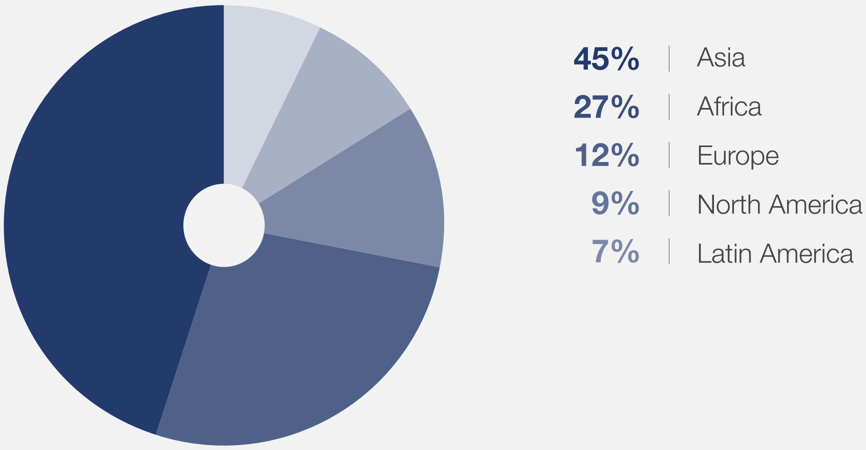
5. Global Workforce Deficit

IDCA Research finds a deficit of slightly more than 100 million jobs in all areas of the technology industry, including operations skills, software development, and management at all levels. The number was derived by comparing the expected number of jobs country-by-country (based on local economic conditions and cost-of-living) with the ideal level found in a highly developed Digital Economy.

Developing nations account for 80 percent of this deficit. Asia represents 45 percent of this need, Africa represents 27 percent, and Latin America 7 percent. Yet even the most highly developed nations have a need for continuous improvement in their education, training, and workforce development.

FIGURE 8.

Worldwide Tech Job Deficit (%)
(Total = 100 Million Tech Jobs)



Source: IDCA Research

6. Evidence of Bright Spots

Even so, there are bright spots to be seen and relative progress to be observed that is doggedly being achieved in numerous developing countries. IDCA Research thus analyzes the relative progress of nations in building out digital infrastructure, building toward Digital Economies, and improving the lives of their people. Thus, dynamic development environments can be found throughout all regions, in all income tiers, and within all Digital Economy phases.

03 Digital Economy National Rankings

Each nation can develop its own unique Digital Economy. IDCA has identified four phases of development and provides a ranking of where each country lies within its phase.

Digital Economy National Rankings

3.1 Overview

Developing a Digital Economy is not reserved for wealthy, developed countries. Particular paths will vary, as will the destinations. By creating a culture of ongoing, steady Digital Readiness, any nation in the world can find its path and build its own unique Digital Economy.

Building a Digital Economy starts with research. Each nation is unique, with its own challenges, opportunities, and path to building a Digital Economy. Key areas in which Digital Economies improve the socioeconomic conditions within a nation include:

* Job creation & decreased unemployment
* Direct and indirect wealth creation
* Elevated standards of living
* National safety and security
* Data sovereignty, rights, privacy, and protection
* Higher education and a newly skilled workforce
* Sustainability and environmental protection
* Attraction of foreign investment

Then, key questions need to be addressed: What is a nation's current situation? How developed is its digital infrastructure? What educational and training needs does it have? What realistic goals can it create and what benefits will result from reaching those goals?

IDCA Research addresses these questions through its Digital Readiness of Nations Index, an important tool and global resource that examines each of the world's nations in the categories of Economy, Environment (including sustainability), Social conditions, and Governance. IDCA's approach is to measure relative conditions and progress – that is, how well is a nation doing given the resources it has? This approach is particularly critical to developing nations, which have the most potential to improve quickly and dramatically.

The data can be used to measure the strength of a nation's technological ecosystem on the one hand, juxtaposed with its socioeconomic ability to take optimal advantage of its installed technology. Logic would tell us that a nation with relatively robust technology ecosystems but less-strong socioeconomic conditions needs to focus on creating services; the obverse case would be a nation with a relatively strong socioeconomic picture but weak technology infrastructure.

As noted below, the Index derives its Overall scores by integrating hundreds of factors into four categories:

- Economy (which focuses on technology infrastructure)
- Environment (which focuses on sustainability)
- Social (which focuses on income parity and physical infrastructure)
- Governance (which focuses on stability and corruption).

The Index is not meant to be a competition, but nonetheless provides a good benchmark as to where a nation sits and what it will take for it to achieve significant improvement. The data currently shows, for example, that developing nations with Index scores in the top 50 percent of their income-level groups have averaged between 4.2 percent and 6.7 percent higher annual economic growth over the past decade than those in the lower 50 percent of each group.

3.2 Global Methodology

The global methodology behind the Index follows more than a decade's worth of work. Hundreds of technology and socioeconomic factors are examined, from openly available sources, including the World Bank, United Nations, International Monetary Fund, United States Department of Energy, Akamai, Trading Economics, International Telecommunications Union, Transparency International, International Energy Agency, and European Commission.

Creating the Index involves a methodology that differs from traditional ranking approaches in several significant ways:

- The process looks at IT infrastructure and ecosystems, and socioeconomic conditions on a relative, rather than absolute, basis. How well are they doing given the resources they have? To answer this question, the data is adjusted for local cost of living and other socioeconomic factors.

- All factors are weighed with respect to their effect on one another, rather than in the arbitrary percentage-based weighting system found in most traditional rankings. This approach is similar to the multiple-body problem encountered in Newtonian physics as well as Kepler's insights about one body's effect on another. The process creates a series of mathematical curves that describe the progress of a nation along any respective factor or combination of factors.

- The results thus produce a partially open-ended series of solutions that integrates factors with a wide variety of disparities, and which is most clearly expressed on a natural logarithmic scale.

- Results are then benchmarked against an optimal state that features an ideal balance of technological access and speed as well as utopian socioeconomic conditions. This serves as a reality check on the overall data integration, as the optimal state will always exceed any actual nation.

- The optimal state is then calibrated to equal 100 on a 0-100 scale, with each of the four main categories – Economy, Environment, Social, Governance contributing 25 percent of the overall score. This ideally balanced state, as with the overall score, exceeds any actual nation and clearly highlights the strong points and areas of development for any particular nation. Expressing results on this scale also provides an intuitive method for users of the Index to evaluate and compare specific countries and regions.

This methodology is uniquely holistic and powerful when implemented. It provides an abstracted look at familiar data while clearly showing how much progress each nation is making in any particular area and the challenge it faces in achieving significant progress.

3.3 Applying the Results

The Index is based on more than a decade's worth of investigation into more than 150 technological and socioeconomic factors. Results are integrated into Overall and Category scores. IDCA Research works with tens of thousands of data points, which reveal trends, patterns, exceptions, outliers, leaders, laggers, diamonds in the rough, and other special cases.

There are many ways to examine the data within the Index and start to envision paths to any specific nation's Digital Economy.

Categorical Path. Ideally, each of the four categories – Economy, Environment, Social, Governance -- contributes 25 percent of the overall score; the reality is there are yawning gaps among categories for most nations and the ideal situation is never achieved.

Examples of nations, for example, that have Economic (ie technology) scores that are relatively stronger than Social and Governance scores include Bangladesh, India, Iran, South Africa, Thailand, Uzbekistan, and Vietnam.

Conversely, nations that have stronger Social and Governance scores than Economic scores include Bahamas, Equatorial Guinea, Puerto Rico, South Sudan, and most of the nations of the Gulf State region.

The first group, with the exception of Uzbekistan, features nations that have been able to bring considerable resources to technology development but are constrained by unique situations: Bangladesh and India face population pressures, Iran is in serious diplomatic isolation, South Africa continues to struggle with its relatively new democracy, Vietnam is highly dynamic and potentially volatile with its Communist/sort-of Capitalist system, and Thailand faces continued civil strife. Uzbekistan makes this list only because its technology development is even lower than its very slow social and governance progress.

The second group includes two of the lowest-income nations in the world, South Sudan and Equatorial Guinea; relatively prosperous Bahamas, which lacks strong technology development throughout its extensive chain of small islands; Puerto Rico, which is well-known for its lack of technology infrastructure; and the Gulf States, all of which have significant needs to upgrade their underlying Digital Infrastructure.

Improved Internet Path. Another way to look at the Index data is to discern which nations have the relatively slowest Internet speeds with the highest overall scores. This approach addresses which nations have the best chances to achieve the bandwidth improvements they need. By "relatively," we mean that wealthier nations are expected to have higher speeds than less-wealthy nations. So we can find both developed and developing nations in this group, all of which could benefit from increased Internet speeds.

The developed group includes Australia, the United States, the UK, Greece, and Italy. The developing group includes Puerto Rico, the Dominican, Guyana, and Mexico, all in Latin America.

Sustainability Path. A third way to look at the Index data is to think about the need for new electricity to build Digital Infrastructure, then find which nations among those with the weakest sustainable grids have the most promising ability to improve them. This approach looks at low Environmental scores versus relatively high scores in the other three categories. Two groups emerge from this view: Indonesia, Singapore and Thailand in ASEAN; and Morocco, Oman, Tunisia, and the UAE in the Arabic world. Poland also stands out in this crowd.

Ranking the World's Sustainable Digital Economies

Human progress in the 21st century demands Digital Economies that are sustainable and global. Building such economies does not require a world government, but does require close cooperation among governments at all levels, regional and global treaty organizations, NGOs, businesses, membership groups, and individuals. It requires renewed, relentless efforts to ending wars, conflicts, and all other forms of violence, working closely with efforts to take a digital-first approach in furthering socioeconomic progress.

A Sustainable Digital Economy can be built within developed nations, but also among developing nations with leadership that's committed to aggressive, fairminded technology development and improving socioeconomic conditions for their people.

The benefits of a global Digital Economy are numerous and non-political. But a top-tier, developed Digital Economy is not created overnight. IDCA Research has thus identified four tiers of development:

- **Pre-Phase.** Underdeveloped digital infrastructure, below average Internet speed & access, very limited eServices and apps, inadequate electricity grids and/or sustainability.
- **Phase I (Early-Stage).** Underdeveloped digital infrastructure, average Internet speed & access, some eServices and apps, inadequate electricity grids and/or sustainability.
- **Phase II (Substantial Development).** Moderately developed digital infrastructure, above average Internet speed & access, widespread eServices and apps, sub-optimal electricity grids and/or sustainability.
- **Phase III (Highly Developed).** Highly developed digital infrastructure, world-leading Internet speed & access, ubiquitous eServices and apps, superior electricity grids and/or sustainability.

The words used to describe the phases in a general way above can be transposed into numbers that add a measure of specificity to where a nation stands. The phases thus follow the overall scores from the IDCA Digital Readiness Index, which is created with detailed algorithms that integrate hundreds of factors, on an open-ended scale that's benchmarked against optimal conditions. No real-world country reaches those optimal conditions, thus always allowing for improvement in even the most highly-developed nations.

The scores are then expressed on a 0-100 scale – 100 represents the optimal case. In the real world, current Index scores range from a low of 8 to a high of 85. A key to this research is its relative approach – progress in digital infrastructure must be measured against local conditions, accounting for the fact that digital infrastructure and economic progress are heavier lifts in developing nations than they are in developed ones.

Thus, the Index answers the question, how well is each nation doing, given its current economic resources? This approach elevates high-performing developing nations relatively higher in the Index than the simplistic approach taken by much of the world's economic research, which simply shows which countries have the most wealth.

Each nation of the world has the potential to develop its own Digital Economy – this is not something reserved for only developed nations. A few key areas to be considered in their relative development include:

Fundamentals:

- Internet access and speed
- Mobile communications
- Mobility
- Data center footprint
- Smart-meter deployment
- Smart transportation grids, including public transportation
- Contactless payment and online payment systems
- eGovernment services
- Industry 4.0 development
- Creation of tertiary (ie services) employment
- Traditional and continuous education levels

Income tiers are defined as:

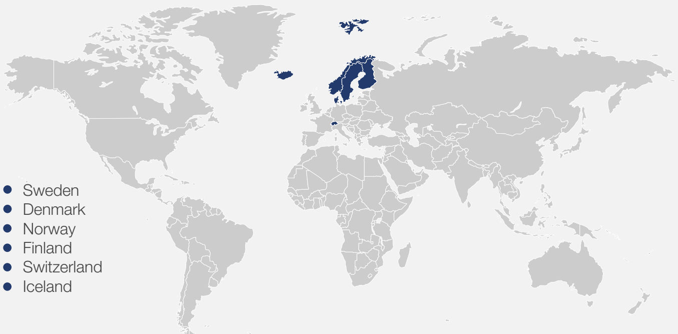
- Least-Developed Countries (LDCs), per-person income <$2,000
- Frontier Markets, per-person income $2,000-$4,999
- Emerging Economies, per-person income $5,000-$14,999
- Edge Countries, per-person income $15,000-$25,000
- Developed Nations, per-person income >$25,000

Rolling all the data together, IDCA Research has found the following results. The leaders are listed here.

Digital Economy Phase III (Highly Developed)

Overall Digital Readiness Index Scores = 80-100

6 nations total

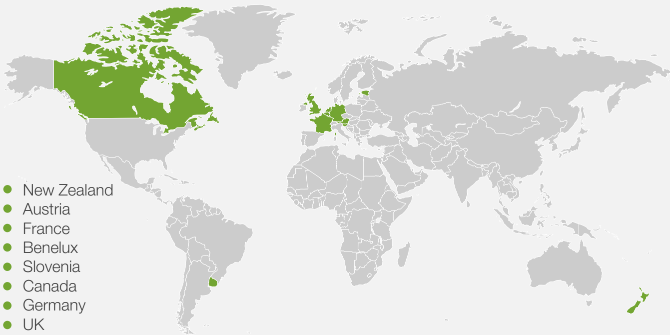


- Sweden
- Denmark
- Norway
- Finland
- Switzerland
- Iceland

Digital Economy Phase II (Substantial Development)

Overall Digital Readiness Index Scores = 59-79

30 countries total – Top 10 listed

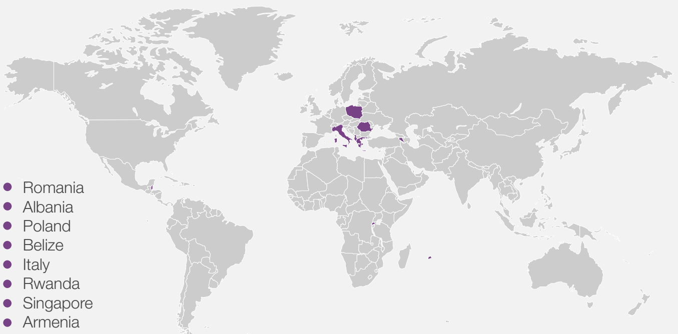


- New Zealand
- Austria
- France
- Benelux
- Slovenia
- Canada
- Germany
- UK
- Uruguay
- Estonia

Digital Economy Phase I (Early-Stage)

Overall Digital Readiness Index Scores = 38-58

79 countries total – Top 10 listed



- Romania
- Albania
- Poland
- Belize
- Italy
- Rwanda
- Singapore
- Armenia
- Greece
- Mauritius

Digital Economy Phase 0 (Pre-Phase)

Overall Digital Readiness Index Scores = <38

68 countries total – Top 10 listed

- Honduras
- Cameroon
- Bahamas
- Gabon
- Qatar
- Madagascar
- Algeria
- Botswana
- Angola
- Timor-Leste

A look across income tiers shows the range of overall Digital Readiness Index scores (with a ratio of the highest compared to the lowest in parenthesis)

- Developed Nations – 40 countries – Range 40 to 85 – (2.13X difference)
- Edge Countries – 17 countries – Range 32 to 69 (2.16X difference)
- Emerging Economies – 38 countries – Range 8 to 62 (7.75X difference)
- Frontier Markets – 28 countries – Range 21 to 62 (2.95X difference)
- Least-Developed Countries (LDCs) – 60 countries – Range 8 to 56 (7.00X difference)

This data shows that Developed Nations and Edge Countries have more parity with one another than do Emerging Economies and LDCs. The group of Frontier Markets also has relative parity, as these nations are typically striving places that have emerged from LDC status and are swimming their way up the economic stream.

National Ranking of Digital Economies (2025)

The world's Digital Economies can be grouped into four phases: Phase III (Highly Developed), Phase II (Substantial Development), Phase I (Early-Stage) and a Pre-Phase. This table groups more than 150 nations into the four groups. The groupings are based on the relative progress of each nation, within the global methodology and processes described in this report.

Digital Economy
Phase III – Highly Developed

Country	Score (0-100 Scale)
Sweden	85
Denmark	84
Norway	83
Finland	82
Switzerland	81
Iceland	80

Digital Economy
Phase II – Substantial Development

Country	Score (0-100 Scale)
New Zealand	76
Austria	74
France	74
Belgium	73
Luxembourg	73
Netherlands	73
Slovenia	72
Canada	70
Germany	70
UK	70
Uruguay	69
Estonia	68
Portugal	66
Spain	66
Lithuania	66
Ireland	64
Czechia	63
Japan	63
Costa Rica	63
Latvia	63
Bhutan	62
Australia	62
Georgia	62
South Korea	62
Chile	61
Croatia	61
Hungary	60
Slovakia	59
USA	59
Malaysia	59

Digital Economy Phase I – Early-Stage	
Country	Score (0-100 Scale)
Romania	57
Albania	57
Poland	56
Belize	56
Italy	56
Rwanda	56
Singapore	56
Armenia	56
Ukraine	55
Belarus	55
Greece	55
Mauritius	54
Ethiopia	54
Cyprus	54
Brazil	54
Malta	53
Bulgaria	53
UAE	53
Seychelles	53
Nepal	52
Taiwan	51
Montenegro	51
El Salvador	50
Hong Kong	50
Colombia	50
Vietnam	50
Ecuador	49
China	49
Namibia	49
Sri Lanka	49
Panama	49
Peru	49
Israel	48
Serbia	48
Argentina	48
Moldova	48
Uganda	47
Paraguay	47
Kenya	47
Tanzania	47
Sierra Leone	47
Bosnia	46
India	46
N. Macedonia	46
Turkey	45
Thailand	45

Digital Economy
Phase I – Early-Stage

Country	Score (0-100 Scale)
Kazakhstan	45
Jordan	45
Russia	44
Zambia	43
Morocco	43
Ghana	43
Pakistan	42
Philippines	42
Indonesia	42
Senegal	41
Tunisia	41
Myanmar	41
Oman	41
DRC	41
Malawi	41
Mongolia	41
Cambodia	40
Maldives	40
Puerto Rico	40
South Africa	40
Jamaica	40
Zimbabwe	40
Nicaragua	40
Bolivia	39
Azerbaijan	39
Laos	39
Egypt	39
Mozambique	39
Saudi Arabia	38
Mexico	38
Cote D'Ivoire	38
Guatemala	38
Mali	38

Digital Economy Phase 0 – Pre-Phase	
Country	**Score (0-100 Scale)**
Honduras	37
Cameroon	37
Bahamas	37
Gabon	37
Qatar	37
Madagascar	36
Algeria	36
Botswana	36
Angola	36
Timor-Leste	35
Burundi	35
Uzbekistan	35
Venezuela	34
Togo	34
Kuwait	34
Djibouti	34
Iran	34
Nigeria	33
Guyana	33
Bangladesh	32
Trinidad	32
Dominican	31
CAR	30
Bahrain	30
Gambia	30
Sudan	30
Iraq	28
Lebanon	28
Niger	27
Congo	23
Yemen	22
Haiti	21
Eritrea	17
Libya	14
Turkmenistan	11
Eq Guinea	8
South Sudan	8

04 Drivers of the Digital Economy

IDCA's research has identified several key drivers of the Digital Economy worldwide, each of which is examined in this section.

Drivers of the Digital Economy

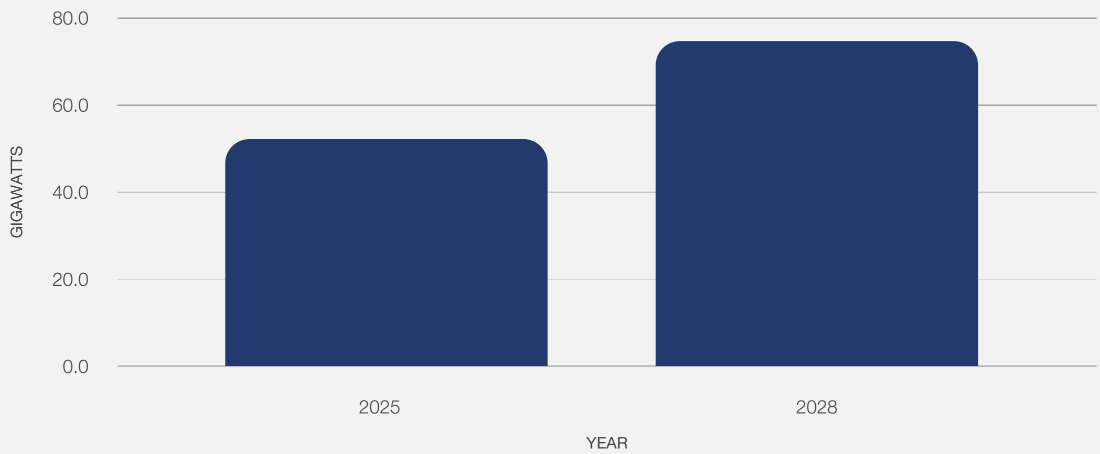
4.1 Data Centers & Digital Infrastructure

Data centers and related digital infrastructure are the physical foundation of the global Digital Economy, yet there are tremendous gaps and disparities in the components of this foundation.

Data Center Footprint. Data centers today have a total footprint of about 33GW, a number that is projected to more than double to 78GW by 2028. The world is thus at an inflection point with respect to its digital infrastructure, with the data centers at the heart of it.

FIGURE 9.

Global Data Center Footprint

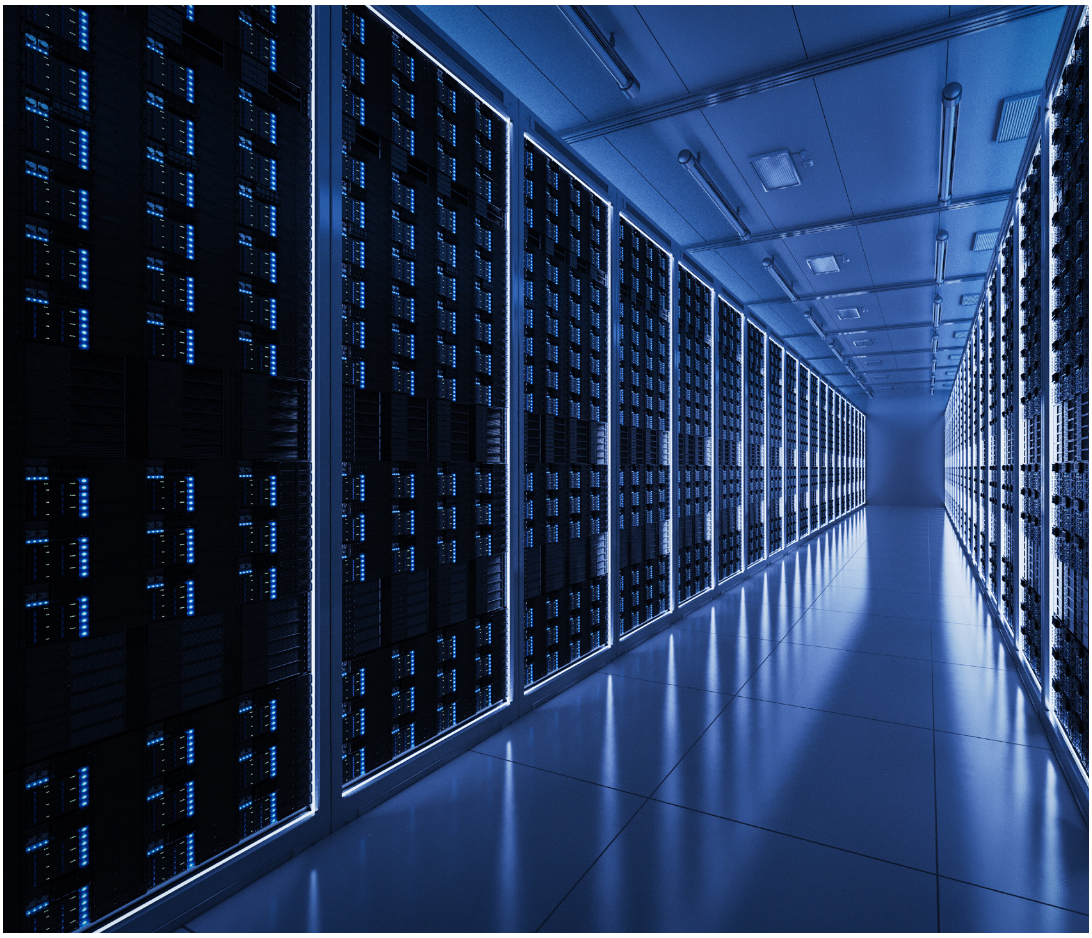


Source: IDCA Research

As noted above, the current footprint commands about 1.1 percent of the world's electricity grid, while IDCA Research shows this number to be 2.8 percent for the United States.

Large data centers today consume 100 to 150MW, with a number of proposed campuses envisioning multiple facilities of that size. The current AI wave and simultaneous early dawn of quantum computing is causing hair-raising projections of individual facilities of several hundred megawatts and campuses exceeding several gigawatts.

So a key challenge to the world's governments, enterprises, and investors is to develop significant data center footprints and hubs as quickly as possible in as many nations as possible. Even though large regional hubs can provide internet access and services to several developing nations simultaneously, especially in Africa, it is still to a nation's advantage to have a local, sovereign data center footprint that can adequately serve the needs of its people.

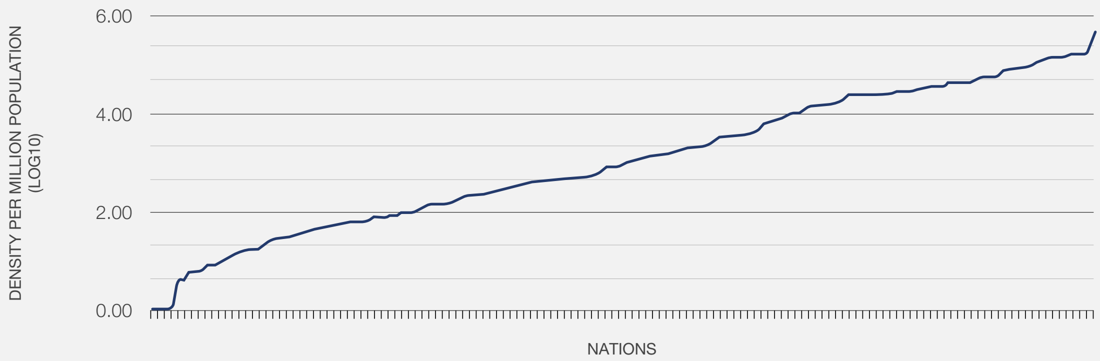


Data Center Disparity. The amount of data center density among nations varies widely, representing by far the most disparity within the arena of technology adoption. For example, none of the world's Least-Developed countries devote even 0.1 percent of their electricity to data centers, even in the context of their woefully underdeveloped electricity grids.

The data server and data center disparity among nations is on the order of 100,000X and more. This disparity in fact is an astonishing five magnitudes of difference larger than the income disparity among nations. The difference is clearly extreme, even when represented as a logarithm as in the accompanying chart.

FIGURE 10.

Server Density by Nation



Source: IDCA Research

There is a world average of 9,200 servers per million population, according to World Bank figures. This number is skewed by the presence of about two-thirds of the world's data centers in the United States, and a significant percentage of those in Northern Virginia (in metro Washington DC). The number is further skewed by a few nations with server densities of more than 100,000 servers per million population, including Denmark, Switzerland, the Netherlands, Ireland, Singapore, and Belize.

But the disparity is too large to be attributed to this skewing only. There are more than a dozen nations with fewer than 10 servers (ie, actual machines) per million population, 40 nations with fewer than 100 servers per million population, and a median of fewer than 1,000 servers per population. The economic giants China and India, despite decades of strong economic progress, remain below the world average.

Deploying more servers and building new data centers should thus be the top priority for most nations in their digital infrastructure and Digital Economy strategy. IDCA's data shows that a minimum of around 3,000 servers per million population is a worthy initial goal for any nation to reach even modest Digital Economy goals.

Internet Access and Speed. The gaps in internet access and speed are less profound than with servers, but likely impede growth to an even greater degree – if people cannot get onto the internet, or labor under execrable bandwidth, they have no chance of economic improvement in the 21st century.

The IDCA Digital Readiness Index shows more than 140 nations with access of at least 10 percent of the population, according to the International Telecommunications Union. The world average is about 63 percent, with a median of almost 70 percent.

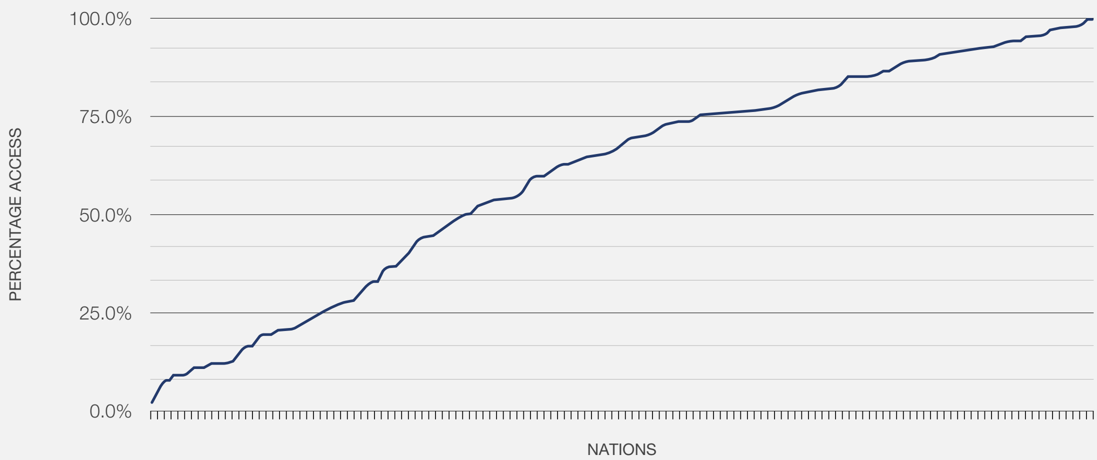
Average speeds range from under 1Mb to almost 30Mb per second, according to consolidated Akamai figures. This is a range of 30X, or slightly more than a magnitude. There are more than 30 nations delivering only about 10 percent of the speeds of the top nations.

Measuring internet speed is fraught with peril, as upload speeds are usually dramatically lower than download speeds, hypothetical speeds are rarely reached, and average speeds can vary dramatically over the course of even a few minutes. IDCA works with general averages to produce an accurate relative picture, knowing that individuals may report dramatically different spot test results.

Nations must look to undersea fiber-optic cable, satellites, and when applicable, neighboring bandwidth resources so as to increase the bandwidth they serve to their people. Developing nations have a particular need in this area, but every country can still find room for improvement in delivering internet service.

FIGURE 11.

Internet Access Among Nations

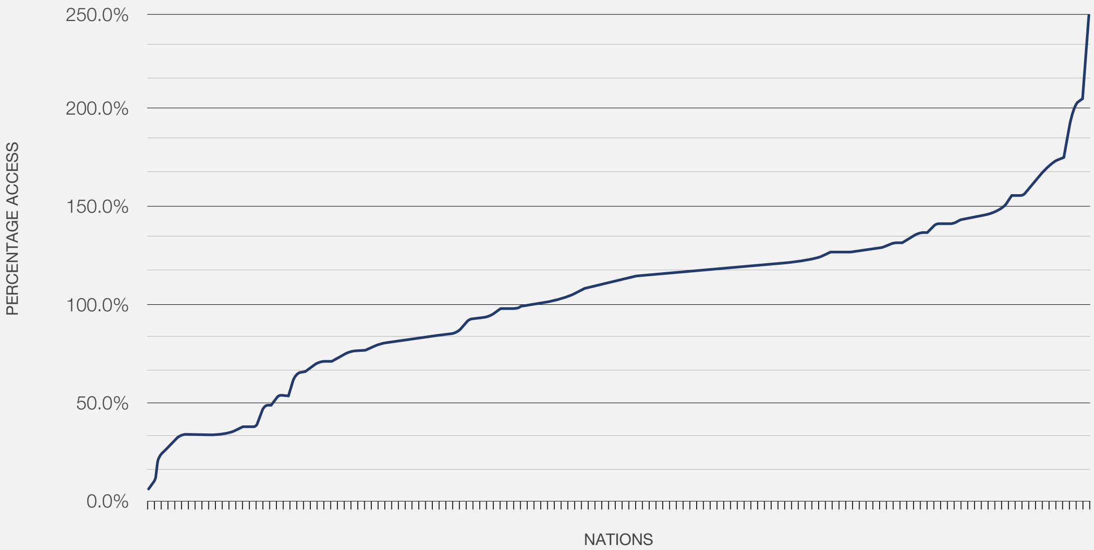


Source: IDCA Research

Mobility. Mobile access provides the most optimistic data within the key areas of digital infrastructure. The world average and median both now exceed 100 percent (ie, there is more than one subscription per person). Almost 100 nations have more than one mobile subscription per person, with 15 nations at 150 percent or above, according to data from the International Telecommunications Union and World Economic Forum. There are more than 40 nations with mobile subscription rates of 50 percent or less, representing as much as 10 percent of the world's population.

FIGURE 12.

Mobile Subscriptions by Nation
(World Average Exceeds 100% of Population)



Source: IDCA Research

In Summary. Thus, a sound data-center development strategy must account for the current state of emissions and sustainability in a given nation, the current size of its data center footprint, its projected economic growth, and the desire within its government and among its people to achieve higher degrees of data sovereignty and local control over its underlying digital infrastructure.

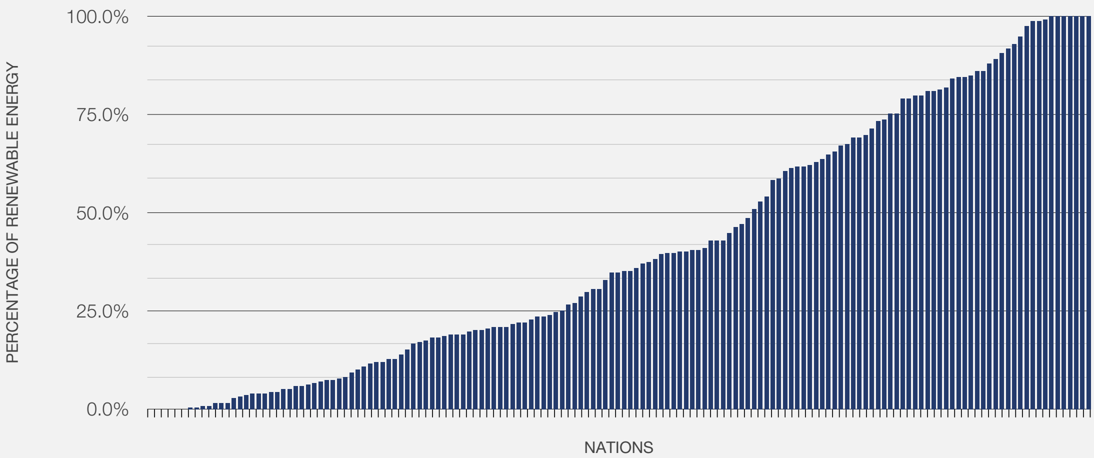
4.2 Energy

Much of the disparity seen in data centers and digital infrastructure has its roots in a lack of adequate electricity grids. Developing nations are easily cited as being deficient in this area, yet even the most highly developed nations are now experiencing electricity supply problems in meeting the needs of an expanding data center footprint. The "Data Center Alley" region of Northern Virginia in the United States is the most prominent example, as the local supplier struggles to meet the needs of a data center footprint that is approaching 4 gigawatts.

The crux of the matter comes from a need to develop sustainable energy rather than rely on yesterday's coal-fired and natural gas facilities. Data from the Vienna-based International Energy Agency (IEA) shows that hydropower currently generates about 16 percent of the world's electricity, wind power 8 percent, and solar energy 6 percent. The total of these three renewable sources is about 30 percent. The world's nations currently rely on these technologies across the entire possible range, from 0 percent to 100 percent.

FIGURE 13.

Percent of Renewable Energy Among Nations

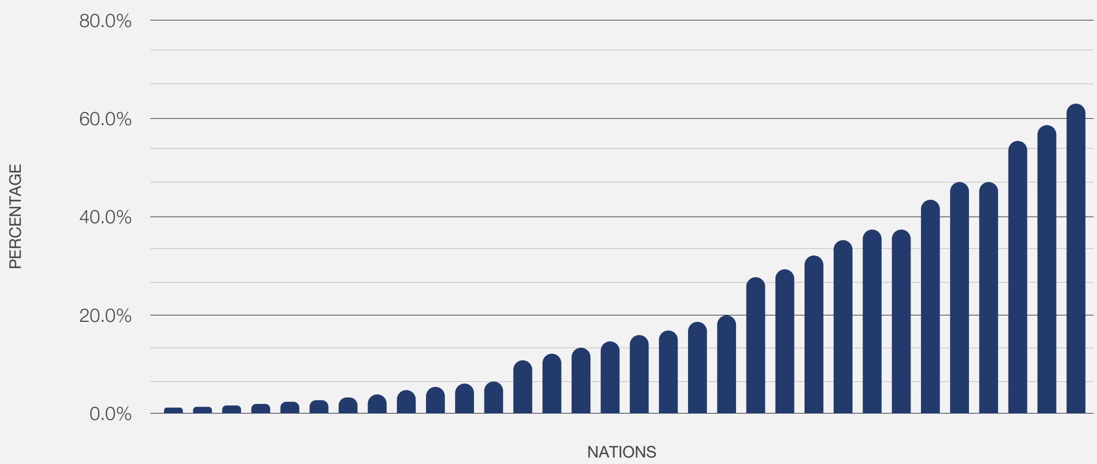


Source: IDCA Research

Nuclear energy, which is not renewable but is considered sustainable, provides another 10 percent to the world's electricity grids. A total of 32 nations rely on it for between 3.3 percent and 62 percent of their electricity.

FIGURE 14.

Percentage of Nuclear Power Among Nations
(Currently in Use in 32 Nations)



Source: IDCA Research

An affirmation of nuclear energy's use came in December 2023 at COP28 in Dubai, with 31 signatories. The consensus was that Small Modular Reactors (SMRs) can be brought to bear for localized power needs. These systems generate from 20MW to 300MW, compared to the 1,000MW reactors found in traditional nuclear facilities.

According to the research company Enerdata, SMR projects totaling 22,000MW are currently in their planning stages (including 4,000MW in the US). A 210MW SMR has been completed and is in operation in China.

Water comes up as a related concern. The world's data centers collectively need about 100 million liters per hour of water for cooling alone. The water resources devoted to hydroelectric power add to this, as would increasing water demands by the creation of more nuclear energy. There are already water shortages for half of the Earth's population, according to the United Nations, especially throughout Africa, South Asia, parts of Latin America, and the US Southwest.

Electricity Grids. Looking beyond the world's general electricity shortage, IDCA Research finds a dramatic disparity in grids is dramatic, as noted above in the Key Findings section. Currently, electricity grids provide between 1 and more than 1,000 watts continuous watts per person, with more than 50 nations producing 3 percent or less of the average per-person electricity enjoyed throughout the EU. More than 100 nations produce less than 20 percent of the EU average.

Within IDCA's Index data, there is a strong correlation between the strength of a nation's electricity grid and its overall digital infrastructure. Planners would be able to connect the dots between a need for new, sustainable sources of electricity to power significant new digital infrastructure throughout the developing world.

Electricity Usage. The relative strength of the grids can be calculated across the five income tiers that IDCA Research uses to categorize economies: Developed Nations, Edge Countries, Emerging Economies, Frontier Markets, and Least-Developed Countries (LDCs).

IDCA Research uses an EU average as an ideal, developed state for electricity consumption. Using the EU average as a benchmark shows the range of the strength of electricity grids as shown below. The strength is listed as a percentage of the EU average.

Developed Nations (40 countries): 34 to 513 percent

Note: Percentages above 100 percent indicate combinations of high energy requirements for a nation's petroleum industry, a very cold climate, or large electricity exports.

Edge Nations (17 countries): 28 to 164 percent

Note: The range is comparable to that of Developed Nations, albeit slightly lower. This confirms the designation of these countries as being on the cusp of having fully developed economies.

Emerging Nations (38 countries): 11 to 135 percent

Note: There are some big energy producers in this group, notably China.

Frontier Nations (28 countries): 1.7 to 250 percent

Note: Frontier Nations are very high risk/reward places by definition. The bottom end of this group shows a dramatic drop in the strength of the local grids. Iran tops this group, reflecting its precarious economy with a critical dependence on petroleum-based exports.

LDCs (60 countries): 0.4 to 96 percent

Note: Laos is the outlier here, with recent, strong, and fast-growing hydropower exports. The second-highest percentage in this group is Zambia, at 15 percent.

The investment required to bring electricity grids in developing nations up to even 25 percent of the EU average encompasses a very broad range of between about 10 percent to more than 100 percent of any particular nation's annual GDP. Simultaneously improving a nation's digital infrastructure in similar fashion would require similar investments.

This sort of investment is the fundamental world challenge in developing Digital Economies in developing nations, with an eye to closing gaping disparities in socioeconomic conditions and progress.

Data Center Impact on the Grid

A useful analysis summarized here shows the relative size of each nation's data center footprint, the percentage of the local grid each footprint consumes, and the sustainability challenge it faces in upgrading its grid and footprint. This latter point is essential to integrate in any infrastructure planning – ideally, all new electricity is sustainable, as is any new data center footprint.

Examining the percentage of the grid each nation's data center footprint consumes, IDCA finds (as noted above) a world average at the moment is about 1.1 percent. The US average stands at 2.8 percent. As always, there are very large disparities. So the use of an average (or even a median) is a blunt instrument brought to bear to a complex task.

Looking across income tiers, the range of average percentages of electricity grids by data center footprints shows the following:

Developed Nations (40 countries): 0.1 to 12.2 percent

Note: The massive disparity is evident even among the most-developed nations, with a number of them having barely any footprint by dint of depending on neighboring countries. This list is topped by singular Singapore, which has well-known shortages and restrictions and is depending increasingly on nearby cities in Malaysia and Indonesia to provide its digital capacity. There are five other nations who have slipped past the 4 percent level, all of whom have expressed concerns: Lithuania, Estonia, the Netherlands, Denmark, and Ireland.

Edge Nations (17 countries): <0.1 to 3.8 percent

Note: While there is a paucity of footprint at the low end, this group has the highest amount of parity among all nations. The region encompassing Hungary, Romania, and Bulgaria has the largest footprints in this group, and thus bear continued watching as they develop. The low end of this group includes Trinidad and Oman.

Emerging Nations (38 countries): <0.01 to 1.16 percent

Note: Malaysia, South Africa, and Brazil lead this group. One key difference that Malaysia and Brazil are on the way up (even as they vary immensely in size), while South Africa's grid is more a legacy of its past than indication of its future.

Frontier Nations (28 countries): <0.01 to 0.47 percent

Note: India leads this group. Given the very heavy lift India has been accomplishing in recent decades, it's clear here that the country can continue to be highly ambitious in its development efforts without putting undue strain on its grid; the caveat is that India is the world's third-largest GHG producer and must devote colossal efforts to become more sustainable as its economy continues to grow.

LDCs (60 countries): <0.01 to 0.31 percent

Note: Rwanda is the star within this group, indicating a lot of recent progress. Other nations seemingly on the way up with their data center footprints include Ethiopia and Nigeria.

The Emissions Reduction Challenge

As noted above, developing sustainable energy and data center practices is the looming issue. It won't be enough just to build the data centers of the past with the energy sources of the past.

Another data set created by IDCA Research measures the specific Emissions Reduction Challenge (ERC) facing the world. Integrating key factors such as total emissions, emissions per capita, current economic growth, and most important, the efficiency of an economy relative to its emissions level, this Index finds the world to be in a dire place. This is not a surprise.

The ERC Index groups 183 nations into four categories: green (representing a relatively small challenge), yellow (moderate challenge), red (serious challenge), and a zone that goes beyond red to purple (severe challenge). The bad news is that most of the world's top emissions producers fall into the purple zone: China, the United States, India, Russia, Brazil, Indonesia, and Mexico. These nations produce at least 60 percent of the world's GHG emissions, and tip the entire world into the purple zone.

Among developed economies, only Scandinavia and the Baltics exist within the green zone. Most nations within the green and yellow zones, by contrast, are in various stages of economic development; their relative lack of emissions is from economic under-development rather than great sustainability (with some notable exceptions such as Rwanda, the DRC, Uruguay and Costa Rica).

The year 2025 is one in which nations of the world should work collectively to reduce digital infrastructure disparities, as a way to address the massive issue of income disparity. The need for stronger, resilient, sustainable electricity grids is the first order of business. These better grids need to support a massively increased data center footprint, which in turn can propel continuous improvement in internet access and speeds.

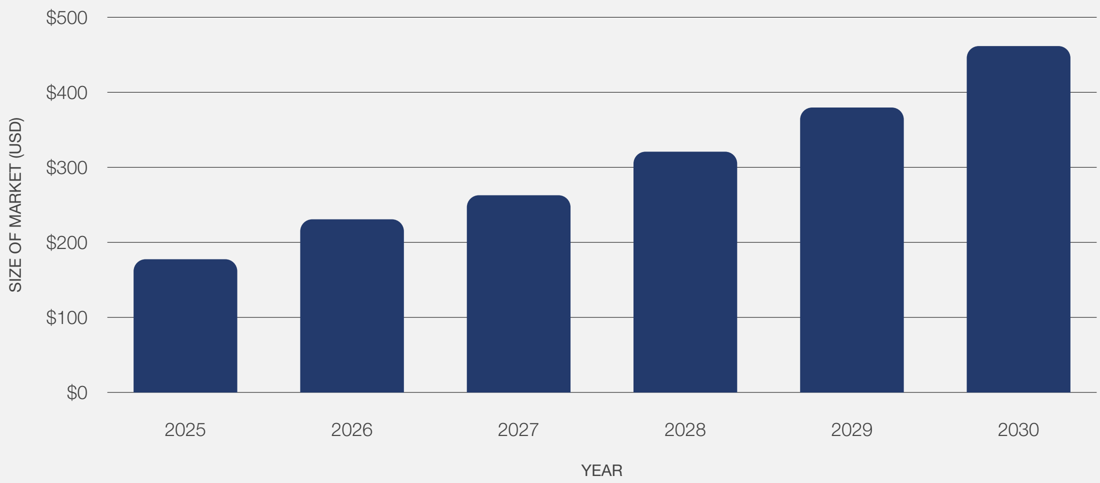
4.3 Artificial Intelligence (AI)

The AI market is expected to grow at a consensus annual rate of 37.3 percent between now and 2030, tripling to $400 billion by 2030. This paves the way for unprecedented opportunities and advancements in the industry, driven by advancements in AI technologies and their increasing adoption across industries.

It thus behooves the nations of the world to embrace and even develop AI technologies as quickly and aggressively as possible. And a big caveat here is that even the most optimistic growth scenarios may be blown away by the pace of advance, given the current dynamism of the AI market.

FIGURE 15.

Growth of AI Worldwide



Source: IDCA Research

By 2030, AI is projected to contribute a 21 percent net increase in US GDP and have a similar effect in much of the world, according to IDCA Research. The top three industries – IT and communications, manufacturing, and financial services – are projected to experience an additional $6 trillion in gross value added by 2035 due to AI.

Netting out growth to an adoption rate, it's found that 83 percent of companies identify AI as a top priority in their business plans, 72 percent of organizations now use AI, a 65 percent of organizations use generative AI in at least one business function (nearly doubling from a year ago), and 48 percent use AI to harness Big Data effectively.

Sustainable Infrastructure. As enterprises invest in AI, sustainability becomes paramount. IDCA emphasizes the importance of developing AI systems that are not only powerful but also environmentally responsible. This includes incorporating green AI strategies, using energy-efficient hardware, and exploring emerging technologies like quantum computing, which can significantly reduce the energy consumption of AI systems.

Smarter and Safer Systems. AI technologies have the potential to transform traditional infrastructure systems into more intelligent, safer, and more responsive entities. This transformation is critical to addressing evolving needs, enhancing resilience against disruptions, and optimizing resource allocation in critical sectors.

A number of emerging trends accompany the above projections:

Responsible AI Development. There is an increased emphasis on developing and deploying AI responsibly, focusing on ethics and fairness.

Multimodal AI and Video Capabilities. AI systems that integrate multiple data types, such as text, vision, and speech, are being adopted increasingly.

Smaller, More Efficient Language Models. Rise of smaller, more efficient language models (SLMs) for specific, localized applications.

AI in Scientific Research. AI is increasingly applied to complex scientific challenges, including climate change mitigation, drug discovery, and materials science.

AI Infrastructure Democratization. Making AI tools and infrastructure more accessible to a broader range of businesses and developers.

Edge AI and Embedded Systems. AI integration directly into devices and user interfaces, enabling more efficient and responsive applications.

AI in Data Centers

Data centers are the backbone of the AI ecosystem, providing the essential infrastructure to meet the vast computational needs of AI applications. These facilities are responsible for storing, processing, and analyzing massive amounts of data, crucial for training and deploying AI models.

AI fundamentally transforms data centers, making them more efficient, secure, and sustainable. As the strategic importance of AI-driven data centers grows, they will continue to play a critical role in supporting the demands of AI and the broader Digital Economy. Integrating AI into data center operations has led to significant improvements in power management, cooling, security, and resilience, ensuring that data centers can meet the growing demands of AI applications while minimizing their environmental impact.

AI's role in data centers will continue to expand, shaping the future of technology infrastructure and driving innovation in the industry.

Yet Artificial Intelligence is not just a change agent for data centers; it's a transformative force that turns them into highly intelligent, efficient, and sustainable infrastructures. Integrating AI into data centers opens the door to automated operations, improved data management, and substantial energy savings. As AI applications continue to expand, the need for robust data center infrastructure capable of supporting the computational requirements of these AI systems is skyrocketing, inspiring a future of unprecedented efficiency and sustainability.

Industry Challenges and Opportunities

Healthcare Challenges

- **Data Privacy and Security.** With increased regulatory scrutiny in 2024, healthcare providers must ensure that AI infrastructure complies with stringent data protection laws like HIPAA and GDPR while guarding against cyber threats.
- **Scalability.** The demand for real-time patient data processing is growing, requiring scalable AI infrastructure capable of handling massive amounts of data, especially with the rise of remote healthcare services.
- **High Compute Requirements.** Advanced AI models for drug discovery and personalized treatment are computationally intensive, necessitating robust infrastructure to manage these workloads.

Healthcare Opportunities

- **Cloud-Based Health Data Platforms.** These platforms leverage cloud-based AI infrastructure to facilitate the storage, processing, and analysis of health data, supporting the shift toward telemedicine and personalized care.
- **AI-Enhanced Diagnostic Tools.** Supporting real-time diagnostics and imaging through AI infrastructure, improving accuracy and speed in healthcare delivery.
- **Personalized Treatment Plans.** Using AI-driven infrastructure to deliver individualized treatment plans, optimizing patient outcomes with precision medicine.
- **IoT and Wearable Integration.** Integrating AI with IoT devices and wearables for continuous patient monitoring, enabled by robust and scalable infrastructure.

Financial Services Challenges

- **Data Latency and Real-Time Processing.** With the rise of high-frequency trading and instant payment systems, financial institutions must ensure ultra-low latency in AI-driven transactions.
- **Regulatory Compliance.** AI infrastructure must be built to comply with evolving financial regulations, ensuring transparency and accountability in AI-powered financial services.
- **Cybersecurity.** cybersecurity threats are more sophisticated, requiring financial AI systems to be fortified against breaches, particularly in fraud detection and blockchain integration.
- **Scalability.** The exponential growth in financial data demands AI infrastructure that can scale rapidly to handle increasing data volumes and complexity.

Financial Services Opportunities

- **High-Performance Computing (HPC).** Utilizing HPC in AI infrastructure to support advanced financial modeling, risk assessment, and trading algorithms.
- **Cognitive Banking Platforms.** Developing AI-powered cognitive platforms that provide personalized banking experiences, enhancing customer satisfaction and loyalty as well as conversational AI systems
- **AI-Powered Fraud Detection.** Implementing AI infrastructure to support real-time, AI-driven fraud detection, reducing financial crime and enhancing security.

Manufacturing Challenges

1. **Integration with IoT Devices**. As smart manufacturing becomes more prevalent, integrating AI infrastructure with a growing array of IoT devices is critical but complex, requiring robust connectivity and data management solutions.
2. **Real-Time Processing.** The need for real-time decision-making on the production floor requires AI infrastructure capable of processing data instantaneously
3. **Predictive Maintenance.** Ensuring that AI infrastructure can support predictive maintenance by processing vast amounts of sensor data to predict equipment failures and optimize uptime.
4. **Energy Consumption.** Managing the energy demands of AI-driven manufacturing processes is a growing concern, especially with sustainability/ESG targets becoming more stringent in 2024.

Manufacturing Opportunities

1. **Smart Factories.** Developing cognitive infrastructure that enables AI-driven automation, improving efficiency, reducing waste, and enhancing production quality.
2. **Digital Twins.** Supporting the creation and use of digital twins for real-time simulation and optimization of manufacturing processes.
3. **Supply Chain Optimization.** Using AI infrastructure to optimize global supply chains, ensuring resilience and efficiency amid disruptions.

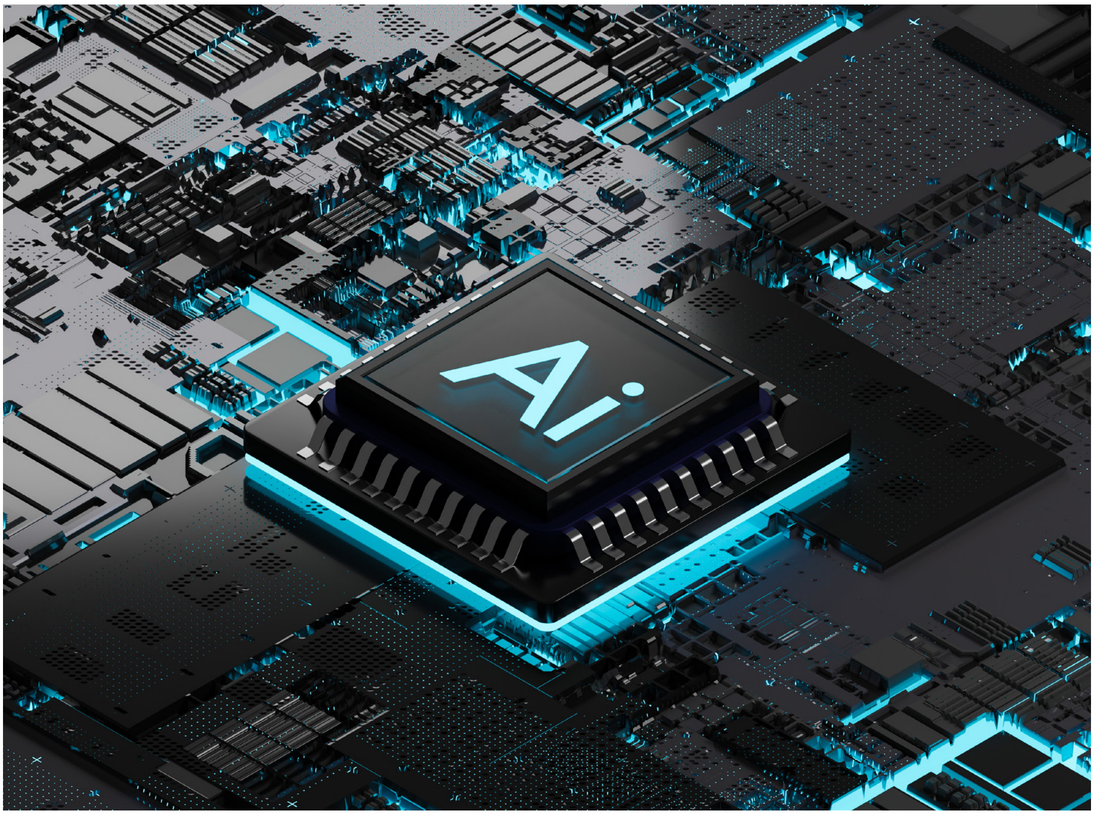
Energy Challenges

1. **Grid Management and Stability.** With the integration of renewable energy sources, AI infrastructure must manage complex and dynamic energy grids, ensuring stability and preventing outages.
2. **Integration with Renewable Energy Sources.** AI infrastructure must be adaptable to the fluctuating inputs from renewable energy sources like wind and solar, which require sophisticated predictive analytics.
3. **Predictive Maintenance for Energy Infrastructure.** Building AI infrastructure to support predictive maintenance across vast energy networks, reducing downtime and operational costs.
4. **Cybersecurity.** As energy systems become more interconnected, protecting critical infrastructure from increasingly sophisticated cyber threats will be paramount in 2025.

Energy Opportunities

1. **Smart Grid Implementation.** Developing AI-driven infrastructure that supports the creation of intelligent grids, improving energy distribution efficiency and reliability.
2. **Energy Consumption Optimization.** Using AI to optimize energy consumption across industrial and residential sectors, reducing costs and improving sustainability.
3. **Renewable Energy Management.** Leveraging AI infrastructure to optimize the production, storage, and distribution of renewable energy, making it more viable and widespread.
4. **AI-Enhanced Disaster Response.** Implementing AI systems that enhance disaster response and recovery for energy infrastructure, ensuring resilience against natural and artificial disasters.

Public Sector Digital Government Challenges	Public Sector Digital Government Opportunities
• **Citizen Data Privacy.** As governments adopt AI for public services, protecting citizen data remains a top priority, especially with the increasing use of AI in areas like surveillance and social services. • **Ethical Use of AI.** Governments must ensure that AI is used ethically, particularly in law enforcement, public policy, and national security. This requires robust oversight and transparent AI infrastructure. • **AI in National Security.** Developing secure AI infrastructure for national defense and intelligence applications while safeguarding against AI-driven threats from adversaries. • **Scalability of Public Services.** As AI is integrated into public services, the underlying infrastructure must be scalable to meet the needs of large and diverse populations.	• **Smart City Infrastructure.** Building cognitive infrastructure that supports AI-driven intelligent city initiatives, enhancing urban management, traffic flow, and public safety. • **AI-Powered Public Services.** Developing infrastructure that enables AI-enhanced public services, such as healthcare, education, and transportation, improving efficiency and accessibility for citizens. • **Disaster Management Systems.** Creating AI-powered infrastructure that enhances disaster prediction, preparedness, and response, improving resilience to natural and human-



4.4 Cybersecurity

The average successful cyberattack already costs G2000 companies around $20 million, according to consolidated IDCA research. Similarly, a report from Commvault and OM Research found that 83 percent of large organizations have experienced a breach at one time or another, with 50 percent reporting a breach within the last six months. These intrusions cost the companies as much as $12 million each day.

But money's not the only issue – many attacks are catastrophic. Vandals, organized criminal gangs, and hostile state actors all want to break into your sites, apps, and data. The potential for deepfake identities and related fraud have made a quantum leap from the past.

A new report from Cisco finds several specific types of cyberattack, each numbering the hundred of millions worldwide every month. This includes trojans and ransomware, along with plain old information-stealing probes. Botnets, backdoor attacks, and attacks on security cameras, and sophisticated advanced persistent threats (APTs) number in an additional tens of millions monthly.

There is thus a growth of more rigorous demands for cybersecurity as data grows and attack surfaces widen. The 800-53 NIST standards have long been followed as the normative cybersecurity standards in the United States. They are continually updated and focus on protecting organizational operations and assets (and people) from hostile attacks, human errors, natural disasters, structural failures, hostile state actors, and general privacy risks. The NIST standards are "derived from mission and business needs, laws, executive orders, directives, regulations, policies, standards, and guidelines," according to the agency.

Europe and much of the rest of the world follows the ISO/IEC 27000 standards. Identity management, access control, and threat identification remain at the heart of this approach. ISO has noted that "most organizations stick to the most basic form of threat intelligence," and urge them to be more curious about the benefits of incorporating a more rigorous cybersecurity environment.

Cybersecurity vendors are projected to grow by at least 12 percent annually for the next several years, and reach a collective $400 billion in 2029, according to Boston-based BCC Research. There is also a continuing need for regulatory frameworks, security policies and practices, and general awareness among users to be vigilant, including being distrustful of unusual messages and behavior.

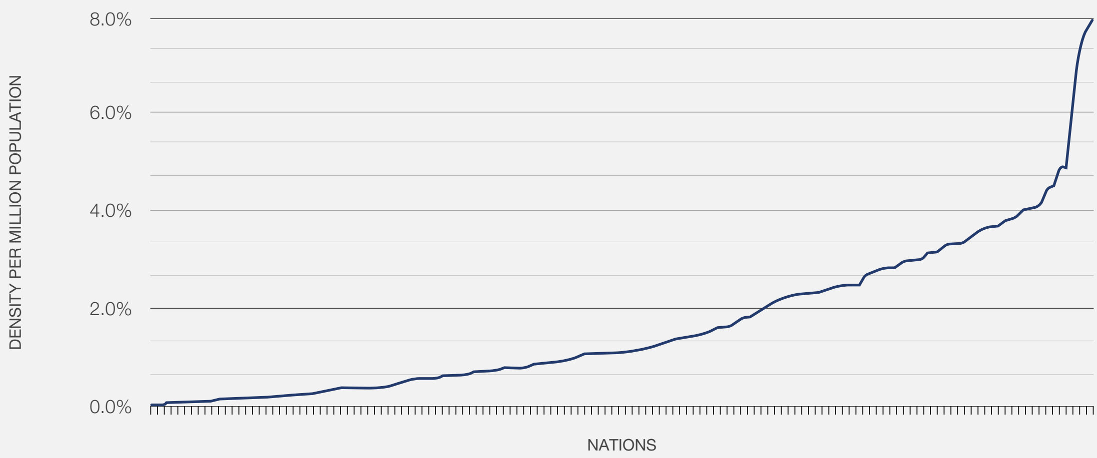
4.5 Human Resources

Nations that are already building successful Digital Economies have committed to educating their people, from basic teaching of concepts in their primary education, to technology-focused programs at the secondary level, to continuous education and training that creates and enhances jobs in the workforce.

Current research shows that ICT and other technology-related jobs comprise a range of between 0.1 percent and 4.0 percent of the population of the world's nations. IDCA's recommendation is that 2.5 percent of a nation's population is employed in tech in some capacity to ensure successful Digital Economy creation and management.

FIGURE 16.

Percentage of Tech Jobs by Nation
(Average=1.2% Ideal=2.5%)



Source: IDCA Research

Within this context, IDCA has drawn up a workforce development program that can be envisioned in 50,000-job increments on a national scale (with the scale being adjustable to other levels). Such a program encompasses a series of courses during a one-year period, ranging in length from one week to six weeks, scalable to certify a total of approximately 50,000 digital infrastructure specialists, experts, authorities, and instructors.

The plan encompasses student instruction to be held in several locations. The plan also creates immediate short-term employment opportunities for students to work as facilitators, supervisors, consultants, and instructors to implement the overall program. The program works on a model similar to that of top-tier executive education programs offered by leading universities throughout the world, but with a focus on preparing students for careers as data center professionals and related employment.

The courses would deliver certifications equal to between 4 and 24 university-level quarterly credit hours, comparable to coursework ranging from a single intensive quarterly lab course to two full semesters of full-time study.

The program addresses the well-recognized Five Pillars of the Digital Economy:

- Core digital infrastructure
- Enabling layer (ie applications and services)
- Direct job creation
- Indirect job creation
- Overall Digital Economy ecosystem

Certification Background and Details

Courses would delivered at four levels and durations as outlined below. They are presented as if scaled to the 50,000-student level.

Students selected for Level I and students who then advance to Level II do not need prior experience in working with or at a data center. Students selected for Levels III and IV must have some relevant experience at a data center or prior experience working with IT systems, as well as an outstanding potential to be a leader and pioneer of the Digital Economy in their country.

Level I – Specialist (one week). Graduates receive an IDCA Specialist certificate, shirt and cap, and use of the IDCA Specialist one-star logo. This level will be attained by 100 percent of initial graduates, with an anticipated 90 percent graduation rate for initial enrollees.

There are 250 students per class, to be held in appropriate classroom facility. The instructor is assisted by six facilitators who work with breakout groups of 40-50 students during the course of instruction, with two supervisors who work with three facilitators each.

Course material covers the following topics: data center principles, systems, and components; policies and procedures; best practices, standards, and frameworks; data center trends; operational needs and critical-service details; efficiency concepts and optimization mechanisms; size and capacity calculations; power and cooling calculations; safety and security systems; IT systems and components optimization; telecom and cabling systems specifications; availability engineering principles.

Level II – Expert (two weeks). This level would be attained by 20 percent of original Level I graduates.

There are 50 students per class, to be held in appropriate large room facility. The instructor is assisted by two facilitators who work with breakout groups of 20-25 students during the course of instruction, with a supervisor to work with the facilitators.

Course material covers the following topics: detailed data center systems specification; analysis of diverse data center technologies; pros and cons of available technologies; sustainability-related technologies, trends, and systems; detailed cooling, power, IT, and M&M systems analysis; system lifecycle optimization; total cost of ownership (TCO) for technologies and systems; alternative technologies and specifications

Level III – Authority (four weeks). This level would be attained by 4 percent of original Level I graduates.

There are 10 students per class, to be held in appropriate size room. Instructor is assisted by a consultant who helps prepare course materials and assists with student interaction.
This course brings students to the top level of understanding and ability to work as a Data Center Authority. A review of previous knowledge gained at the Specialist and Expert level is followed by deep analysis of the data center industry, to enable graduates to make their own contributions to the industry. They will obtain commanding data center knowledge, and authoritative data center expertise, with the knowledge to lead constructive industry movements and become a valuable asset to data center stakeholders.

Level IV – Instructor (six weeks). This level would be attained by about 1 percent of original Level I graduates. A single class of between 6 and 12 students would be held at a single location. Some students may need to be flown to the class. The instructor is assisted by a consultant who helps prepare course materials and assists with student interaction.

Instruction Cycles

Classes would be held in-person with live instruction. Courses would be taught within six-week cycles. A ramp-up week delivers Initial sessions to provide certification and training to students who can start assisting with courses during Cycles I through VI.

Then, each cycle accommodates a total of six Level I sessions, five Level II sessions, three Level III sessions, and a single Level IV session in each location. There are as many as 12 instructional locations.

Instructors would be be assisted by a range of facilitators, supervisors, consultants, and new instructors from this program. This type of program would also create jobs as it is rolled out, calling for more than 15,000 job-days across 3,000 separate roles, equivalent to about 100 FTE positions.

Job Opportunities

At the conclusion of the ramp-up and six cycles, the program calls for creation of:

- 48,600 Level I (specialist) certified graduates
- 8,100 graduates also receiving Level II (expert) certification
- 972 graduates also receiving Level III (authority) certification
- 65 graduates also receiving Level IV (instructor) certification

There would be approximately 100 FTEs for instructors and teams to assist them during the instruction.
Upon certification, Level I graduates would expect employment on operations teams at data centers of all sizes and locations throughout the world. Level II, III, and IV graduates would expect employment at data centers as well as corporate positions that interact with data centers at specialist, engineering and management levels.

As such a program progresses, there would be creations of alumni networks within individual countries and industries.

4.6 Environment

There are two key environmental issues related directly to the digital infrastructure involved in creating Digital Economies: greenhouse gas (GHG) emissions and water usage. Both of these issues are factored directly into the Environment component of the IDCA Digital Readiness Index and Digital Economy rankings. Other issues such as air quality, deforestation, the impact of mining, and the consequences of industrial development are factored into sub-algorithms within the Social and Governance components.

Emissions are traditionally reported by most organizations as a total (usually expressed in millions of metric tons), or a per-capita basis (in metric tons). These numbers are useful, but don't tell the entire story. In contrast, IDCA measures emissions in terms of tons per million dollars of nominal GDP. This method shows how efficiently a country's economy is in producing its emissions. This metric currently runs from 39.9 to 1,878 tons per million dollars, with a world average of 354.2.

The United States runs at 177.5. We can compare this to Germany (153.1), France (105.1), Mexico (275.0) and Canada (287.1). Note that these countries are all below the world average. China (708.5) and India (721.7), in contrast, are far less efficient than the first group of countries cited here. Russia (1,016.5), South Africa (1,083.0) and Iran (1,817.5) provide examples of large countries with the highest levels of emissions per GDP in the world.

The per-GDP metric itself is not perfect; for example, many developing nations will also have very low per-GDP emissions simply because their economies highly underdeveloped. So, Switzerland (39.9), the DRC (51.7), and Sweden (64.4) reside next to one another in this metric. The United States (177.5) resides next to Kenya (178.5). Yet, at minimum is provides a more intriguing look than per-capita rankings, which show China (8.89 tons per person) as more efficient than the United States (14.28 tons per person), for example.

The Digital Readiness Index Environment score relies on the per-GDP score more heavily than other ways of measuring emissions. But the numbers cannot address another key issue, that of accountability. China's ranking, for example, is partly a function that the United States and other developed nations have outsourced much of their industrial base to China over the past three decades. China is producing these emissions, yet populations in the developed world are consuming the product of these emissions.

The oil business generates a very high amount of emissions, too, even as oil consumers so often reside in nations that produce lower emissions. So, the data is real and has a direct affect on national rankings, but the road maps and solutions to improving this picture must transcend national borders. These numbers provide a classic example of a globally linked, interdependent economy.

Water usage is the other major issue with digital infrastructure. Data centers use large amounts of water as a cooling resource to mitigate the heat that computing systems and related hardware produce. They can use water from from local, natural resources, including potable water, treated effluent and reclaimed/recycled water. Reclaimed water can cause more corrosion and microbial growth than potable water, and in all cases engineers monitor factors such as pH levels, conductivity, total dissolved solids, chlorides, silicon, and microbial counts.

There is a broad quantitative spectrum of water usage, depending on local climates, rack densities and spacing inside a facility, facility architecture, and resource utilization levels. A hyperscale data center may use as much as 500,000 gallons per day, and it's not unusual to find reservoir tanks holding several million gallons of water. In North American facilities, water-cooling engineering can begin by knowing that with airflow, 0.3-0.35 gallons (1.1-1.3 liters) per minute of water will evaporate for every 1°F (0.56°C) of water temperature reduction at 100,000 CFM (2.83M CLM). A more general metric is to estimate 25.5 million liters of water per year per megawatt (not accounting for how much is reused).

The bottom line is that although the global data center footprint currently consumes less than 0.1% of the water that flows in a major waterway such as the Mississippi or Yangtze Rivers, the reality is that accessible water is a scarce, unevenly distributed resource. The United Nations Department of Economic and Social Affairs has found that almost 3 billion people live in areas of water scarcity or shortages. Programs to combat desertification and ensure secure food supplies have been implemented.

Meanwhile, projections of the world's data center footprint doubling in a few years add to overall stress and particular stress in many regions. The IDCA Digital Readiness Index and Digital Economy rankings do not directly account for this situation at the moment, but include it within overall human development factors within the Social category.

4.7 Strategy and Planning

When analyzing and working with the data contained within the Digital Readiness Index, there is never a single, simple answer to any question. There are indeed many nations that should prioritize the creation of new digital Infrastructure. Others may have a pronounced lack in a single area. Others have sufficient technology, but must address their social structures before having a chance to achieve further progress. As much as our approach is optimistic, it's clear that progress is highly unlikely to impossible in some nations, given their current conditions.

Building a Digital Economy requires a clear overall vision and specific, detailed plans to build out a robust ecosystem that involves governance, legal and ethical policy frameworks, education system, executable roadmaps, local as well as global alliances, national security, economic drivers and incentives, land and urban development, AI/ML, cloud, connectivity, and data centers.

All factors must be fully synchronized to create maximum synergy and optimum utilization of national resources and opportunities. Obtaining positive results does not require massive overhead and squadrons of inexperienced analysts, but rather the deep knowledge and passion of a highly specialized task force.

Digital Economies can be built – are being built – bit by bit, from projects to put a particular government service online, to bringing faster bandwidth speeds to local internet service, to fostering innovation, building and using new apps.

Creating a detailed roadmap involves a series digital infrastructure projects, educational and training programs, government incentives and initiatives, milestones, five-year goals, and expected outcomes. Progress is measured continuously and all roadmap projects and initiatives are coordinated to maintain steady job creation and socioeconomic progress.

In addition to overall goals, roadmaps can include programs to build out the use of IoT initiatives in public transportation and smart grids, contactless payment, advanced manufacturing processes, government eServices, and specialized FinTech apps built around the cultures and needs of people in their particular country.

4.8 Governance and Policy

The global economy appears strong enough to enable nations in all regions and throughout all income tiers to continue to develop their Digital Economies. Opportunities abound in all phases, whether a nation is in the Pre-Phase of a Digital Economy, is is in Early-Stage form, Emerging form, or already Highly Developed.

But to achieve true progress in developing a Digital Economy, IDCA's research and activities shows three essential steps to be taken:

1. Create sufficient digital infrastructure to support a Digital Economy, while being highly mindful of sustainability and energy challenges.

2. Educate and train people to develop a workforce equal to the challenges of the 21st century.

3. Leverage AI to create apps and services, while following a unique path through the phases of Digital Economy development.

This process can be part of a positive feedback loop, as ideas germinate and turn into apps and services, justifying the need for more data centers, networking, and devices, with the need for sufficient education and training remaining omnipresent.

A commitment to sustained, robust digital infrastructure growth delivers tangible benefits. IDCA Research has found that in developing nations, the countries in the top half of their regions and income tiers have seen economic growth 4.7 percent to 6.2 percent higher per year for the past 10 years than countries in the lower half of their groups.

Among developed nations, countries with digital infrastructure in the lower half of the Index rankings face development challenges between 35 percent and 50 percent on average more difficult – and costly – than those developed nations in the upper half.

Furthermore, the gap between the highest and lowest 20 percent across all categories is generally more than a magnitude larger than the average.

But In all cases, steady incremental improvement over the medium and long term achieves steady progress. Even though technology moves very quickly, the best way for any nation to keep up is to be consistent and dogged in pursuit of improving its Digital Economy and society.

4.9 Finance

The largest private equity (PE) companies in the world (eg Apollo, Blackrock, Blackstone, Carlyle, KKR) currently have about $14 trillion under management. There is an estimated $4 trillion in “dry” (unallocated) PE, and another, separate $3.2 trillion of private debt and real-estate investment. Seen from another angle, there has been between $1 trillion and $1.5 trillion of Foreign Direct Investment (FDI) each year throughout the world annually in recent years.

In contrast, the world’s total economy (GDP nominal) will reach about $111 trillion this year. Unallocated PE can thus be seen as representing a few percentage points of global GDP, with FDI representing about 1 percent of global GDP.

With this data as a backdrop, an IDCA analysis shows how much investment is required by each of the world’s developing nations to achieve substantial progress toward creating Digital Economies. This analysis does not presume investment in highly developed economies, even though these nations continue to strive to improve their economies within relatively low-risk investment environments. It’s also interesting to note that China, which sits between the categories of developing and developed, already produces a developed-world level of electricity.

The developing-world analysis must start with a look at each nation’s electricity grid. Digital infrastructure is then built upon that, and an overall Digital Economy built upon the digital infrastructure.

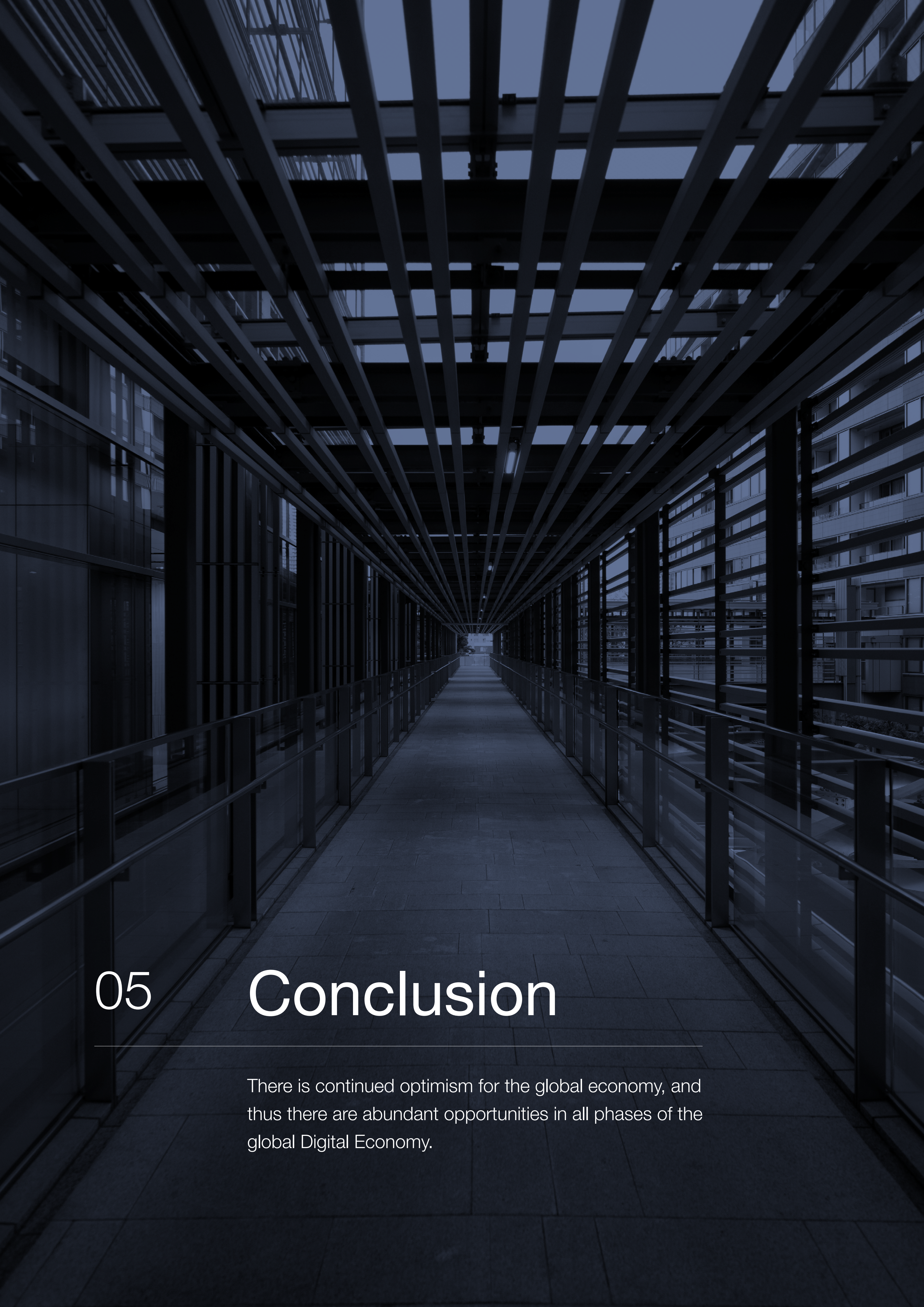
An effective way to examine the grids from a high level is to see how much power per-person (per capita) they provide to their populations.

Developing nations produce between 1 and 24 percent of the EU average (which IDCA uses as the developed-world standard). Looking at where each of these nations lies with respect to its current Digital Readiness Index ranking reveals that within the range of percentages, 25 percent and 40 percent of this standard provide two levels of development that can be considered substantial and significant.

Thus, looking at bringing the developing world’s electricity grids up to 25 percent of the standard involves an investment of about $600 million, with about $1.4 trillion required to achieve the 40-percent level. From that each nation would need to determine how much data center footprint it needs and wants. Looking at the 40-percent number, for example, shows an investment of about 1.2 percent of the annual global GDP. Spread over five years, this equals only about 0.2 percent of each year’s GDP. This number demonstrates that it would take a relatively small amount of investment to bring the developing world up to a substantially higher level.

Incidentally, the world’s other super-populated nation, India, currently produces 20% of the IDCA developed-world standard, so would require as much as 25% of the total investment of the developing world.

The overall number does not factor in inflation, delays, and how each nation’s respective bond rating may affect investments. Nor does it assume any specific nation’s economy will be equal to the task of consuming the new power that’s being generated. But it serves as a useful starting point from which to dive down into a nation’s needs and potential.



05 Conclusion

There is continued optimism for the global economy, and thus there are abundant opportunities in all phases of the global Digital Economy.

Conclusion

The global economy appears strong enough to enable nations in all regions and throughout all income tiers to continue to develop their Digital Economies. Opportunities abound in all phases, whether a nation is in the Pre-Phase of a Digital Economy, is in Early-Stage form, Substantially Developed form, or already Highly Developed.

But to achieve true progress in developing a Digital Economy, IDCA's research and activities shows three essential steps to be taken:

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