The Infrastructure Company Classification Standard (*TICCS®*)

2022 Edition – includes NACE & EU Taxonomy

EDHEC*infra*
Documentation

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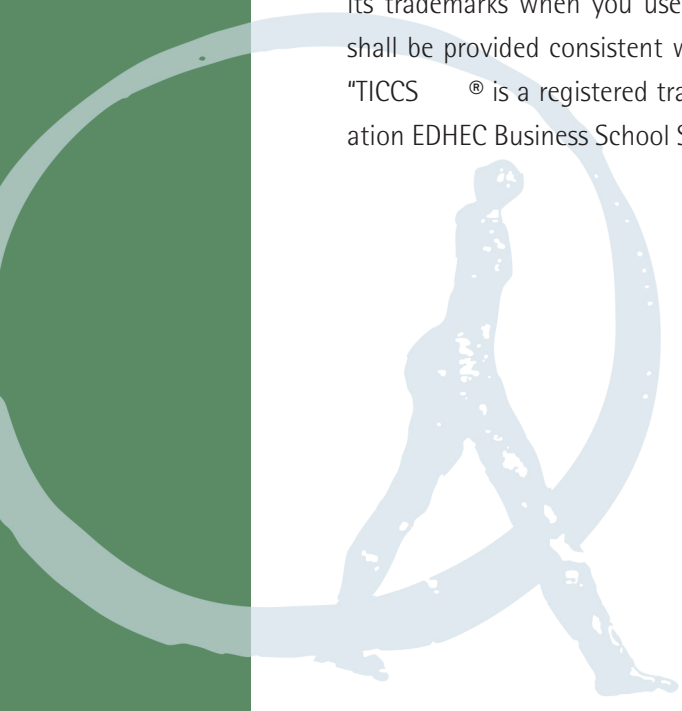


1. *TICCS*® Overview

*Private infrastructure investment is developing rapidly as a global asset class. This evolution requires a clear and robust classification of the individual infrastructure companies that equity investors can acquire or debt investors can lend to. The Global Infrastructure Company Classification Standard (TICCS®) was created by EDHEC*infra *to provide investors with a frame of reference to approach the infrastructure asset class. It offers an alternative to investment categories that were inherited from the private-equity and real-estate universe (e.g., "Core" vs. "Core+"), which may not be the most informative when trying to group infrastructure investments and design strategies or simply to document the structure of the sector. TICCS® is designed to be compatible with other standard investment-classification schemes, but it also uses fundamental insights from the academic literature to create a classification that embodies some of the key aspects of infrastructure businesses' risk profiles.*

What is *TICCS*®?

Any infrastructure investment ultimately corresponds to shares (or quasi-equity) invested in a company or debt instruments issued by a company (or borrower). The Infrastructure Company Classification Standard or *TICCS*® is a taxonomy designed to classify and organise data about equity and debt investments in infrastructure companies.

TICCS® is a class-based taxonomy: it consists of four pillars (business risk, industrial activity, geo-economic exposure and corporate structure) each of which is made of non-overlapping super-classes, classes and sub-classes of *pure* characteristics.

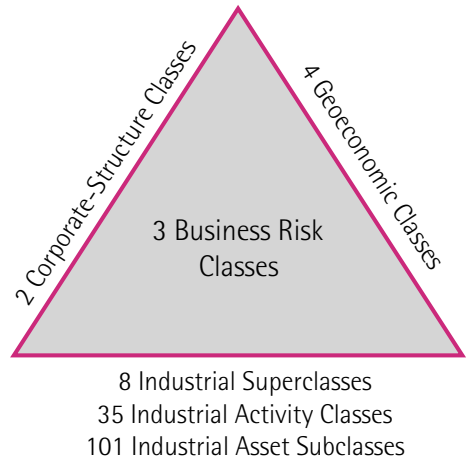
Real-life infrastructure companies *always* belong to each individual pillar and may also fall into *multiple* classes within each pillar e.g. an infrastructure project company may own both a water treatment plant and a power generation asset. This 'one-to-many' approach to classifying infrastructure companies allows keeping the *TICCS*® taxonomy pure, which was a recommendation of the TICCS Review Committee in January 2020, following the 2019 Market Consultation. In practice, if a company falls under multiple *TICCS*® categories within a pillar, users may assign weights to each class e.g. in the example above: 30% water, 70% power.

Some classes tend to be correlated across pillars. For instance, network utilities (IC80) tend to be corporates (CG02). *TICCS*® ignores such correlations but applying *TICCS*® allows documenting the structure of the investment universe empirically in terms of each pillar. Thus, the largest share of the investible market on the equity side is made of corporate utilities.

TICCS® is also about risk. However, *TICCS*® is not designed to discriminate between pure sources of systematic risks in infrastructure companies. Rather, as a taxonomy of infrastructure companies, *TICCS*® aims to be an exhaustive list of objective, real world, distinguishing characteristics i.e. a system to organise information about actual firms.

Each *TICCS*® pillar captures a different dimension of what makes infrastructure companies unique and relatively more homogenous. In that sense, the *TICCS*® pillars capture differences in aggregate risk profile that represent combina-

Figure 1: The 4 Dimensions of the TICCS® framework



tions of systematic risk factors, but these are not the object of the taxonomy.

TICCS®, A Standard for the Industry

TICCS® is a common classification standard that can be used by asset owners and managers, regulators, banks, and other investors across the various stages of the infrastructure-investment value chain, including consultants and researchers. It is designed to help investment and research professionals:

- take into account the evolution of the infrastructure-procurement landscape in space and time;
- compare sectoral- and business-risk exposures of investor portfolios with broad market benchmarks;
- document investable infrastructure markets;
- analyse the contribution of individual categories of companies to an infrastructure portfolio; and
- design consistent sector- and business-risk-driven investment strategies in infrastructure globally.

TICCS® Structure and Methodology

TICCS® is a four-pillar multi company-classification system designed to capture the characteristics of infrastructure investments. It consists of:

- 3 classes and 5 sub-classes of business risk;
- 8 industrial superclasses, corresponding to 35 industry classes of specific industrial activities and 101 industrial asset-level subclasses;
- 4 geoeconomic classifications; and
- 2 corporate structure classes with 4 subclasses

Companies are classified on the basis of individual qualitative and quantitative criteria, including their contractual and regulatory structure and environment; their source of revenues; and their type of industrial activity, including the complexity and level of uniqueness of the relevant infrastructure both from a construction and an operational perspective. Their financial and corporate structure is also taken into account.

Key Features of *TICCS®*

- **Robust**: *TICCS®* is built on the basis of academic research about the financial economics of infrastructure companies.
- **Global**: The range of categories available ensures that any private infrastructure company worldwide can be integrated into this framework, be it a regulated utility or a solar-project company.
- **Risk focused**: While *TICCS®* aims to categorise companies on the basis of their prima facie characteristics, it focuses on groupings that are

relevant to understanding risk and that play a role in asset pricing and portfolio construction.

- **Dynamic**: Infrastructure companies evolve over their lifecycles and with changes in national and sector regulation. The evolution of their characteristics plays an important role in infrastructure investment and can be reflected consistently and homogeneously over time.

The *TICCS*® Comparative Advantage

TICCS® is built in the context of the EDHEC*infra* database of private infrastructure investments, the largest of its kind, which tracks the financial performance of hundreds of infrastructure companies globally. Each national market included in the EDHEC*infra* universe is analysed in detail, including all the relevant aspects of infrastructure-procurement history and regulation in order to match this classification. *TICCS*™ is also reviewed regularly as new markets and companies are added to the EDHEC*infra* universe. The design of this universe is described in the **Index Methodology Standards** document available on the EDHEC*infra* website.

2. Defining Infrastructure

What is infrastructure?

Approaches to Defining Infrastructure

There are several ways to define what constitutes or is considered 'infrastructure'. The OECD proposes a broad definition encompassing the 'system of public works in a country, state or region, including roads, utility lines and public buildings'. However, this can be hard to operationalise. The World Bank proposes a limited list of 'essential' services (see appendix) that seems restrictive for the purpose of classifying all potential infrastructure investments globally. The OECD and World Bank approaches are rooted in public-policy considerations and focus on what infrastructure does, that is, service delivery.

For the purposes of classifying **investments** in infrastructure, a better approach focuses on what infrastructure 'is like'. This is the route taken by financial regulators in their effort to define **qualifying infrastructure assets** under various prudential frameworks. Criteria-based definitions of qualifying infrastructure companies exist under the Basel-II Accord, the Solvency-II Directive, and the CRR-2 Regulation of European banks (See appendix for details.)

These definitions focus on the financial economics of infrastructure companies and aim to identify criteria differentiating them from other types of corporate equity or debt investments, especially with respect to known or expected differences in their risk profiles.

The definition put forward by the European Insurance and Occupational Pension Authority (EIOPA) for Solvency-II stipulates that 'the infrastructure assets and infrastructure project entity are governed by a contractual framework that provides debt providers and equity investors with a high degree of protection'. EIOPA argues that 'the cash flows generated for debt providers and equity investors shall be considered predictable' and in particular that the revenues qualifying infrastructure investment should be either:

1. 'availability-based',
2. 'subject to a rate-of-return regulation'; or
3. 'subject to a take-or-pay contract' (see appendix).

Such prudential definitions aim to isolate what is expected to be a lower level of business and financial risk found in infrastructure companies.

The *TICCS*® View

TICCS® is not strictly speaking a definition of what is and what is not 'infrastructure' but a taxonomy designed to organise in an objective manner the constituents of the infrastructure investment universe.

To this end, *TICCS*® relies on a set of fundamental assumptions about what makes infrastructure companies different from other businesses. These assumptions are rooted in financial economics and academic insights into the nature of such investments.

In that sense, *TICCS*® is normative: it is not enough to be labelled 'infrastructure' or to be 'infrastructure-like' to quality under the taxonomy.

Instead a number of fundamental economic criteria have to be present for a company and its assets to be meaningfully designated as infrastructure:

- **Single-use investment**: infrastructure assets can be described as "relationship-specific" i.e. the investment required only makes sense in

the context of a 'relationship' – typically a contract, license or concession, which justifies the demand or usefulness of the investment.

- **Sunk or irreversible capital investment**: a relationship must exist for infrastructure investment to take place because the initial capital expenditure is 'sunk' i.e. irreversibly invested and unusable for any other purpose than the one originally intended.
- **Large size requiring a long repayment period**: not only are infrastructure investments sunk, they must be sizeable in absolute terms, making the repayment period necessarily long (multiple decades).
- **High operating leverage**: operating infrastructure at its design capacity implies highly predictable fixed (operating) costs and low variable costs, resulting in high operating leverage. In turn, investing in infrastructure requires a higher degree of certainty in future revenue streams, which underpins the requirement for long-term contracts, especially since infrastructure assets have little to no alternative uses.
- **Infrastructure as a service**: infrastructure companies have value because their assets provide a useful service to its users, the demand for which is the sole justification for the investment. Thus, despite consisting mainly of large tangible, immobile assets, the nature of infrastructure assets and the business of infrastructure companies is to provide a service.
- **Not a store of value**: it follows that, unlike other 'real' assets such as land, building, commodities or art, infrastructure investment cannot be considered as a store of value, infrastructure assets must be useful (and infrastructure companies provide a service) for them to have (social, economic and financial) value.

Assets and companies that can be categorized under *TICCS*® are expected to meet these fundamental criteria, all of which are the result of the long-term and durable nature of infrastructure assets and the companies that hold them and the commitment of their owners to only recoup the value of their investment over a long time period.

TICCS® takes these myriad perspectives into account and uses a four-pillar multi-criteria approach that uses a number of academic insights about the industrial nature as well as financial economics of infrastructure companies:

1. A **business-risk classification** takes into account the financial economics of infrastructure companies, in particular the role of contracts and regulation.
2. An **industrial classification** uses a very granular taxonomy of industrial activities, technologies, and asset-level characteristics that capture the potential diversity of infrastructure companies' services and products.
3. A **geoeconomic classification** captures the degree of common economic exposure of different infrastructure companies;
4. A **corporate structure classification** reflects the expected difference of behaviour between single-project and multiproject infrastructure ventures.

The rest of this document presents each pillar of the *TICCS*® classification in more detail.

3. Business-Risk Classifications

The first *TICCS*® pillar is the business-risk classification of infrastructure companies. Broad families of business-risk or business-model profiles can be identified on the basis of how stand-alone, investable infrastructure is created using different forms of long-term contracts. In turn, these families of infrastructure-business risk are fundamental drivers of the financial structure and total risk profile of infrastructure companies. *TICCS*® business-risk profiles are found across various industrial activities classifications (the second *TICCS*® pillar).

Academic Insights

While infrastructure assets are usually understood to be tangible assets–physical structures of steel and concrete–from the point of view of financial economics, infrastructure investment is better defined as a high-sunk-cost, long-term investment in immobile, relationship-specific assets. It is contracts, not concrete, that matter.

In other words, the physical characteristics of tangible infrastructure only determine the need for long-term contracts, which in turn determine the investment profile of infrastructure investments. Outside of contractual and regulatory relationships, tangible infrastructure assets have no or little value. This is what fundamentally differentiates infrastructure from other so-called real assets: infrastructure is never a store of value. It needs to be used to have value. And its usability is entirely determined by a combination of long-term contractual commitments.

The contracts that allow infrastructure investment to take place are characterised by risk-sharing mechanisms embodied by their revenue model. While numerous risk-sharing agreements can be envisaged, in practice, three types of contractual arrangements are used:

The first type are *contracted* or availability-payment schemes, by which a public- or private-sector client commits to paying a fixed income over a pre-agreed period, typically in excess of two decades. In exchange, the investor accepts more or less unlimited responsibility for the investment, operating, debt, and equity cash flows incurred to invest in the delivery of an infrastructure service, according to an agreed output specification. Terminal value can be set to zero and control of the physical assets is returned to public-sector clients at the end of the contract. This model is typically used to deliver social infrastructure projects like schools, hospitals, or government buildings. It is also common in the energy sector, including in renewable-energy projects, but it can also be found in a range of other sectors including transportation projects such as roads or port terminals.

The second type of arrangements are *merchant* or commercial schemes, by which the public- or private-sector client enters into a similar long-term contract with an investor but in exchange for a risky income stream. This is typically the case with tolled transportation projects, for which an investor is granted the right to collect tolls/tariffs from users. Likewise, terminal value is often zero in most jurisdictions. This model is typically used for transport projects with real tolls but also energy projects connected to a competitive power or gas market, as well as privatised airports or certain rail projects. Merchant telecom companies are also common.

Regulated schemes are typically associated with large network industries that benefit from a natural monopoly, such as water or gas utilities or power distribution networks. They require regulation in order to ensure efficient operations at a reasonable cost to end users, who are

Table 1: TICCS® Business-Risk Classification

Business-Risk Classes	Business-Risk Subclasses	
Code and Definition	*Code and Definition*	*Synonyms*
BR1 – Contracted: Contracted infrastructure firms enter into long-term contracts to pre-sell all or most of their output at a pre-agreed price. All or the majority of market risk (price and/or demand) is transferred to a third party. The contract is for a significant period of the investment's life, typically one or several decades.	**BR10 – Fully contracted income**: Fully contracted infrastructure firms enter into a long-term contract by which they will provide a service or product corresponding to the entirety of their activity. Hence they do not engage in any other activity during the life of the contract.	- Availability-based infrastructure or project - Take-or-pay off-take agreement - Capacity agreements - Tolling agreements - Large-scale generation certificates (LGCs) and small-scale technology certificates (STCs)
	BR11 – Partially contracted income: Partially contracted infrastructure firms commit to deliver a certain level of service or output below their full capacity level.	- Shadow tolling arrangements - Partial capacity agreements - Partial power purchase agreements - Feed-in tariff
BR2 – Merchant: Merchant infrastructure firms are mostly or fully exposed to market risk (price and demand risk).	**BR20 – Variable income**: Merchant infrastructure firms collect fees and tariffs from end users as a function of the effective demand for service.	- Real toll roads - Merchant power plants
BR3 – Regulated: The regulator can set allowable limits on tariffs, rate of returns, or revenues. Also referred to as "discretionary regulation."	**BR30 – Rate-of-return regulation**: The regulator is expected to set tariffs high enough to cover the costs of an efficient firm, including operating-expense depreciation and a reasonable return on invested capital.	- Cost-of-service regulation - Commission regulation (US)
	BR31 – Price-cap regulation: The regulator sets a multiyear price cap typically defined in terms of the rate of inflation minus an expected rate of productivity improvement. Firms can increase their profits by cutting costs between regulatory reviews, thus creating incentives for efficiency gains.	- Incentive regulation

typically captive and receiving "essential services" from the companies in question. Terminal value may not always be set to zero, for example, privatised utilities own tangible assets outright and in perpetuity. Regulators set tariffs to achieve multiple economic and financial objectives and often aim to mimic competitive market forces through so-called yardstick competition. Such schemes exist because of the universal tendency of monopolies to overcharge and underinvest (irrespective of public or private ownership). They also create up- and downside limits on business risk, which sets them apart from contracted and merchant infrastructure companies. For a detailed discussion of these three types of arrangements and of the related academic literature, see Blanc-Brude (2013). For a discussion of the role of contracts in infrastructure finance see Brealey et al. (1996). An empirical analysis of the difference of cost of capital and credit risk between contracted and merchant infrastructure business models is provided by Blanc-Brude and Strange (2007) and Blanc-Brude et al. (2018). For a detailed discussion of regulated infrastructure, see Gomez-Ibanez (2003).

The *TICCS*® Business-Risk Classification

Using the insights above, *TICCS*® includes three business-risk classes. Each business-risk class can be further divided into subclasses.

- BR1: Contracted infrastructure companies
  - BR10: fully contracted infrastructure companies
  - BR11: partially contracted infrastructure companies
- BR2: Merchant infrastructure companies
  - BR20: variable-income infrastructure companies
- BR3: Regulated infrastructure companies
  - BR30: Rate-of-return regulated infrastructure companies
  - BR31: Price-cap regulated infrastructure companies

Table 1 describes the *TICCS*® business-risk classification.

4. Industrial Classification

The second *TICCS*® pillar categorises infrastructure companies by groups of industrial activities. Industrial-sector group classifications (or superclasses) represent broad areas of industrial activity but also transaction or project-development expertise. Industrial sector and subsector classifications (or classes and subclasses) represent specific industrial activities and types of physical assets and technologies.

Academic Insights

Standard industrial classification can be ill-suited to represent different types of infrastructure companies. They focus on broad industrial activities only but do not take into account other aspects of the delivery of infrastructure projects and services. For instance, an airport operator and an airline-catering company are typically bundled together. Thus, under MSCI's Global Industrial Classification Standard, 'operators of airports and companies providing related services' are classified together.

Likewise, many road-operating companies are categorised as construction firms, while some project-financing vehicles are often found under 'financials.'

Instead, the activities of infrastructure companies can be seen as broad families of technical and financial skill sets that are relevant not only to creating and operating but also to investing in infrastructure companies.

Infrastructure investments also require highly specialised knowledge of various industrial processes, such as power generation or the construction and maintenance of major structures but also project management and financial structuring.

Transportation projects have common technical and industrial features, as do renewable-energy or social infrastructure projects, which correspond to broad groups of professionals that have the relevant know-how to understand and execute individual transactions.

For instance, stand-alone power generation facilities may use different fuel types and water-treatment companies may serve residential (potable water) or industrial clients (ultra-pure water). Wind power generation may be on-shore or off-shore. Such industrial activities can be sufficiently differentiated to warrant individual classifications. For example, different types of power-generation fuel (coal vs. gas vs. nuclear) have an impact on the level of regulatory risk taken by investors.

The *TICCS*® Industrial Classification

TICCS® uses a multicriteria classification system focusing specifically on infrastructure-related industrial activities, as well as varying degrees of complexity, size, and scale. Using the insights above, *TICCS*® includes the following industrial classes and subclasses:

- 8 industrial-group classifications (or superclasses)
- 35 industrial classes
- 101 industrial subclasses or asset-level categories

Table 2 describes the *TICCS*® industrial classification. Table 3 and Table 4 provide the corresponding definitions.

Table 2: TICCS® Industrial Classification

Industrial Superclass		Industrial Class		Industrial Asset Subclass	
Code	Name	Code	Name	Code	Name
IC10	Power Generation x-Renewables	IC1010	Independent Power Producers	IC101010	Nuclear Power Generation
				IC101020	Gas-Fired Power Generation
				IC101030	Coal-Fired Power Generation
				IC101040	Combined Heat and Power Generation
				IC101050	Other Fossil-Fuel-Fired Power Generation
		IC1020	Independent Water and Power Producers	IC102010	Power and Water Production
IC20	Environmental Services	IC2010	Waste Treatment	IC201010	Non-Hazardous Waste Treatment
				IC201020	Hazardous Waste Treatment
				IC201030	Waste-to-Power Generation
				IC201040	Waste incineration
				IC201050	Gaseous Waste Treatment
		IC2020	Water Supply and Treatment	IC202010	Potable Water Treatment
				IC202020	Industrial Water Treatment
				IC202030	Sea Water Desalination
				IC202040	Water Supply Dams
		IC2030	Wastewater Treatment	IC203010	Residential Wastewater Treatment and Reuse
				IC203020	Industrial Wastewater Treatment and Reuse
		IC2040	Environmental Management	IC204010	Flood Control
				IC204020	Coastal and Riverine Locks
				IC204030	Energy Efficiency
				IC204040	Carbon Capture
IC30	Social Infrastructure	IC3010	Defence Services	IC301010	Strategic Transport and Refuelling
				IC301020	Training Facilities
				IC301030	Barracks and Accommodation
		IC3020	Education Services	IC302010	Schools (Classes and Sports Facilities)
				IC302020	Universities (Classes, Labs, Administration Buildings)
				IC302030	Student Accommodation
		IC3030	Government Services	IC303010	Police Stations and Facilities
				IC303020	Courts of Justice
				IC303030	Prisons
				IC303040	Street Lighting
				IC303050	Social Accommodation
				IC303060	Government Buildings and Office Accommodation
		IC3040	Health and Social Care Services	IC304010	Hospitals
				IC304020	Clinics
				IC304030	Residential and Assisted Living
				IC304040	Crematorium
		IC3050	Recreational Facilities	IC305010	Stadiums and Sports Centres
				IC305020	Public Parks and Gardens
				IC305030	Convention and Exhibition Centres
				IC305040	Arts, Libraries, and Museums
IC40	Energy and Water Resources	IC4010	Natural Resources Transportation Companies	IC401010	Gas Pipeline
				IC401020	Oil Pipeline
				IC401030	Water Pipeline
				IC401040	Wastewater Pipeline
				IC401050	LNG Ships
		IC4020	Energy Resource Processing Companies	IC402010	Liquefied Natural Gas - Liquefaction
				IC402020	Liquefied Natural Gas - Regasification
				IC402030	Crude Oil Refinery
				IC402040	Bioethanol Fuel
		IC4030	Energy Resource Storage Companies	IC403010	Gas Storage
				IC403020	Liquid Storage
				IC403030	Other Storage
				IC403040	Floating Storage Units - FSU
IC50	Data Infrastructure	IC5010	Data Transmission	IC501010	Cell towers
				IC501020	Long-Distance Cables
				IC501030	Communication Satellites
				IC501040	Radio and media towers
		IC5020	Data Storage	IC502010	Data Centres
IC60	Transport	IC6010	Airport Companies	IC601010	Airport
		IC6020	Car Park Companies	IC602010	Car Park
		IC6030	Port Companies	IC603010	Tool Port
				IC603020	Bulk Goods Port
				IC603030	Container Port
				IC603040	Other Port
		IC6040	Rail Companies	IC604010	Heavy Rail Lines
				IC604020	High Speed Rail Lines
				IC604030	Freight Rail Rolling Stock
				IC604040	Passenger Rail Rolling Stock
		IC6050	Road Companies	IC605010	Motorways
				IC605020	Motorway Network
				IC605030	Dual-Carriage way roads
				IC605040	Stand-Alone Tunnels
				IC605050	Stand-Alone Bridges
		IC6060	Urban Commuter Companies	IC606010	Urban Light-Rail
				IC606020	Underground Mass Transit
				IC606030	Overground Mass Transit
				IC606040	Bus Transportation
IC70	Renewable Power	IC7010	Wind Power Generation	IC701010	On-Shore Wind Power Generation
				IC701020	Off-Shore Wind Power Generation
		IC7020	Solar Power Generation	IC702010	Photovoltaic Power Generation
				IC702020	Thermal Solar Power
		IC7030	Hydroelectric Power Generation	IC703010	Hydroelectric Dam Power Generation
				IC703020	Hydroelectric Run-of-River Power
				IC703030	Pumped Hydroelectric storage
		IC7040	Other Renewable Power Generation	IC704010	Biomass Power Generation
				IC704020	Geothermal Power Generation
				IC704030	Wave Power Generation
		IC7050	Other Renewable Technologies	IC705010	Battery storage
				IC705020	Off-Shore Transmission (OFTO)
				IC705030	Thermal storage
		IC7060	Hydrogen power generation	IC706010	Hydrogen-fired power generation
				IC706020	Hydrogen fuel cells
				IC706030	Hydrogen storage

Industrial Superclass		Industrial Class		Industrial Asset Subclass	
Code	Name	Code	Name	Code	Name
IC80	Network Utilities	IC8010	Electricity Distribution Companies	IC801010	Electricity Distribution Network
		IC8020	Electricity Transmission Companies	IC802010	Electricity Transmission Network
		IC8030	District Cooling/Heating Companies	IC803010	District Cooling/Heating Network
		IC8040	Water and Sewerage Companies	IC804010	Water and Sewerage Network
		IC8050	Gas Distribution Companies	IC805010	Gas Distribution Network
		IC8060	Data Distribution Companies	IC806010	Data Distribution Network
		IC8070	Smart Metering Companies	IC807010	Smart Metering Network

Table 3: TICCS® Industry-Classification Definitions

Industrial Superclass		Industrial Class	
Code	Definition	Code	Definition
IC10	Stand-alone power generation using a range of technologies except wind, solar, and other renewable sources.	IC1010	Independent power producers (IPP) provide electricity to power distribution and transmission companies or directly to industrial or commercial clients.
		IC1020	Independent water and power producers (IWPP) are power producers with a colocated water-desalination or filtration facility. Industrial, potable, or ultra-pure water is typically a by-product of the power generation process.
IC20	Companies involved in the treatment of water, wastewater, and solid waste for sanitation and reuse purposes.	IC2010	Waste treatment services include the collection and disposal of waste refuse from residential, commercial, or industrial sources.
		IC2020	Stand-alone water treatment companies produce water for various uses, including residential, commercial, and industrial end users.
		IC2030	Stand-alone wastewater treatment companies treat wastewater from residential, commercial, and industrial sources to a certain discharge or reuse standard.
		IC2040	Environmental management companies invest in projects that conserve natural resources, protect habitats, and control hazards.
IC30	Companies involved in the delivery of support and accommodation services for public or other services.	IC3010	Defence infrastructure companies provide noncombatant support services to public-sector military organisations, including strategic transport, training facilities, and telecommunications.
		IC3020	Infrastructure companies providing education services through the development and maintenance of school and university buildings and related facilities for the use of public or private institutions.
		IC3030	Infrastructure companies providing support and accommodation services to government departments and other public-sector organisations and agencies.
		IC3040	Healthcare infrastructure companies provide support service and facilities to public- or private-sector medical treatment units.
		IC3050	Convention, entertainment, and recreational facilities infrastructure companies deliver and maintain various large-scale leisure facilities typically requiring a bespoke structural-engineering component.
IC40	Companies involved in the treatment and delivery of natural resources.	IC4010	Natural Resources Transportation Companies develop and operate high-pressure transmission pipelines and natural resources transportation.
		IC4020	Energy natural resource processing companies transform crude oil, natural gas, and other commodities into various derivative or transformed products.
		IC4040	Energy natural resource storage companies provide storage services to private and public clients by exploiting large natural caverns or buildings and maintaining over- or underground tanks.
IC50	Companies involved in the provision of telecommunication and data infrastructure.	IC5010	Data transmission companies involved in the construction, operation, and maintenance of data transmission assets including telecommunications towers, land or sea based long-distance communication cables, and communication satellites.
		IC5020	Data storage companies involved in the development, operation, and maintenance of physical data storage infrastructure. This does not include companies that offer data storage in addition to other products.
IC60	Companies involved in the provision of transportation infrastructure services.	IC6010	Airport companies build, maintain, and operate airport terminals, runways, and associated support and logistical services. Large airports also lease property for commercial and retail purposes.
		IC6020	Car park service companies provide individual and commercial end users with vehicle-parking facilities. They are relatively small-scale structures built over- and underground mostly within large urban areas.
		IC6030	Port infrastructure companies build, maintain, and operate port jetties, passenger terminals, and freight transit and storage facilities.
		IC6040	Rail companies provide long-distance, intercity passenger and freight services.
		IC6050	Road companies build, maintain, and operate roads and motorways including bridges and tunnels.
		IC6060	Urban commuter companies build, maintain, and operate urban rail routes from light (tramway) to mass-transit rail tracks, including over- and underground rail lines.
IC70	Stand-alone power generation and transmission companies using wind, solar, hydro and other renewable energy sources. Also energy storage companies.	IC7010	Wind power companies produce electricity using wind power to operate various types of electromagnetic turbines.
		IC7020	Solar power companies produce electricity by capturing solar radiation using a range of solar-cell technologies.
		IC7030	Hydroelectric power generating companies use water to produce electricity. This can either be from a dam or from a river.
		IC7040	Other renewable power generation companies using various physical phenomena or alternative renewable fuels (other than the wind, sun, or hydro) to generate electricity.
		IC7050	Other renewables technology companies use a variety of different methods to provide, store and transmit renewable energy.
		IC7060	Hydrogen fired power generating companies that use hydrogen as a fuel. In which the fuel was produced through the electrolysis process. Further involves infrastructure in containing hydrogen through a common method of pressurized storage.

Industrial Superclass		Industrial Class	
Code	Definition	Code	Definition
IC80	Companies operating an infrastructure network with natural monopoly characteristics (barriers to entry, increasing returns to scale).	IC8010	Electricity distribution companies distribute medium-voltage electricity to final consumers.
		IC8020	Electricity transmission companies transmit relatively high-voltage electricity from the point of generation source to a distribution network.
		IC8030	Heating or cooling companies provide service in urban areas using combined heat and power to recycle or reuse waste heat.
		IC8040	Water and sewerage companies provide potable water treatment and distribution services as well as the collection, treatment, and disposal of wastewater and sewerage.
		IC8050	Gas distribution companies operate low-pressure pipeline networks delivering natural gas to end residential, commercial, and industrial consumers.
		IC8060	Data distribution companies involve in provision of essential data network especially to sectors of economy (e.g. financial systems, industrial supply chain, public utilities, etc) through utilisation of fiber networks, cell towers, data centers and other data infrastructure.
		IC8070	A metering system that monitors and records the utility consumption in a building or area. It usually consists of networked meters built together with sensors and controllers.

Table 4: TICCS® Industrial Asset Subclass-Classification Definitions

Industrial Asset Subclass		
Code	Name	Definition
IC101010	Nuclear Power Generation	Nuclear power plants heat water in producing steam using nuclear reactors combined with the Rankine cycle. It is a nuclear fission process whereby the steam is used to spin large turbines that generate electricity.
IC101020	Gas-Fired Power Generation	Gas-fired power plants that utilise Open-cycle gas turbine (OCGT) and Combined Cycle gas turbine (CCGT) technologies. OCGT plants burn natural gas to create a pressurised gas as the working fluid used to turn a turbine to extract energy in the form of electricity. While CCGT plants employ both gas turbine and steam turbines in combination to maximise electricity output where it uses the resulting waste heat from the gas turbine to produce steam to run the steam turbine.
IC101030	Coal-Fired Power Generation	Coal-fired plants where coal is pulverized and injected into a boiler and burned to produce steam that flows into a turbine that spins a generator to generate electricity.
IC101040	Combined Heat and Power Generation	Cogeneration power plant that concurrently generates electricity and thermal energy used for a district or industrial heating from a single fuel source.
IC101050	Other Fossil-Fuel-Fired Power Generation	Power plant where crude oil and gaseous fuels other than natural gas are used to generate electricity.
IC102010	Power and Water Production	Power producers with a co-located water-desalination or filtration facility. Industrial, potable, or ultra-pure water is typically a by-product of the power generation process.
IC201010	Non-Hazardous Waste Treatment	Waste treatment facilities that treat common residential, commercial and industrial waste that is considered non-hazardous in solid or non-solid states. The facilities include landfills, transfer stations, compost facilities, recyclers, and processors.
IC201020	Hazardous Waste Treatment	Waste treatment facilities that are meant for hazardous waste originating from residential, commercial or industrial sources whereby the treatment involves chemical, biological and physical methods. The facilities also have a safety containment system for temporary storage before landfill disposal.
IC201030	Waste-to-Power Generation	Power plants that burn solid waste at a high temperature to produce superheated steam that drives generators to produce electricity.
IC201040	Waste incineration	A plant that incinerates waste through a moving grate, rotary kiln, thermal oxidizers for gases, fumes, and liquid waste. The types of waste include residential, hazardous, medical, and many others. No electricity as by-product.
IC201050	Gaseous Waste Treatment	Waste treatment facilities that treat gaseous waste via thermal and dry or wet gas treatment.
IC202010	Potable Water Treatment	A water treatment facility that removes impurities in the raw water collected from a lake, reservoir or river to produce water that is consumable for humans. Water flows into the tank, where coagulation, flocculation, and clarification, followed by sedimentation, occur.
IC202020	Industrial Water Treatment	Industrial wastewater treatment is used to treat contaminated waters by industrial activities before it can be reused or release into the environment.
IC202030	Sea Water Desalination	A facility that removes salt and other elements from water in order to generate clean water. Typically, it separates water molecules from seawater using reverse osmosis technology.
IC202040	Water Supply Dams	A water dam is a structure built across a river or a stream used to supply water for agriculture, industrial uses and household uses.
IC203010	Residential Wastewater Treatment and Reuse	Residential wastewater treatment facility employed to reduce contamination level for reuse. Those include Constructed wetlands, biogas settlers, anaerobic baffled reactors, septic tanks, leach fields, evapo-transpiration beds, and surface or subsurface groundwater recharge.
IC203020	Industrial Wastewater Treatment and Reuse	Companies that employ Industries wastewater purification and recycle for reuse through methods such as sedimentation, aerobic biological treatment, oxidation ponds, biological nutrient removal and disinfection.
IC204010	Flood Control	Drainage infrastructure system to hold rainwater in order to prevent urban flooding. This includes temporary rainwater storage tanks and drains and canals. The flood control infrastructure also includes temporary flood barriers such as sheet-piling or raised embankments in flood-prone areas.
IC204020	Coastal and Riverine Locks	Lock systems that protect marine habitats, control connectivity between rivers and their tributaries and barriers that keep seawater out at the coastal for flood protection.
IC204030	Energy Efficiency	Energy efficient infrastructure that helps reduce energy demand, while improving energy efficiency and prioritizing emission reductions.
IC204040	Carbon Capture	Carbon capture facility refer to point-source carbon capture from the energy, industrial and manufacturing processes. The captured carbon is transported via pipeline to underground carbon dioxide storage in geological formations or reusing it for other purposes.
IC301010	Strategic Transport and Refuelling	Provision of defence services by a facility in strategic transport and refuelling aircraft.
IC301020	Training Facilities	Buildings, facilities and grounds that are used by defence forces for military training.
IC301030	Barracks and Accommodation	Army barracks and provision of defence living accommodation.
IC302010	Schools (Classes and Sports Facilities)	Buildings with facilities necessary for instructional for primary and secondary students and have the related supporting purposes including classrooms, libraries, cafeterias and physical sport spaces.
IC302020	Universities (Classes, Labs, Administration Buildings)	Buildings with facilities necessary for instructional for tertiary students and have the related supporting purposes including classrooms, libraries, cafeterias and physical sport spaces.
IC302030	Student Accommodation	Dormitories for students to live in, with residential quarters for large number of students.
IC303010	Police Stations and Facilities	Buildings with office spaces available to officers, detectives and administrative employees and has other related facilities, including cells for detainers.
IC303020	Courts of Justice	Buildings and facilities for provision of judicial system.
IC303030	Prisons	Secure confinement of people who have been convicted or charged with crimes and in removing them from free society.
IC303040	Street Lighting	Streetlights that provide source of light along public roads, back lanes and service roads.
IC303050	Social Accommodation	Public housing whereby it is meant for lower-income households to rent and acquire. It is usually set at a fairly low cost by organisations such as the local council.
IC303060	Government Buildings and Office Accommodation	Buildings used for governmental purposes and manage government agencies' office accommodation needs.
IC304010	Hospitals	A building that is used to house one or more wards with beds for inpatients and health facilities with medical equipment and device for nursing care, treatment to a patient, and other healthcare services.
IC304020	Clinics	A facility or hospital department where outpatients get medical treatment or consultation, from general medical care to specialist services.
IC304030	Residential and Assisted Living	Nursing homes for people who need daily care and primary provision of health and personal care services.
IC304040	Crematorium	A building with facilities including a cremation furnace and chamber.
IC305010	Stadiums and Sports Centres	It is a venue with a field or stage surrounded by tiers of seats that house a large scale of spectators for sports events, concerts or other events.
IC305020	Public Parks and Gardens	An area designed for active or passive public recreational use.
IC305030	Convention and Exhibition Centres	A large building with exhibition facilities and halls designed exclusively for convention and exhibition.

Industrial Asset Subclass		
Code	Name	Definition
IC305040	Arts, Libraries, and Museums	Buildings with collections of literature, history of arts and architecture and provision of services for visitors and students.
IC401010	Gas Pipeline	An infrastructure composed of pipes that transport extracted natural gas from the point where natural gas was extracted to the point where it was processed or delivered to the starting point of the distribution system.
IC401020	Oil Pipeline	Pipelines that move crude oil production from wells to central stations for further handling. It includes pipelines that deliver oil to larger transmission pipelines transporting their products to refineries and export facilities.
IC401030	Water Pipeline	An infrastructure of high-pressure and long-distance water conveyance pipelines used to move water to serve urban and agricultural users from major sources of water.
IC401040	Wastewater Pipeline	Pipelines that collect wastewater produced at production sites and pumps it at high pressure to remote storage or a disposal site.
IC401050	LNG Ships	Ship vessel equipped with containment systems carrying LNG in bulk. The system has heavy-insulated, temperature-controlled tanks that ensure the LNG is kept in a liquid state, enabling gas transportation between the liquefaction plant and the regasification site.
IC402010	Liquefied Natural Gas - Liquefaction	LNG facilities where the natural gas is processed and treated through the gas liquefaction cycle, before storage or transportation.
IC402020	Liquefied Natural Gas - Regasification	Facilities that convert the liquefied natural gas back to a gaseous state by using a heat exchanger with sea water as a heat medium to increase the heat of the natural gas to change it from liquid to a gaseous state.
IC402030	Crude Oil Refinery	An oil refinery is an industrial plant that transforms or refines crude oil into various usable petroleum products. The process involves distillation, cracking and reforming.
IC402040	Bioethanol fuel	A type of fuel that is derived from plant material. In most cases, this means that the fuel is made from corn or other types of grain. The plant material is fermented using a fermentation tank and then distilled to create the final product.
IC403010	Gas Storage	Natural gas is typically held underground in three types of reservoirs: depleted oil and gas fields, depleted aquifers, and in salt beds and salt caverns.
IC403020	Liquid Storage	Liquid terminals and above-ground storage tank facilities are interconnected with and used to store natural resources in liquid form.
IC403030	Other Storage	Storage facilities for natural resources other than liquid and gas.
IC403040	Floating Storage Units - FSU	Floating terminal with storage facilities for LNG.
IC501010	Cell towers	A short structure that houses equipment for transmitting and receiving radio signals between a cell phone and a network. The equipment at a cell tower site includes a tower, equipment shelter, generator, and battery backup.
IC501020	Long-Distance Cables	Long distance cables on land and subsea cables where fibre optic cables connect countries across the world via cables typically buried underground or laid on the seabed.
IC501030	Communication Satellites	Satellite companies own and operate individual or constellations of commercial or military satellites to serve various private- or public-sector clients.
IC501040	Radio and media towers	A tall structure usually have large antennas on top to enable the transmission of radio waves over long distances for television and radio stations.
IC502010	Data Centres	A dedicated physical facility that used by enterprises to store and share applications and data.
IC601010	Airport	Airport companies build, maintain, and operate airport terminals, runways, and associated support and logistical services. Large airports also lease property for commercial and retail purposes.
IC602010	Car Park	Building or space designated for parking. It can be in the form of attendant facility, metered facility, or operated by means of automatic parking gates.
IC603010	Tool Port	A port model where port infrastructure companies leases both the port infrastructure and superstructure assets from the authority and provides services to 3rd parties. The assets are owned, developed and maintained by the port authority.
IC603020	Bulk Goods Port	Industrial port that has all the facilities required for the storage and transhipment of bulk cargo.
IC603030	Container Port	It is a facility where cargo containers are transhipped between different types of transport vehicles - for example, container vessel to container trucks or trains.
IC603040	Other Port	Ports other than tool port, bulk goods port and container port.
IC604010	Heavy Rail Lines	Long-distance heavy rail tracks out to the suburbs or between the cities.
IC604020	High Speed Rail Lines	Long-distance tracks with dedicated electrification, grade separated from roads and other railroads that allow rail transportation to at higher speed than traditional rail traffic.
IC604030	Freight Rail Rolling Stock	Railway vehicles in both powered and unpowered vehicles usually in the form of rail freight locomotives and heavy-haul wagons.
IC604040	Passenger Rail Rolling Stock	Coaches that designed to carry passengers on a railway.
IC605010	Motorways	The motorway connects two or more important cities, and usually, the traffic is uninterrupted without traffic signals. It allows vehicles to travel at high speed, and it is common in two lanes per side of the road and has tollgates as motorways charge tolls.
IC605020	Motorway Network	A network of roads with inter-city features that have a number of lanes and connect different towns and cities with intersecting roads via traffic lights is a system of highways in any country.
IC605030	Dual-Carriage way roads	Divided highway which multiple lanes with traffic going in opposite direction.
IC605040	Stand-Alone Tunnels	Underground passageway purposed to connect passage under a mountain or river and divert traffic from congested urban areas.
IC605050	Stand-Alone Bridges	A structure spanning and providing passage over a gap or barrier, such as river or roadway. Types of bridges include arch bridge, beam bridge, girder bridge, cable stayed bridge and truss bridge.
IC606010	Urban Light-Rail	A system of tramway tracks and powered by overhead electrical wires and used for medium-capacity local transportation in metropolitan areas.
IC606020	Underground Mass Transit	Underground railway system within suburban areas.
IC606030	Overground Mass Transit	Overground railway system within suburban areas.
IC606040	Bus Transportation	A bus rapid transit system that runs within the metropolitan area. The infrastructure assets include stations, terminals and bus fleet.
IC701010	On-Shore Wind Power Generation	Onshore wind energy is generated by wind turbines that are located on land and use the wind occurring in terrestrial locations.
IC701020	Off-Shore Wind Power Generation	Offshore wind energy that relies on the power of the wind at sea, where it has greater speed and is more consistent due to the lack of barriers. Megastructures, seated atop the seabed and equipped with turbines, are utilized to harness this powerful resource.
IC702010	Photovoltaic Power Generation	Uses Photovoltaic (PV) panels that convert sunlight into electricity energy. A photovoltaic (PV) system is composed of one or more solar panels combined with an inverter, a mounting apparatus (Racking) and other electrical and mechanical hardware that use energy from the Sun to generate electricity.
IC702020	Thermal Solar Power	Solar thermal energy generation that collect and concentrate sunlight to produce the high temperature heat needed to generate electricity.
IC703010	Hydroelectric Dam Power Generation	Power station that has turbines relying on gravity flow of water from the dam to generate electricity.
IC703020	Hydroelectric Run-of-River Power	Power station that harness the energy from a flowing river to generate electricity.
IC703030	Pumped Hydroelectric storage	Hydroelectric energy storage facilities that store energy via interconnected reservoirs with one at a lower elevation.
IC704010	Biomass Power Generation	Power facilities that convert biomass waste, logging residue or agriculture to energy through processes of direct combustion to create heat in generating electricity.

Industrial Asset Subclass		
Code	Name	Definition
IC704020	Geothermal Power Generation	Power plants that uses geothermal energy to generate electricity via flash system, binary cycle system or dry steam system.
IC704030	Wave Power Generation	Facilities that generate electricity from harnessing the wave energy from oceans.
IC705010	Battery storage	Storage devices enable energy from renewables, like solar and wind, to be stored and released when the users require it.
IC705020	Off-Shore Transmission (OFTO)	Electrical transmission assets that connect offshore wind farms to the onshore electricity network.
IC705030	Thermal storage	Energy storage system that store thermal energy to be used later. It operates by means of heating or cooling a media such as water tank.
IC706010	Hydrogen-fired power generation	Power plants that generate electricity from the hydrogen fuel cells.
IC706020	Hydrogen fuel cells	Electricity from renewable sources will be fed into an electrolyser with water to make green hydrogen. Where the hydrogen fuel will be compressed, stored, and sold for use as a carbon-free fuel.
IC706030	Hydrogen storage	Storage facilities that store hydrogen in either gas or liquid forms through means such as salt caverns and pipe storage.
IC801010	Electricity Distribution Network	Distribution lines are low-voltage power lines that transport energy from substations to residences, businesses, and other end users. The lines are shorter and span less distance.
IC802010	Electricity Transmission Network	Transmission power lines connect power plants to substations at a high voltage. Transmission lines can transport electricity from one end of the country to the other using interstate connections.
IC803010	District Cooling/Heating Network	A heating network generates and distributes heat in the form of hot water and superheated steam using one or more generating units. While district cooling refers to a cooling network in a centralized system that provides chilled water to supply an air conditioning system.
IC804010	Water and Sewerage Network	Water is delivered to end consumers via a network of pipelines, mains, and pumping stations, and is stored in a system of urban water service reservoirs. While sewerage systems are made up of service branch lines from the end users, which feed into reticulation mains. The mains feed into pump stations and trunk sewers, which then lead to treatment plants.
IC805010	Gas Distribution Network	Gas distribution deals with the medium and low pressure gas mains that convey gas to end customers by a distribution utility.
IC806010	Data Distribution Network	Fibre-to-the-Home (FTTH) network whereby a network that connects telecom facilities with the end-users over optical fibre to provide communication signals.
IC807010	Smart metering network	Smart meter assets installed in the distribution grids to improve energy and gas management and reduce carbon emissions. And water meters in homes and businesses to measure water consumption and encourage water conservation.

5. Geoeconomic Classification

The third *TICCS*® pillar classifies infrastructure companies into four levels of geoeconomic exposure that are relevant to understanding potential correlations between investments. Business-risk families defined in the first *TICCS*® pillar capture the resemblance between infrastructure firms' business models, including how they may or may not covary as contracted or merchant companies. But an additional dimension is the exposure of each company to different geographic levels of the economy which they serve and on how to relate assets with one another. The latter considers the impact of an infrastructure business to other infrastructure companies, given the correlation in business risk.

Academic Insights

Infrastructure companies operate large immobile structures. Their position in space is a lifelong constant. However, the type of economic activity they are involved in can correspond to different economic factors, creating a multitude of possible interactions between infrastructure companies.

A first intuition is that two merchant toll roads can be expected to be less correlated if they are farther away from each other in space. This assumes that traffic variability is mostly determined by local economic conditions. However, the roads in question could be part of a regional transport corridor spanning hundreds or thousands of kilometres and thus exhibit a high level of revenue-risk dependency.

Likewise, two fully contracted (BR11) infrastructure companies can be expected to be relatively unrelated unless they have a similar or the same counterparty, e.g. the national government for a road concession in Spain (GE3).

Certain infrastructure companies are part of and exposed to the global economy. This includes large transportation hubs such as major airports and ports, which are not only exposed to the business cycle but, as a result of that, tend to be correlated with each other (see for example Choi et al., 2006; Lee, 2009).

Conversely, global and regional or national infrastructure companies can be less correlated with each other even though they may be relatively close in space and have similar business models. This is the case in the port sector, which can be divided into several categories of global container-shipping hubs; regional ports, which act partly as distribution networks of global port traffic; and national or subnational ports which cater to the local economy.

Certain infrastructure companies are also exposed to global commodity prices: gas pipelines or coal terminals, even when they have a contracted business model, face a highly correlated counterparty risk because commodity price movements can make their off-take contracts uneconomic or bankrupt their sole client (Bonetti et al., 2010).

In a global economic shock, global transport assets, including global airports, are more exposed to the impact than regional and subnational airports. Subnational airports only deal with traffic from local destinations, regional airports are mostly exposed to countries in that region. In contrast, global airport is a destination airport or a major transport hub servicing traffic from around the world.

The *TICCS*® Geoeconomic Classification

The EDHEC*infra* data-collection process includes recording the GIS data of infrastructure assets in

Table 5: TICCS® Geoeconomic Classification

Geoeconomic Classes		
Code and Name	*Definition*	*Examples*
GE1 – Global infrastructure companies	The relevant infrastructure is exposed to global economic factors, e.g., international airports, oil and gas pipelines, some ports, etc.	Major transportation hubs, projects exposed to global commodity prices.
GE2 – Regional infrastructure companies	The relevant infrastructure is exposed to a group of national economies, e.g., energy transmission between two or more countries, airports serving regional routes. A regional regulator or legal framework may also exist such as the European Union.	Medium-size container ports, transborder projects like transmission lines or certain road corridors.
GE3 – National infrastructure companies	The relevant infrastructure is exposed to the national economy, e.g., domestic airports and national electricity transmission assets, and is relevant to the national government or a national regulator.	Large-scale road or telecommunication networks, companies regulated by a national-level entity.
GE4 – Subnational infrastructure companies	The relevant infrastructure serves the local economy, e.g., schools and hospitals, and has subsovereign public clients or counterparts.	Municipal or other subsovereign-entity social infrastructure projects.

order to understand their exact positions in space. To qualify this information, and using the insights above, the third *TICCS*® pillar uses four classes of geoeconomic exposure to classify infrastructure companies:

- Subnational infrastructure companies
- National infrastructure companies
- Regional infrastructure companies
- Global infrastructure companies

Table 5 describes the *TICCS*® geoeconomic classification.

6. Corporate Structure Classifications

The fourth *TICCS*® pillar classifies the corporate structure of infrastructure companies into two classes and two subclasses. The behaviour of a firm and its managers differs depending on if it was created to develop a single project or multiple projects. Furthermore, the level of external debt financing impacts the behaviour of a firm as well. External debt financing creates a demand for monitoring on the part of creditors, especially with single-project firms. External monitoring impacts the predictability of behaviour of the firm and its managers.

Academic Insights

Infrastructure companies typically take one of two corporate forms: "projects" or "corporates." Infrastructure project companies are single-project firms or project-financed. Infrastructure corporates are multiproject companies more akin to corporate structures found in other industrial sectors. These two types of firms can be expected to have fundamentally different behaviours.

Infrastructure project companies are created in the context of a long-term contract between an investor (the owner of the project company) and a public- or private-sector client. Project companies are created for the sole purpose of delivering a new tangible infrastructure asset and operating it for the length of the contractual period. Infrastructure project companies are also referred to as special-purpose vehicles (SPVs) or special-purpose entities (SPEs). They typically serve as the focal point of a nexus of contracts between investors, builders, operators, a client, and providers of long-term finance, usually in the form of long-term senior debt. The formal definition of project financing put forward in the Basel-II Accord is reproduced in the appendix.

Debt plays a significant role in project finance because it tends to be the main source of capital. The theoretical literature on project finance and corporate Structure (see for example Shah and Thakor, 1987) highlights the role of leverage as one of the most counterintuitive dimensions of project financing. Project financing reduces the net financing costs associated with large capital projects (Esty, 2004) because external debt plays an important disciplinary role by preventing managers from wasting or misallocating free cash flows and deterring related parties, including the public sector, from trying to appropriate them (Jensen and Meckling, 1976; Hart, 1995).

Because leverage mitigates these costly incentive conflicts among capital providers, managers, and investors, it increases expected cash flows available to capital providers, thereby establishing a link between financing structure and asset values. In this context, the presence of significant loan financing is a signal of creditworthiness (Fama and French, 1997).

Indeed, infrastructure assets have few growth options, which hinders overinvesting in negative-NPV projects and makes investment decisions more easily monitored by external claim holders. When raising financing, infrastructure project companies typically commit to a given capital program and are not able to seek other sources of financing without the explicit involvement of their original creditors. In the event of various credit events, senior creditors have control rights akin to those of majority shareholders and can require a financial restructuring or even take over the company from its original owners.

The empirical literature on infrastructure project finance (Brealey et al., 1996; Esty, 2002; Blanc-Brude and Strange, 2007; Blanc-Brude et al.,

Table 6: TICCS® Corporate-Structure Classification

Corporate-Structure Classes	Corporate-Structure Subclasses	
Code and Definition	*Code and Definition*	*Synonyms*
CS1 – Infrastructure project companies: Companies according to the Basel-II definition of project finance created for the sole purpose of building and operating a well-defined tangible infrastructure asset limited in time and space.	**CS10 – With creditor oversight project companies**: Infrastructure project companies with presence of external senior debt.	- Special-purpose vehicle - Special-purpose entity - Single-project company
	CS11 – Without creditor oversight project companies: Infrastructure project companies without presence of external senior debt.	
CS2 – Infrastructure corporates		- Multiproject company

2018), shows that project financing typically relies on high levels of nonrecourse external debt financing (typically between 60 and 90%) and concludes repeatedly that project finance loans have different characteristics from corporate debt. In corporate finance, debt can be used to increase returns on equity, creating incentives to take risks. In project finance, because the financial viability of a single project has to be demonstrable ex ante with a high probability, debt is used to minimise the cost of capital and creates incentives to minimise risk.

In contrast, infrastructure "corporates" or multiproject companies have all the usual characteristics of the firm: managers have more freedom to make various investment decisions and can change course both strategically and financially over time. They can take on new projects, including those in sectors that are not directly related to infrastructure (e.g., utilities investing in media companies) or invest internationally in other infrastructure firms (e.g., European utilities invested in Asian utilities in the mid-1990s), thereby changing their business-risk profile.

Likewise, infrastructure corporates are free to change their financial structures and can use multiple sources of private and public financing. Creditors play a much more limited monitoring role and do not have different control rights in the event of default than with other corporate borrowers. Nor do they play a leading role in the financial structuring of the firm either before or after credit events.

As a result, high or increasing levels of indebtedness in infrastructure corporates is typically interpreted as signalling higher credit and equity risk. UK water utilities are a case in point (see Helm, 2009).

The *TICCS*® Corporate-Structure Classification

Single-project infrastructure companies can be found in any of the industrial classifications identified in the *TICCS*® second pillar, in particular social infrastructure, road, and conventional or renewable power generation projects. Infrastructure corporates or multiproject companies tend to be found in the utilities sector and in some transportation sectors (ports and airports), where they have often existed for several decades. Regulated infrastructure companies defined in the first *TICCS*® pillar also tend to be infrastructure corporates. In principle however, the *TICCS*® corporate-structure classifications are not exclusive of any of the other classes defined in the other three pillars.

As noted above, external debt financing creates monitoring mechanisms that can be expected to have a significant impact on the behaviour of managers and and the predictability of the firm's activities and risk profile.

As asset owners and managers become the new owners of infrastructure project companies, they sometimes reimburse senior creditors early (prepayment) and replace external senior debt instruments with shareholder-provided debt or

refinance project debt at the portfolio or group level (e.g., holdco).

Such decisions can lower the cost of external financing, but they also remove the project-level monitoring function of external creditors that is so characteristic of single-project infrastructure companies and has contributed to its historic performance track record.

Using these insights, the *TICCS*® fourth pillar includes two classes of corporate structure and two subclasses. We differentiate between subclasses of "monitored" and "unmonitored" companies as shown.

- CS1: Infrastructure projects
  - CS10: Infrastructure project companies with presence of external senior debt.
  - CS11: Infrastructure project companies without presence of external senior debt.
- CS2: Infrastructure corporates

Table 6 describes the *TICCS*® corporate-structure classification.

7. Implementation Guidelines

Pillar 1 – Business Risk

Business risk classifications pertain to the business model of infrastructure companies and thus focus on the nature of their revenue stream, and not on other types of cash flows (e.g. costs). Business risk classifications are dynamic i.e. they can change over time as a company's business model evolves. This classification is assessed on an ongoing basis for companies included in the EDHEC*infra* universe.

Defining 'Contracted' infrastructure companies (BR1)

1. A minimum of 50% to 70% of revenues should be contracted for a material period of time going forward from the data of evaluation
2. The contracted period is considered material if it represents between 50% and 75% of the remaining asset life.

Hence the two-by-two matrix as described within Table 7.

These guidelines are to be applied on a case by case basis. For example, a company that enters into relatively short-term contracts but that are expected to renew automatically with a degree of certainty can be considered Fully Contracted if this pattern is expected to continue for the rest of the firm's life. Conversely, a company that corresponds to a 50-year asset (say, a bridge) with a 25-year revenue contract that is not expected to be renewed would be considered Partially Contracted.

Contracted revenues may be linked to an index. This is considered an attribute of the company's business risk classification but not a category in itself. As a result, *TICCS®* does not distinguish between contracted revenues that are index-linked and contracted revenues that are not.

Defining 'Merchant' infrastructure companies (BR2)

1. The company's business is not regulated in the sense of the BR3 class (see below).
2. Less than 50% of the company's revenues are contracted for less than 50% of the remaining asset life (see above).

Defining 'Regulated' infrastructure companies (BR3)

1. The business is regulated by a third party (which may or may not be independent from the local or central government).
2. Regulation pertains to the business model of the firm e.g. tariffs, capex, return on capital, but not to other regulated aspects of business activities e.g. health and safety, which are not specific to infrastructure.

Pillar 2 – Industrial Activities and Assets

Defining Industrial Activities

The classification of any firm under this pillar should *always start at the asset subclass level*. The remaining classifications (Industrial activity classes and super-classes) simply flow from the Asset sub-class level.

While infrastructure companies tend to own only one type of industrial asset, even a single asset, some companies can have multiple types of assets e.g. a power generation unit and a water treatment plant. In this case, the firm in question may be categorized in multiple industrial activity classes or super-classes.

Table 7: TICCS® Business-Risk Classification Selection Rules

		Share of Revenues Contracted	
		50%	*70%*
Share of Remaining Life	*75%*	Partially Contracted **(BR11)**	Fully Contracted **(BR10)**
	50%	Not Contracted	Partially Contracted **(BR11)**

Identifying Industrial Assets

TICCS® includes a detailed definition of each type of industrial asset considered under the second pillar.

Minimum investment size

Because infrastructure assets are understood to represent a sizeable investment requiring a long-term repayment period, a minimum cumulative capital expenditure of USD50m (in 2005 dollars) is added as a filter in the EDHEC*infra* universe.

Pillar 3 – Geo-economic Classification

The *TICCS®* Geo-economic classification aims to capture how any infrastructure company may be impacted by the business of other infrastructure companies (correlation in business risk). Two infrastructure companies may be very far apart in space but very closely related business-wise, and vice-versa.

This is in part related to the firm's business model:

- Any fully contracted company (BR11) would be exposed at the level of the contract counterparty e.g. the national government for a road concession in France (GE3), a subnational entity for a Hospital PFI in the UK (GE4).
- A partially contracted company (BR12) can be exposed to two different levels of geo-economic risk e.g. an LNG terminal with a national off-taker (GE3) and a spot market exposure (GE1)
- Merchant companies (BR2) are the most exposed to geo-economic risks
  - Companies in the Transport (IC60) and Data (IC50) industrial classes like large airports and ports and cable companies are exposed to the global economy (GE1)
  - Certain toll roads or ports and airports are exposed to regional economic fluctuations (GE2)
  - Most merchant infrastructure is linked to the national or subnational (e.g. ring road) economy.
- Regulated companies (BR3) are exposed to their regulator, which is typically a national entity (GE3) but not necessarily.

Pillar 4 – Corporate Structure

The distinction between projects and corporates aims to capture expected differences of behavior between firms. These differences are primarily driven by the purpose for which the firm was created and the balance between the control rights of equity owners and those of external creditors.

Defining Infrastructure 'Project Companies' (CS1)

Single-project vehicles (SPVs) or companies are identified thus:

1. The company was created (or activated) for the purpose of holding an infrastructure asset or assets in the context of a single contract or tender;
2. Its financing was raised for the sole purpose of developing and operating this or these assets;
3. External financiers (when they are present) have significant control rights including contingent control rights (step-in rights);
4. Its business model has finite life (expected end date) tied to the asset or contract life.

Projects may or may not be exposed to significant creditor oversight. The difference between the CS10 and the CS11 classification is deter-

mined by the presence of external senior debt in the capital structure.

A collection or portfolio of single-project companies continues to be a collection of individual projects and does not become a corporate entity.

Defining Infrastructure 'Corporates' (CS2)

Infrastructure Corporates are companies that do not meet the criteria to be classified under CS1. They are typically part of a larger group of companies and benefit from financial and revenue support from this group.

Choice of corporate entity

The corporate entity to be considered should be the one that best represents the infrastructure business as a whole. In other words, *TICCS®* does not determine whether the *HoldCo*, *BidCo* or *ProjCo* should be considered. This is a matter of judgement to be exercised on a case-by-case basis, depending on the nature of these corporate structures. For example, if the *HoldCo* carries most of the debt related to the underlying investment (e.g. Heathrow) then it would be considered the most relevant level for the purpose of identifying or classifying infrastructure investments.

8. Sustainability: NACE and EU taxonomy

There are several popular taxonomies used to identify and categorise the environmental credentials of business entities and activities. These all aim to measure how business and investment practices contribute – positively or negatively – to the process of climate change. In this document, we look at harmonising three of these taxonomies, namely the EU taxonomy and NACE, with EDHECinfra's own *TICCS*® classification system, and identifying a clear mapping across each of the three pairs.

- By considering the **EU taxonomy** together with *TICCS*®, analysts can identify the environmental sustainability of infrastructure investment. Combining the two taxonomies reveals the extent to which infrastructure assets contribute to the European Environmental objectives.
- We also consider how the European industry classification system **NACE** alongside *TICCS*®. Our mapping aligns relevant economic activities identified by NACE to the *TICCS*® infrastructure activities at the subsector level. The economic activities of the EU taxonomy are themselves derived using NACE as the basis, but use only those activities relevant only to its environmental objectives. Consequently, its categories do not correspond directly to those activities found in NACE. As a result, some activities listed in the EU taxonomy do not have a NACE code equivalent, while others cover multiple codes.

The following sections set out the steps taken in applying NACE and EU taxonomy to the *TICCS*® industry pillar.

TICCS® to NACE

Initially, we have reviewed and created a shortlist of relevant NACE codes that are deemed to be infrastructure activities. We considered the principal activities and underlying assets of each *TICCS*® code and mapped them to themes that align with the relevant NACE code following the list. In addition, we identified NACE codes that were in fact infrastructure specific but omitted from our initial mapping and added these to the mapping. In those instances where we found no direct map of an asset TICCS subclass to a NACE code, we instead mapped it to the "closest" NACE group instead. For example, The *TICCS*® subclass **Public Parks and Gardens** (IC305020) is mapped to the NACE group **Botanical and zoological gardens and nature reserves activities** (R91.04).

Several assumptions were made during the mapping exercise:

- **Trade of electricity** (NACE 35.14) is tagged to *TICCS*® subclasses under the umbrella of IC10 **Power Generation x-Renewables** and IC70 **Renewable power**, given that their business activities involve the sale of electricity.

Asset Code	Industrial Asset Subclass	Nace Code
IC101010	Nuclear Power Generation	D35.14
IC101020	Gas-Fired Power Generation	D35.14
IC101030	Coal-Fired Power Generation	D35.14
IC101040	Combined Heat and Power Generation	D35.14
IC101050	Other Fossil-Fuel-Fired Power Generation	D35.14
IC102010	Power and Water Production	D35.14
IC701010	On-Shore Wind Power Generation	D35.14
IC701020	Off-Shore Wind Power Generation	D35.14
IC702010	Photovoltaic Power Generation	D35.14
IC702020	Thermal Solar Power	D35.14
IC703010	Hydroelectric Dam Power Generation	D35.14
IC703020	Hydroelectric Run-of-River Power	D35.14
IC704010	Biomass Power Generation	D35.14
IC704020	Geothermal Power Generation	D35.14
IC704030	Wave Power Generation	D35.14

- **Installation of industrial machinery and equipment** (NACE 33.20) is mapped to *TICCS*® subclasses that require unique, specialised machinery to operate. For instance, it is mapped to all assets in IC20 **Environmental Services**, including IC204010 **Flood Control** which involves a drainage infrastructure system to hold rainwater to prevent urban flooding.

Asset Code	Industrial Asset Subclass	Nace Code
IC201010	Non-Hazardous Waste Treatment	D33.20
IC201020	Hazardous Waste Treatment	D33.20
IC201030	Waste-to-Power Generation	D33.20
IC201040	Waste incineration	D33.20
IC201050	Gaseous Waste Treatment	D33.20
IC202010	Potable Water Treatment	D33.20
IC202020	Industrial Water Treatment	D33.20
IC202030	Sea Water Desalination	D33.20
IC202040	Water Supply Dams	D33.20
IC203010	Residential Wastewater Treatment and Reuse	D33.20
IC203020	Industrial Wastewater Treatment and Reuse	D33.20
IC204010	Flood Control	D33.20
IC204020	Coastal and Riverine Locks	D33.20
IC204030	Energy Efficiency	D33.20
IC204040	Carbon Capture	D33.20

- For **Construction of residential and non-residential buildings** (NACE 41.20), we follow the definition of a building in the NACE guidelines. In that respect, we only include standalone "buildings" here and not buildings within facilities. For example, an office building in a nuclear power plant is not mapped to this code. Greenfield projects were considered in this mapping.

Asset Code	Industrial Asset Subclass	Nace Code
IC301030	Barracks and Accommodation	D41.20
IC302010	Schools	D41.20
IC302020	Universities	D41.20
IC302030	Student Accommodation	D41.20
IC303050	Social Accommodation	D41.20
IC303060	Government Buildings and Accommodation	D41.20
IC304010	Hospitals	D41.20
IC304020	Clinics	D41.20
IC304030	Residential and Assisted Living	D41.20
IC305010	Stadiums and Sports Centres	D41.20
IC601010	Airport	D41.20
IC602010	Car Park	D41.20

- The exercise ignores **Specialised construction activities** (NACE 43.00) and **Specialised consultancy services** (NACE 71.00). In principle, these activities should be mapped to all *TICCS*® asset subclasses, but these are excluded to allow proper analysis and comparison by market participants when using the taxonomies.

We consider as many relevant NACE codes as possible in our mapping of *TICCS*® to NACE at the granular level, including those of construction activities, renting equipment and construction of buildings where necessary.

TICCS® to EU taxonomy

First, we examine the list of activities relevant for each objective of the EU taxonomy which was taken from the EU Taxonomy Compass (European Commission, 2021).

Two out of six environmental objectives of EU taxonomy are currently defined, but the EU taxonomy regulation foresees additional objectives to be defined in the future.

The EU taxonomy regulation defines the two objectives investments must achieve in order to be labelled as sustainable: **Climate change mitigation** and **Climate change adaptation**. These objectives cover broadly the same activities with some differences, as a result, which led us to tag additional items for climate change adaptation.

Asset Code	Industrial Asset Subclass	Climate *Mitigation*	Climate *Adaptation*
IC302010	Schools	*Not avail.*	CA7.2
IC302020	Universities	*Not avail.*	CA7.2
IC304040	Residential and Assisted Living	*Not avail.*	CA7.2
IC305030	Convention and Exhibition Centres	*Not avail.*	CA13.1
IC305040	Arts, Libraries, and Museums	*Not avail.*	CA13.2

Each activity defined in the EU Taxonomy will have a corresponding NACE code and thus a corresponding *TICCS*® code.

Much like the approach we adopted in TICCS to NACE mapping, only relevant infrastructure activities are considered.

The Taxonomy Compass assigns NACE codes to activities. This code assignment is not strictly followed in our mapping exercise since we need to be as granular as possible.

During the mapping process, several assumptions were made:

The EU taxonomy activities are tagged to the infrastructure that enables them. **Roads** are

tagged to **Vehicles** (i.e. taxi, bus, land transport vehicles) while **Taxi operation** (NACE 49.32) and **Other passenger land transport n.e.c.** (NACE 49.39) are mapped to **Road companies** (IC6050). Similarly, **Ships** are tagged to **Ports and Aircraft** to **Airports**. This is partly done to enable Scope 3 assessment.

- Activity 6.7 **Inland passenger water transport** is not tagged to Ports because these appear to be smaller docks and ferry terminals.
- Activity 7.3 **Installation, maintenance, and repair of energy efficiency** equipment is ignored because it is not considered essential for infrastructure.
- Activity 4.17 through 4.25, where heat/cooling is generated within other renewable projects such as solar etc., are tagged to the individual renewable technologies in TICCS and an additional NACE code D35.30 **Steam and air conditioning supply** is tagged to the corresponding TICCS code.

Asset Code	Industrial Asset Subclass	Climate Mitigation	Climate Adaptation
IC702010	Photovoltaic Power Generation	CM4.21	CA4.21
IC702020	Thermal Solar Power	CM4.21	CA4.21
IC704010	Biomass Power Generation	CM4.24	CA4.24
IC704020	Geothermal Power Generation	CM4.22	CA4.22
IC803010	District Cooling/ Heating Network	CM4.22	CA4.22

Appendix: Accepted Definitions of Infrastructure

OECD Definition of Infrastructure

Infrastructure: "The system of public works in a country, state or region, including roads, utility lines and public buildings."

Source: https://stats.oecd.org/glossary/detail.asp?ID=4511

World Bank Definition of Infrastructure

- "Electricity - generation, transmission, and distribution
- Natural gas - transmission and distribution
- ICT - ICT backbone like hard infrastructure cable assets (such as fiber optic networks and other types of broadband networks) where the government is involved either through being a contracting authority (i.e. a party to a concession agreement), the owner of the assets, or some other form of government support.
- Airports - runway and terminal
- Ports - channel dredging and terminal
- Railways - fixed assets, freight, local passenger/light rail, and regional passenger
- Roads - bridge, highway, and tunnel
- Treatment plant - potable and sewerage treatment plants
- Utilities - water utilities with and without sewerage service, sewerage collection and treatment"

Source: https://ppi.worldbank.org/methodology/glossary

Basel-II Definition of Project Finance

"Project finance is a method of funding in which investors look primarily to the revenues generated by a single project, both as the source of repayment and as security for the exposure. In such transactions, investors are usually paid solely or almost exclusively out of the money generated by the contracts for the facility's output, such as the electricity sold by a power plant. The borrower is usually a Special Purpose Entity (SPE) that is not permitted to perform any function other than developing, owning, and operating the installation. The consequence is that repayment depends primarily on the project's cash flow and on the collateral value of the project's assets." (BIS 2005)

Solvency-II Definition of Qualifying Infrastructure

1. For the purposes of this Regulation, qualifying infrastructure investment shall include investment in an infrastructure project entity that meets the following criteria:
   (a) the infrastructure project entity can meet its financial obligations under sustained stresses that are relevant for the risk of the project;
   (b) the cash flows that the infrastructure project entity generates for debt providers and equity investors are predictable;

(c) the infrastructure assets and infrastructure project entity are governed by a contractual framework that provides debt providers and equity investors with a high degree of protection including the following:

(a) where the revenues of the infrastructure project entity are not funded by payments from a large number of users, the contractual framework shall include provisions that effectively protect debt providers and equity investors against losses resulting from the termination of the project by the party which agrees to purchase the goods or services provided by the infrastructure project entity;

(b) the infrastructure project entity has sufficient reserve funds or other financial arrangements to cover the contingency funding and working capital requirements of the project;

- Where investments are in bonds or loans, this contractual framework shall also include the following:

(i) debt providers have security to the extent permitted by applicable law in all assets and contracts necessary to operate the project;

(ii) equity is pledged to debt providers such that they are able to take control of the infrastructure project entity prior to default;

(iii) the use of net operating cash flows after mandatory payments from the project for purposes other than servicing debt obligations is restricted;

(iv) contractual restrictions on the ability of the infrastructure project entity to perform activities that may be detrimental to debt providers, including that new debt cannot be issued without the consent of existing debt providers;

(d) where investments are in bonds or loans, the insurance or reinsurance undertaking can demonstrate to the supervisor that it is able to hold the investment to maturity;

(e) where investments are in bonds for which a credit assessment by a nominated ECAI is not available, the investment instrument is senior to all other claims other than statutory claims and claims from derivatives counterparties;

(f) where investments are in equities, or bonds or loans for which a credit assessment by a nominated ECAI is not available, the following criteria are met:

(i) the infrastructure assets and infrastructure project entity are located in the EEA or in the OECD;

(ii) where the infrastructure project entity is in the construction phase the following criteria shall be fulfilled by the equity investor, or where there is more than one equity investor, the following criteria shall be fulfilled by a group of equity investors as a whole:
- the equity investors have a history of successfully overseeing infrastructure projects and the relevant expertise; - the equity investors have a low risk of default, or there is a low risk of material losses for the infrastructure project entity as a result of the their default; - the equity investors are incentivised to protect the interests of investors;

(iii) the infrastructure project entity has established safeguards to ensure completion of the project according to the agreed specification, budget or completion date;

(iv) where operating risks are material, they are properly managed;

(v) the infrastructure project entity uses tested technology and design;

(vi) the capital structure of the infrastructure project entity allows it to service its debt;

(vii) the refinancing risk for the infrastructure project entity is low;

(viii) the infrastructure project entity uses derivatives only for risk-mitigation purposes.

2. For the purposes of paragraph 1(b), the cash flows generated for debt providers and equity investors shall not be considered predictable unless all except an immaterial part of the revenues satisfies the following conditions:

(a) one of the following criteria is met:

(i) the revenues are availability-based;

(ii) the revenues are subject to a rate-of-return regulation;

(iii) the revenues are subject to a take-or-pay contract;

(iv) the level of output or the usage and the price shall independently meet one of the following criteria:

- ✓ it is regulated;
- ✓ it is contractually fixed;
- ✓ it is sufficiently predictable as a result of low demand risk;

(b) where the revenues of the infrastructure project entity are not funded by payments from a large number of users, the party which agrees to purchase the goods or services provided by the infrastructure project entity shall be one of the following:

(i) an entity listed in Article 180(2) of this Regulation;

(ii) a regional government or local authority listed in the Regulation adopted pursuant to Article 109a(2)(a) of Directive 2009/138/EC;

(iii) an entity with an ECAI rating with a credit quality step of at least 3;

(iv) an entity that is replaceable without a significant change in the level and timing of revenues."

Source:https://ec.europa.eu/transparency/regdoc/rep/3/2015/EN/3-2015-6588-EN-F1-1.PDF

EU Capital Requirement Regulation Use of the EIOPA Definition

"A preferential treatment to specialised lending exposures aiming at funding safe and sound infrastructure projects. These are defined through a set of criteria able to reduce the risk profile of the exposure and enhance the capacity of institutions to manage that risk. The criteria are consistent with those identifying qualifying infrastructure projects that receive a preferential treatment in the Solvency II framework."

Source: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016PC0850

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