BCG
THE BOSTON CONSULTING GROUP

Disruption Coming to Your Home: Decentralized Solar Generation in Brazil

Solar energy: in a country famous for its sunny climate, it sounds inevitable

By Jean Le Corre, André Pinto, Ricardo Simas, Georges Almeida, Luis Daniel Viana, Damien Delaunay and Daniel Gorodicht

April 2017

AT UTILITY-SCALE, PHOTOVOLTAIC GENERATION is already a reality – and even if it currently represents less than 1% of the generation mix, recent auctions place it on relatively competitive terms with other power sources, and the government expects it to grow significantly over the next ten years.

As a very intermittent source of power generation, it already requires a different approach to capacity planning and operation, in a system that was until recently used to nearly instantaneously dispatchable hydro[1].

However, it is still a central generation source - the sort the current system and regulation were designed for.

This article is about the potentially more disruptive nature of distributed solar generation. A recent revision of net metering rules by ANEEL, and the introduction of new incentives schemes by the Government have in essence set off a market segment that could grow rapidly to a meaningful share of the installed capacity – in the single digit range, yet with disproportional impacts on grid players and their economics -- as has happened in other markets.

In the first section of the paper, we briefly recapitulate the current state of development of distributed PV in Brazil. We then review the factors (structural, regulatory, etc) that will drive its development. In a third section we develop and contrast scenarios of adoption. Finally, we discuss the impact it may have on utilities, and how they can react to these changes or – better - anticipate them.

Even if these scenarios are still mostly directional - given the limited history and dataset in which to ground them -, we hope this exercise may be useful for distribution players to reflect both on the opportunities and threats it may represent to their core business.

State of the local landscape

Brazil enjoys many of the elements that have driven significant solar growth in other regions. High solar irradiation, electricity rates charged on a purely variable basis, and expected long-term growth in load place it among the most promising solar markets in the world.

Box 1 | Current net metering rules

In November 2015 ANEEL issued a new resolution No.687 that amends and modifies previously enacted rules and sets out the framework to enable distributed solar generation on a broader scale and with potential improved financial returns for investors. The chief components of the new resolution are as follows:

- Expands the net metering program by allowing generators of up to 5 MW to offset their electricity bills with credits from the energy they inject to the grid
- Establishes that the credits obtained by the producer now expire after 60 months
- Introduces the concept of shared/community solar, allowing several energy customers to share the benefits of a single solar power generating facility as one single consumer
- Allows participating consumers to distribute net-metering credits among multiple electric service accounts, for instance, on a multi-tenant commercial property or a residential apartment building
- Allows for the net-metering credits not used by a generating facility to offset the excess electricity consumption of other sites provided that (i) ownership of both sites is the same; and (ii) sites are in the same concession area

Since ANEEL revised net metering rules in December 2015 (see box 1 for details), the large majority of Brazilian states have reached grid parity according to our estimates. This has driven a higher than four-fold increase from ~1,150 to ~5,000 in solar installations over the 12 months to September 2016 – admittedly from a very low base.

At the same time, a number of factors at play may delay adoption and market growth:

- **System costs:** they have been decreasing globally -- driven by soaring demand, and experience effects. But in Brazil, duties, tariffs and import costs add up so that full system costs are today ~30% higher than in Germany - whereas the average income is approximately 1/3 of Germany's. As a result, potential customers are often discouraged by the size of the upfront investment, in particular when compared with the variable cost of grid power. Even if more attractive over the long term, solar PV may only be adopted by people who have the means to afford a long payback time.

- **Macroeconomic environment:** Brazil's current economic crisis, coupled with continually high interest rates , has negatively impacted consumer confidence, and private lending and investment;

- **Future retail power prices:** to some extent a reflection of the complex and unstable context, they are also somewhat hard to predict. As investing in a solar rooftop system is in essence a bet on future retail prices, such uncertainty also tends to discourage investments. Case in point: after five year of almost constantly increasing prices, two utilities in São Paulo (CPFL Piratininga and EDP Bandeirante) dropped retail prices for residential customers by ~20% in 2016.

Besides these market factors, some provisions in the current regulation also limit the attractiveness of investing a PV system:

- **Cap on PV system size:** Capacity installed must not exceed peak load on-site or demand. This has the de facto effect of limiting the use of PV systems for self-consumption rather than maximizing generation potential and exports to the grid, in particular for larger commercial and industrial consumers

- **Direct resale not allowed:** In addition to not being able to be remunerated for exporting to the grid beyond current consumption, selling to third-parties at mutually agreed prices is not permitted. This has reduced attractiveness for popular PPA and renting business models that have reduced investments costs for individuals and contributed for solar DG growth in other geographies.

Still, a number of new players and business models have emerged in Brazil, in general with a promise for residential customers to enjoy the benefits of solar PV while lowering the risks associated with the initial investment.

Beyond the traditional financing and leasing options, there are for example alternatives where the costs are borne by the company that then guarantees a reduction in the energy bill, out of which a monthly commission is paid back by the customer. In other countries, roof space rental and direct resale further assist in this.

In essence, this young ecosystem is born on the assumption that the economics will continue to be favorable to PV adoption, and that the sector will continue to grow.

Drivers of future adoption

There are good reasons to believe in a positive outlook for distributed solar PV. In December 2015, the Brazilian government announced a national incentive program (ProGD) for developing power generation through distributed sources, with a special focus on solar PV. Tax incentives include:

- Exemptions of the state value-added tax (ICMS) and Social Integration/Social Security Contribution taxes (PIS/COFINS) on net electricity injected to the grid - of note, the majority of states have since already passed exemptions on ICMS on electricity; and.

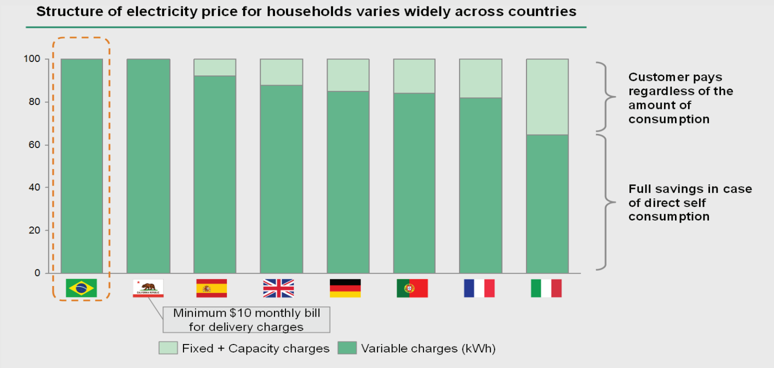
- Reduction of import taxes levied on capital goods used to produce PV solar equipment and related components, from 14 percent to 2 percent, until the end of 2016 – we expect this to eventually be extended from 2017 onwards.

In addition, and perhaps more importantly, the program sets the ground for future direct selling of excess energy on the liberalized market (ACL), subject to a feasibility and impact study, and proposes the creation and expansion of credit lines for distributed generation projects, addressing a topic for market development.

With the continuation of the current stimulus agenda - be it explicit, such as the tax exemptions mentioned above, or implicit, embedded in the variable tariff structure as explained in Box 2 – and as manufacturers and service providers in the Solar DG ecosystem continue to innovate improve their offering, it seems almost inevitable that distributed generation will emerge as a meaningful source of power production in the next decade.

Box 2 | The Brazilian tariff structure

In Brazil – differently from many other countries - the bill for residential customers is assessed on a purely variable basis, as illustrated in the chart below:

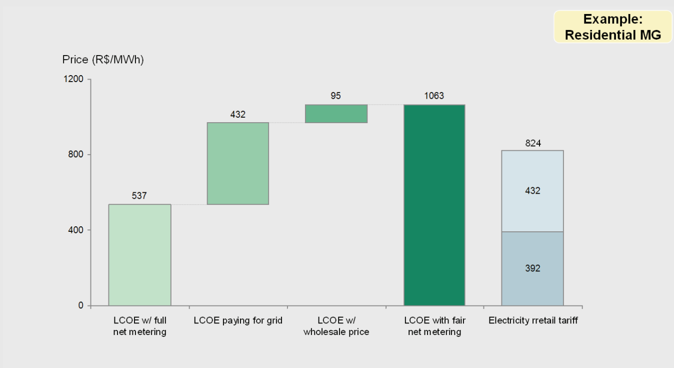


Note: Considers LV tariffs for 6kW capacity and 3500 kWh yearly consumption based on tariffs without ToU; California PGE has a minimum $10 monthly fee for delivery charges.
Source: Portugal – EDP; Spain – Iberdrola; UK – EDF energy; Italy – Enel; France – EDF Energy; Germany – eOn; California – PGE; BCG analysis

As such, there is an implicit subsidy in any net metering mechanism with fully variable tariffs, given that the portion corresponding to grid maintenance and operations also gets "netted out" of the electricity bill together with the portion corresponding to power retail. Additionally, the portion for power itself is netted out at the retail rate, so that the customer is in essence selling power at the full retail rate when generating, reducing the DisCo's profit.

The following chart represents the multiple parts of a bill based on a hypothetical residential customer in Minas Gerais and the impacts to LCOE of removing the subsidies implicit in the current net metering structure:

Effect on LCOE of hidden subsidies



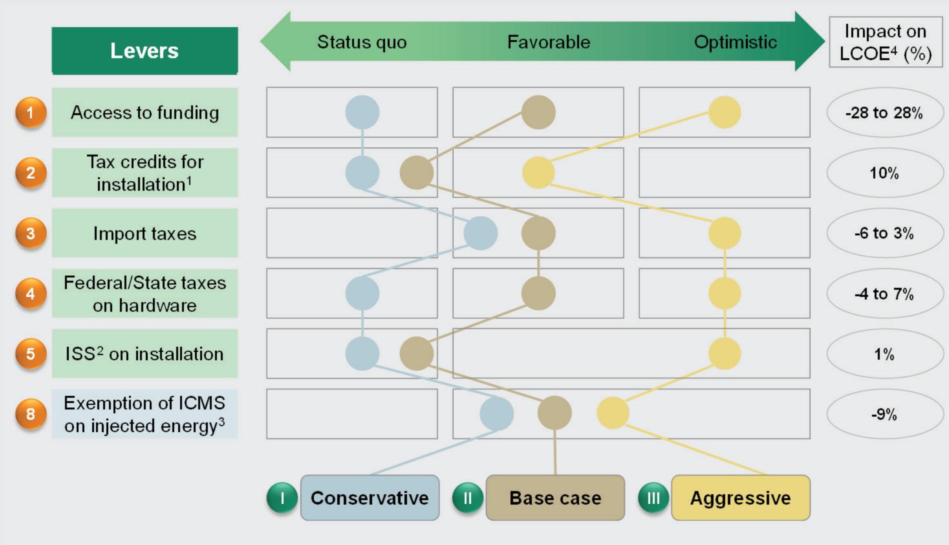
Note: LCOE paying for grid includes TUSD costs for all the generated energy (which is equivalent to a fixed charge that pays for the grid and transmission).
LCOE w/ wholesale price considers wholesale price for all the energy consumed from the grid (~40%) and retail prices for the self-consumed energy.
Source: BCG analysis

Scenarios design and input parameters

To assess the future development and penetration of solar distributed generation we first devised three growth scenarios considering possible combinations of regulatory / policy levers to support market development. These levers include the maintenance of the above-mentioned incentives to reduce the costs of funding, reductions of import taxes for solar PV hardware and exemption of ICMS and PIS/COFINS on net electricity injected to the grid. They even include, in a more optimistic scenario, the introduction of tax credits for new installations and the exemption of VAT on PV installations (see exhibit 1). However, for modeling purposes, we considered only the Conservative and Base Case scenarios given the likelihood of ANEEL not letting uncontrolled growth happen without quickly adjusting net metering rules.

Given the strong interest of green tech companies recently expanding operations in Brazil for manufacturing of solar PV modules and the growing market for solar service providers we do not expect any supply chain hurdles to growth in any scenario.

EXHIBIT 1 |



1. For residential and small commercial only 2. ISS: tax on services 3. Already the case in 21 out of 27 States. 4. Compared to Base case.
Source: BCG analysis

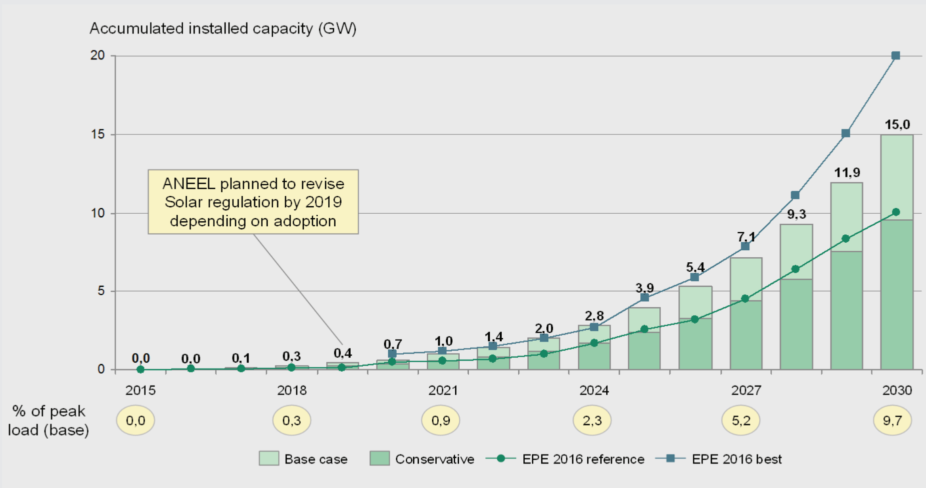
Results

In our base case, our study suggests that distributed solar generation could grow faster than currently anticipated by the sector authorities and could account for almost 5% of new installed capacity in Brazil until 2024, reaching around 3 GW of capacity installed and covering ~2% of the peak demand – of note, growing from an almost non-existent base in 2016[4]:

Breaking down this growth by region, we see São Paulo as the leading state in total installed capacity by 2024, despite comparatively less favorable solar irradiation in the region. This is largely explained by higher than national average income levels that contribute decisively for such a large investment decision. Take-up rates in SP could reach around ~1.5% of total state demand, in line with Brazil's expected average.

Following São Paulo, our study suggests that Rio de Janeiro and Minas Gerais will be next for installed DG solar capacity. Both states enjoy high solar irradiation with relatively high grid prices. By 2024, we expect RJ and MG to install a total capacity of 0.5 GW and 0.2 GW of solar PV and reach take-up rates of ~3% and ~2% of total demand, respectively.

In base case scenario, solar DG installed capacity could reach ~2,3% of peak load in Brazil by 2024



Note: for 2015 Peak load ~86 GW, here we assume steady increase of peak load with a 4% CAGR. LCOE calculated based on previous LCOE model. Capacity factor varies from state to state and is based on LCOE model as well. Adoption law using Bass model and parameters using USA's experience. For residential, maximum potential calculated by estimating consumption from people A & B class in Brazil, who use houses with a correction factor of 70% (leaving 30% out). For commercial, 50% of the peak load considered the maximum reachable target and peak load considered proportional to energy demand.
Source: Final report PDE 2024 ; EPE Energy demand report 2014 ; IBGE ; ANEEL ; BCG analysis

These scenarios do not take into account possible revisions to net metering rules, which ANEEL has already signaled could be considered in case of rapid uptake of the technology, nor the phasing out of solar stimulus in the short-term. As a matter of fact, without the net metering scheme currently in place, hardly any region in Brazil would be at grid parity. Fiscal incentives, be they through the remuneration of energy injected to the grid, or through reduced import costs of solar PV hardware, are a crucial driver of the future development of solar PV. Our study suggests that such incentives are equivalent to a 20% discount in the solar levelized cost of electricity.

All considered, however, the prevailing scenario should be one of vigorous growth of distributed solar generation (~40-50% per year on average), resulting in significant penetration within a decade, and consolidation of a "solar ecosystem" in Brazil.

That penetration will affect several aspects of the current energy landscape. Traditional utilities may be amongst the most impacted.

DG's impact on utilities

Electric utilities face a number of threats from the proliferation of distributed solar energy in their concession areas.

The first immediate threat stems from the erosion in retail and distribution revenues triggered by solar DG. Every unit of power generated by a decentralized solar system reduces the demand on the grid for energy from central generation sources (also known as "total net load"). In Brazil, with an almost purely-variable tariff for residential customers a lower net load means that utilities will see a reduction in income from electricity tariffs meant to pay for grid maintenance and generation operational costs that are typically fixed.

A second, potential threat is associated with the increased load volatility induced by solar DG, and the operational stress it may create in the grid. When local decentralized energy production exceeds local consumption, power refluxes back into the networks resulting in grid overload and voltage fluctuations, for which those networks may not be properly designed. Furthermore, steep ramps of net demand around peak hours pose balancing problems that are not always well dealt with by traditional, centralized control technologies.

We may be far from a scenario where this is a significant risk, given the magnitude of solar DG uptake we are anticipating, but it is something to bear in mind as utilities plan their future investments, especially if there are concentrated pockets of solar DG.

Investments in the grid will be necessary to deal with these challenges, which become more frequent and severe as penetration of DG increases . With net metering in place, fewer customers will be charged in full for these grid investments.

We believe it is a matter of time before Brazilian power utilities face similar challenges. In this context, it is essential for them to develop an early approach towards decentralized energy, considering not only operational and regulatory challenges but also competitive pressures and opportunities.

Utilities response – lessons from other markets

Experience in other geographies suggests that utilities are better off when they anticipate the growth of distributed solar energy.

As utilities see their revenues diminish, they may be tempted to recover their costs by requesting increased retail rates for conventional consumers. This creates an implicit cross-subsidy between the two consumer groups and further increases the relative attractiveness of decentral solar systems, feeding a vicious cycle. At large enough scale utilities will find it harder to persuade regulators and governments to protect utilities' revenues at traditional consumers' expense.

In other markets, in particular in the USA, some utilities have in the past taken an approach of confrontation, actively pursuing regulatory measures against distributed generation. For instance, several companies tried to oppose net metering, implement system size caps or reduce net exports compensation. Others have tried broader measures such as increasing fixed charges in the retail price structure or introducing specific solar charges for distributed generators.

If we expand this discussion to broader terms, the notion of selling kWh may be intuitive for utilities and regulators, but from a customer's perspective what is actually being purchased is light, comfort, etc. As such, alternative price formation mechanisms could be explored, with some international utilities pushing for fully-fixed tariffs, especially where generation is mostly fixed cost (e.g. renewables and nuclear).

However, many such efforts have had mixed results. Some companies faced backlash from lawmakers but also customers: their regulatory positions negatively impacted brand perception and customer loyalty.

On the other hand, a passive 'wait and see' mode has also hardly been a winning strategy. It exposes utilities to the risk of reduced revenues and "missing out" on the business opportunities created by the emergence of solar DG. For instance, in New York State, utilities mainly adopted an approach with no clear response to emerging trends and with a passive role in driving the regulatory policy agenda in presence of increasing solar penetration. In this context, the State regulators proposed a new initiative, "Reforming the Energy Vision," with the goal of revising the state's generation and distribution systems. The effort has the potential to force utilities to merely operate as so-called "distribution system platforms".

Under this proposed regulatory framework, utilities will act as platform providers with the obligation and the financial incentives to support the use of distributed energy resources. However, these utilities will have limited legal opportunities to own distributed energy resources beyond storage for system operations and may have missed the opportunity to seize significant value in a market undergoing significant growth and disruption.

More recently, other utilities (in both North America and Europe), have developed a more balanced approach, recognizing solar systems not only as threats, but also as opportunities to participate in new business models: by entering the market as installers of small-scale solar power on customer rooftops or even by building larger scale community solar farms. Others have decided proactively to support distributed generation through grid modernization and new investments such as storage. Increasingly, distributed generation is becoming a lever for utilities to increase their regulated assets base and, therefore, their revenues.

Possible implications for utilities in Brazil

Some utilities in Brazil are already anticipating the trend, by asking themselves three sets of questions:

- **Business:** Which position to take on the DG value chain?
- **Operations:** How to prepare the grid to support growing DG penetration?
- **Regulation:** How to better ensure value is fairly distributed among all agents in the market?

To develop a DG strategy, utilities must consider in what steps of the value chain they want to play a role. One option would be to focus on assets such as rooftop solar installations or solar community, but they could also offer services “behind the meter” such as advanced metering instruments or storage. Moreover, utilities can choose to simply be enablers of third-party services or to compete as fully integrated providers.

The overall economic value of a decentralized energy customer is much higher than that of the typical utility customer, once we include the amount invested in the DG system. Utilities should be aware of that factor when deciding what share of that value to try and capture.

However, before they develop such a strategy, utilities should first consider how the introduction of new business models may impact current retail electricity sales and how they can explore them in a sustainable manner. For that, they must consider a clear linkage between their business strategy and their operational and regulatory approaches to control or enable decentralized energy.

As the capacity of DG systems grows, distribution systems will still be fundamental parts of future electric networks. The challenges brought by increased penetration of intermittent dispersed solar generation on the balancing of the grid will require investments in flexible and innovative grid resources such as smart-grid solutions, grid automation, advanced solar inverts and other new technologies.

Independently of their strategic option, players will have to adapt and develop new investment plans to enhance the grid and reduce the risk of stranded assets as net demands shrinks. This will require an active approach from the very beginning to determine future needs and revise investment plans with regulators and consumers to ensure that everyone is aware of the upcoming challenges and costs.

The role of regulatory management will be crucial and must consider impacts on utilities' brand equity and customer loyalty. Rather than fighting DG, utilities would be better off seeking a rate structure that more accurately reflects their costs and avoids cross-subsidies among consumers.

The all-variable tariff in Brazil for households benefits those who install their own distributed generation at expense of all other consumers who still rely solely on the grid. Utilities should lobby for a rate design that prevents cost shifting and keeps price to a minimum while continuing to enable more integration of DG on the grid.

There's an array of approaches to achieve these objectives such as minimum bills, grid access fees or even time of use rates that encourage the use of power during times when solar is more productive. Perhaps less controversially, utilities can push for stricter technical rules for new distributed solar installations that will ease grid operation, such as advanced inverter standards.

Conclusion

The quick adoption of new distributed sources and the evolution of technologies will transform the electric power landscape. The rising competitive threat now lies on every rooftop across Brazil. Utilities will face a more complex environment with new technologies, services and pricing structures. New responses, capabilities and business models will be required, with greater focus on customers and innovation.

As a starting point, we believe there are a series of low-risk 'no regret' moves that utilities can already pursue today to prepare for this potential disruption:

- **Aim for operational excellence:** gaining efficiency, reducing costs, maximizing revenues in their traditional businesses - ensuring operational and economic "fitness" to best face the multiple challenges posed by solar DG;

- **Push for a fairer tariff structure** that helps recover grid costs and reduce cross subsidies, potentially including a fixed component;

- **Identify potential generation assets at risk** of becoming stranded in the next decade as net demand reduces. We expect that the relatively more expensive gas-fired plants will be at higher risk of losing merit order position;

- **Revise investment plans in the grid** to incorporate the changing net load profile.

Thinking ahead, utilities should also engage in a deeper reflection on their positioning in the DG space, the competitive advantages they enjoy or can develop (starting with access to capital, brand equity, operational expertise and knowledge of their customers) and how to best leverage them to maximize the value of the DG revolution for themselves and their shareholders.

NOTES

1.Except for periods of potential or actual shortage

2. For residential consumers, even the grid portion of the bill is assessed based on power consumption

3. Brazil's Central Bank recently (jan/17) announced interest rate cuts, however, that may signal a more meaningful trend of reduction in the near future

4. For simplicity, we utilized a Bass curve to model the adoption rate. This states that the number of customers that will purchase a product at time t is p x Remaining Potential + q x Adopters x Remaining Potential, where p= Coefficient of innovation and q=Coefficient of imitation.
We adjusted coefficients based on US experience to reflect the lower income level for Brazil, the penetration of houses vs. apartments plus the relative economic attractiveness given local interest rates. However, it should be noted that, naturally, these are just assumptions. There is not sufficient data to perfectly assess adherence to real-life values (although we did try to adjust them so as to match the growth rate observed over 2015 and 2016)

About the Authors

Jean Le Corre is a senior partner and managing director in the São Paulo office of The Boston Consulting Group. You may contact him by e-mail lecorre.jean@bcg.com.

André Pinto is a partner and managing director in the Rio de Janeiro office of The Boston Consulting Group . You may contact him by email pinto.andre@bcg.com.

Ricardo Simas is a principal in the Rio de Janeiro office of The Boston Consulting Group . You may contact him by email simas.ricardo@bcg.com.

Georges Almeida is a principal in the Rio de Janeiro office of The Boston Consulting Group. You may contact him by e-mail almeida.georges@bcg.com.

Luis Daniel Viana is a consultant in the São Paulo office of The Boston Consulting Group.

Damien Delaunay is a associate in the São Paulo office of The Boston Consulting Group.

Daniel Gorodicht is a Senior Knowledge Analyst in the Rio de Janeiro office of The Boston Consulting Group.

For additional contacts

The Boston Consulting Group (BCG) is a global management consulting firm and the world's leading advi- sor on business strategy. We partner with clients from the private, public, and not-for-profit sectors in all regions to identify their highest-value opportunities, address their most critical challenges, and transform their enterprises. Our customized approach combines deep insight into the dynamics of companies and markets with close collaboration at all levels of the client organization. This ensures that our clients achieve sustainable competitive advantage, build more capable organizations, and secure lasting results. Founded in 1963, BCG is a private company with 85 offices in 48 countries. For more information, please visit bcg.com.

Follow bcg.perspectives no Facebook e Twitter.

04/17

Abu Dhabi
Amsterdam
Athens
Atlanta
Auckland
Bangkok
Barcelona
Beijing
Berlin
Bogota
Boston
Brussels
Budapest
Buenos Aires
Calgary
Canberra
Casablanca
Chennai
Chicago
Cologne
Copenhagen
Dallas
Detroit
Dubai
Düsseldorf
Frankfurt
Geneva
Hamburg
Helsinki
Ho Chi Minh City
Hong Kong
Houston
Istanbul
Jakarta
Johannesburg
Kuala Lumpur
Kyiv
Lisbon
London
Los Angeles
Luanda
Madrid
Melbourne
Mexico City
Miami
Milan
Minneapolis
Monterrey
Montreal
Moscow
Mumbai
Munich
Nagoya
New Delhi
New Jersey
New York
Oslo
Paris
Perth
Philadelphia
Prague
Rio de Janeiro
Rome
San Francisco
Santiago
São Paulo
Seattle
Seoul
Shanghai
Singapore
Stockholm
Stuttgart
Sydney
Taipei
Tel Aviv
Tokyo
Toronto
Vienna
Warsaw
Washington
Zürich