

Real Options in the Brazilian Power Generation Sector: Are Domestic Equity Research Analysts Blind-Sighted or Is It Just a Temporary Glitch?

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Abstract

The Real Options theory (“ROT”) states firms should be approached as a combination of real assets and real options. Domestic equity research analysts do not seem to evaluate companies applying ROT. After reviewing 344 (from a total estimated 368) equity research reports or analyses on Brazilian listed power generation companies produced between December 31, 2020, and April 30, 2021, we find only discounted cash flow (“DCF”) techniques are applied. No single mention to ROT is made. To estimate the magnitude of potential misvaluations, we use the Black-Scholes method to price the growth plans made publicly available by each of those 15 companies in that period and compare the outcome with the analysts’ forecasted equity value upside per company. Our results suggest local analysts have ignored a sizeable intrinsic value to those companies by failing to apply ROT. Potential explanations range from behavioral biases to low power sector representativeness at IBOVESPA.

Keywords: Real Options, Power Generation Sector, DCF, Misvaluations, equity research

1. Introduction

While traditional valuation (DCF) theory assumes firms’ capital budgeting decisions are static (a “go-or-no-go” approach), Real Options Theory (ROT) suggests a dynamic approach where firms should be valued as a combination of two types of assets: real assets and real options. Especially when uncertainty is high (e.g., the COVID-19 pandemic period, election years, or simply a business cycle downturn imminence), ignoring the value of all available options (i.e., puts and/or calls) may end up undervaluing a project or firm under analysis. DCF either ignores high uncertainty associated with cash flows or penalizes their present values through higher discount rates. Following the opposite route, the higher the uncertainties, the more valuable the Real Options (RO’s). As a result: (i) a negative NPV project based only on a DCF valuation may be reverted after accounting for RO’s, and (ii) projects with RO’s are at least as valuable as equivalent ones without RO’s. However, since DCF is still the dominant approach to evaluating companies and projects, whether (and to which extent) financial analysts use ROT in their equity valuations is still an open question.

The capacity to enhance the expected value of projects under uncertainty makes ROT particularly suitable for assessing the value of capital-intensive projects, such as those in power generation (Ceseña, Mutale, & Rivas-Dávalos, 2013). Such importance has increased due to deeper environmental concerns, power market de-regulation, and global dependence on electricity to sustain future GDP growth. The more de-regulated a business activity (which is increasingly the case with power generation in Brazil), the higher the associated uncertainties and implied RO value.

While Trigeorgis (1996) and Amram and Kulatilaka (1998) have undertaken RO-related case studies in the energy industry, other authors approached RO’s in Brazil’s thermal generation industry (e.g., Moreira, Rocha, & David, 2004; and de Moraes, & Carpio, 2006) or addressed growth RO’s in the local distribution sector (Alonso Bonis, Azofra, & de la Fuente, 2009). Their publications inspired our research, which also builds on Venetsanos, Angelopoulou, and Tsoutsos (2002). The latter devised a framework to evaluate wind power projects in a de-regulated power market (Greece), applied the Black-Scholes model, and compared it with the DCF results.

However, to our knowledge, no academic study on RO approaches the whole set of listed Brazilian power generation players, valuing and comparing their RO and DCF-based growth plans, to conclude on the aggregate misvaluation potential. This article aims to fill this gap as a contribution to the academic literature.

Specifically, our research focuses on real growth options underlying the expansion plans made public by each of the 15 Brazilian power generation companies between December 31, 2020, and April 30, 2021. The reasons for this research outline are three: (i) as an emerging market with a long-term sector expansion plan, capital investments in power generation until 2050 are forecasted to be multi-billionaire. Volatile political and economic environments command RO value; (ii) the free market has been gaining preponderance over the regulated market for new power destination in Brazil. Higher de-regulation calls for higher RO value; (iii) distribution and transmission are more regulated activities than generation, yielding little flexibility for capital budgeting decisions to delay, switch, scale, stage, growth or abandon a project.

Outside emerging market economies, North American financial institutions have increasingly used ROT to assess the value of power plant projects since the early 2000s (Frayer & Uludere, 2001). On the industrial side, Fleten, Haugom, and Ullrich (2017) performed an empirical analysis involving 1,121 electric power generators in the US in 2001-2009 and found sound evidence of RO effects. They conducted statistical tests and concluded that, for large generation companies, the option value effect (increased cash flow uncertainty increases the value of an existing generator, and start-up value) dominates the information effect (increased cash flow uncertainty increases the “wait and see” option value). In the UK and Europe, Bakke, Fleten, Hagfors, Hagspiel, Norheim, and Wogrin (2016) developed a RO framework to conclude on investment prospects for grid-battery banks in the UK and in Germany. Although both investments yield positive NPVs if able to operate in the spot and balanced markets, the high volatility associated with development costs favors the decision to postpone an investment for at least one year.

However, this valuation mindset adjustment does not seem to have landed in the Brazilian equity research community covering the domestic power generation sector. Our research uncovers 344 (from a total estimated 368) equity research reports or analyses on the 15 Brazilian listed power generation companies produced between December 31, 2020, and April 30, 2021. These companies divulged or updated long-term growth plans in this period. We find that only DCF valuation techniques are applied. No single reference to ROT is noted in any report or analysis. To estimate the magnitude of potential misvaluations, we use the Black-Scholes method to price the publicly available growth plans and compare the outcome with the analysts’ equity value upside forecasts per company. Results indicate that the consolidated undervaluation potential could range from 37% to 112% (bottom-up). Two special cases are made by narrowing the initial sample, first by excluding the companies that did not announce expansion plans in that period and then by eliminating the ones whose largest business contribution to EBITDA in 1Q21 did not stem from power generation – potential undervaluation ranges increase to 62% to 138% and 304% to 1,642% (bottom-up), respectively.

Our research concludes that domestic equity research analysts have ignored a sizeable intrinsic value to listed Brazilian power generation companies by failing to incorporate ROT into Target Prices. Potential explanations rely on: (i) behavioral biases: decision fatigue, herding, first impressions, confirmation bias, and limited attention (Hirshleifer, 2020). On the flip side of those growth projects, documented biases to project managers include: bounded rationality, hindsight, and over-optimism, which may be induced by agency conflicts (Garvin & Ford, 2012; Hackbarth, 2009); (ii) technical limitations: the challenges of developing customized valuation algorithm models that adequately match the analyzed project characteristics (Bowman & Moskowitz, 2001; and Triantis, 2005), the mathematical complexity of RO models, the lack of intuition associated with the solution process or the presence of restrictive assumptions (Brandão, Dyer, & Hahn, 2005) or the structural RO methodology short-falls (Frayer & Uludere, 2001); (iii) long-dated sector valuation approach: analysts have historically classified the domestic power sector as defensive and passive; (iv) research coverage prioritization: the number of listed power generation players in Brazil is limited (15). Moreover, only 9 of these comprised the IBOVESPA stock index in April 2021, having accounted for just 5% of the index’s average daily trading volume between January 2019 and April 2021. These issues reduce analysts’ attention span to those players, underpricing the power generation deregulation trend underway.

This article is structured as follows: Section 2 brings a summary of the Brazilian power generation regulation and covers ROT applied to the Brazilian power industry. Section 3 discusses the research methodology applied, focusing on growth options priced using the Black-Scholes model. Section 4 consolidates the results for the listed power generation companies, elaborates on two special cases, discusses the results (including robustness tests) in light of the RO literature, and highlights the limitations of this research. Section 5 concludes.

2. Regulatory Environment and Real Options in the Brazilian Power Sector

2.1 Summary of the Regulation and Power Trading Environments

Under the Brazilian Constitution, electric power services, facilities, and water resources to produce electric power belong exclusively to the Federal Government, which may operate them directly or through authorizations, concessions, or permits granted to third parties.

Since 2004, the Brazilian industry has been regulated by the “New Electricity Sector Model Law” (Law 10,848/2004). Under this model, distributors contract 100% of the power required to meet their demand through government-sponsored auctions. In practice, each distribution company presents the government with forecasts for its demand over the coming five years, which shall base these auctions. The Ministry of Mines and Energy (MME) is the ultimate decision maker, following the recommendations from the sector regulatory agency (ANEEL).

Key features of the New Industry Model Law include: (i) establishment of two power trading “environments”: the Regulated Market (ACR) and the Free Market (ACL); (ii) restrictions on certain activities of distributors, which can only sell power to Captive Consumers; (iii) elimination of self-dealing (e.g., the vertically integrated generation-to-distribution operation within the same economic group), in order to provide an incentive to distributors to purchase electricity at the lowest available prices rather than buying electricity from related parties.

The ACR is a market in which the prices are established and regulated through public auctions and which guarantees power supplies to end consumers – those served by the distributors. It contemplates the purchase by distribution companies through public auctions of all electricity necessary to supply their “Captive Consumers”. ANEEL coordinates the auctions, and the winners are the generation projects that bid to receive the lowest energy price. Each generation company that participates in an auction executes a contract for the purchase and sale of power (PPA) with each distribution company in the country, in proportion to the latter’s estimated demand for electricity. These PPAs vary between 15 and 30 years. In short, a market segment where generators sell power to distribution companies, that resell it to Captive Consumers.

The ACL is a more competitive and riskier environment where generators sell power directly to non-regulated entities (“Free Consumers”, Specific Special Consumers, or commercialization companies). In this segment (ACL), prices practiced can be negotiated freely, paving the way for competition (a trend observed in the Brazilian power generation industry).

Generators can choose to allocate their power between ACR and ACL, following trading strategies involving risk (counterparty risk concentration in ACL versus pulverized credit risk in ACR) and return (higher margins apply in ACL than in ACR).

The principal regulatory authorities for the Brazilian power generation sector are: the Ministry of Mines and Energy (MME), National Energy Policy Council (CNPE), Brazilian Electricity Regulatory Agency (ANEEL), National Electrical System Operator (ONS), Electric Energy Trading Chamber (CCEE), Energy Research Company (EPE) and Energy Industry Monitoring Committee (CMSE).

2.2 Real Options Applied to the Brazilian Power Sector

Since 1970, the global energy sector has undergone market, regulatory and technological changes, shifting from a regulated and monopolistic to a de-regulated, uncertain, and highly competitive business environment in several countries (Awerbuch, Dillard, Mouck, & Preston, 1996).

More recently, global climate change concerns have fostered many renewable energy policies and projects worldwide. From 2010 until 2017, the values globally deployed into renewable power generation technologies surpassed US\$ 200 billion (Beluco, Beluco, & Mendes, 2018). While these new unconventional power sources are environmentally friendly, with shorter construction timetables, they also fit an increasingly de-regulated power generation environment, particularly in Brazil, where solar and wind have gained prominence over time. In this context, traditional capital budgeting methods have increasingly lost the capacity to properly evaluate investment decisions in this sector. This was the background for ROT as a valuation technique that went beyond (and complemented) the projected free cash flow approaches.

As a result of adequately addressing future uncertainties on project valuation, the combined DCF and RO values may eventually suggest a diametrically opposite capital budgeting decision compared to a scenario where only DCF is applied. The more de-regulated the sector or business activity, the higher the level of associated uncertainty and, consequently, the higher the RO value. This is the case with the Brazilian power generation

activity, gradually becoming less regulated as the ACL gains preponderance over the ACR for new power generation projects. However, this is not the case with the distribution and transmission segments of the domestic power sector, as: (i) distribution concessions have tight operational performance targets (notably DEC and FEC, respectively duration and frequency of blackouts in a year), which require continuous capital investments in the concession region to be achieved. In addition, the growth through acquisitions (M&A) is currently limited since most of the distribution companies in Brazil were privatized between 1999 and 2021; (ii) by force of regulation, the power transmission business model is not exposed to demand risk, resembling, in practice, a fixed income asset class.

ROT is known as a modern approach for the economic valuation of projects under uncertainty (de Moraes Marreco, & Carpio, 2006) and can address options at different stages of projects (Ceseña et al., 2013; Martins et al., 2015): (i) planning; (ii) operational, and (iii) design stages. Projects involving a multistage investment consisting of design, construction, and operation phases are frequently treated as sequential compound options. Most existing RO literature focuses on the planning (e.g., investment decisions assessment, including stage, growth, or defer ROs) and operational stages (e.g., altering a project's operating scale, switching fuels, or abandoning it).

Some authors argue that the most common option used at the planning stage is the defer RO, followed by the option to grow (Kozlova, 2017). This would be the case, especially regarding investment decisions for isolated projects subject to future electricity price uncertainty (Barria et al., 2011) or renewable energy projects, often modular (Fernandes et al., 2011). Nouicer (2015) emphasizes the value beyond the defer and abandon ROs, particularly for solar and wind farms.

Notwithstanding, we sustain in this article that, for the Brazilian power generation system, the growth option is the most valuable RO when approached in isolation and based strictly on publicly available information (e.g., absent private information). This public information is the one domestic equity research analysts use to derive their target prices. As such, the other ROs are of lower relevance or value to this research. The rationale is as follows:

Defer option. Hydroelectric power generation is subject to public auctions. Once the entrepreneur is awarded a project in a public auction, it has a well-defined period to build and start commercial operations. Otherwise, financial penalties (e.g., fines imposed by ANEEL) or exposure to the volatile spot market price may apply. Other sources of power generation (subject to authorizations, instead of concessions) depend on multiple short-lived stage environmental approvals for the construction stage to begin. Finally, once a PPA is set, delaying a decision to deploy capital only exposes the entrepreneur to a tighter construction schedule, regulator-imposed fines and future spot price risk.

These local market characteristics limit Brazil's actual value of "wait-and-see" options. Caporal and Brandão (2008, p. 114) noted the flexibility to delay the investment in Brazil is null and once the investor receives the authorization from ANEEL to build and operate a small hydroelectric plant, he/she must start the investment immediately after that, "given that the projections of the ONS [National System Operator] for verification of the risk of energy rationing (demand > supply) contemplate the project's generation".

Option to stage. This option would apply to biomass, wind, solar (centralized generation), HFO, coal-fired, and gas-fired power plants in Brazil. However, considering the increasing competitiveness in the ACR public auctions (driven by the lowest PPA price acceptable by the bidders), higher project scales became the norm for winning bids at greenfield generation auctions, as they are better positioned to negotiate more competitive EPC prices and O&M terms. This means that smaller-scale projects have much lower chances of yielding attractive returns and, as a result, lower capacity to attract competitive debt financing terms. As a result, they become at inception less competitive in ACR auctions. One exception refers to projects that sell energy in ACL, in the "self-production" format, having hard commodity producers as off-takers. The latter can admit project staging commensurate with off-takers' production growth schedule. In addition, HFO and coal-fired power projects face increasing resistance from environmental authorities for new approvals.

Option to change scale. It is becoming increasingly rare, as it requires complex environmental and technical approvals (large hydroelectric, gas, and coal-fired power plants), additional land lease agreements, and available substation connections (windmill and solar clusters) or higher confidence in sugar cane bagasse supply and land availability (biomass thermal power plants). A caveat to the option to scale up a power generation project could be made regarding the re-potentialization of old power plants (mainly hydroelectric facilities), replacement of existing wind turbines in an existing operational site by more powerful ones, the substitution of one-sided solar panels by double-sided ones, and addition of trackers to solar farms so that they can capture

irradiation in any direction. In addition, the option to scale down an operational power plant with an outstanding PPA exposes the entrepreneur to volatile spot market prices to serve an already firm PPA, leading to potentially high future project losses.

Option to abandon. Some authors advocate in favor of the value of the options to “wait to invest in a new hydropower plant and an abandon option, representing the transfer of concession rights” (Noronha, Lima, Ferreira, Unsihuay, De Souza, & Abiape, 2009, p. 1). However, the latter is conditioned to the existence of buyers to act as counterparties to the trade. Due to increasing ESG-related concerns, buyers of operational coal-fired power plants in Brazil are increasingly rare. Although on a smaller scale, a similar scenario can be observed with domestic gas-fired thermal power plants. The sale to a third party may also command expenses associated with the seller’s future obligation to indemnify the buyer, contingent upon future adverse events. This is ex-post quantifiable and private information (e.g., not applicable to our research, focused on public information). The shutdown alternative, for its turn, faces, among others, the following challenges: (a) the estimated decommissioning expenses (local HFO and coal-fired power plants); (b) exposure to the volatile spot market prices (to serve surviving PPA’s), which might lead to significant future losses.

Option to switch. Kozlova (2017) claims that bioenergy projects possess operational flexibility, such as the ability to change raw material and fuels used or to modify output products in reaction to volatile price conditions has the flexibility to be converted into different outputs (e.g., electricity, biofuels, charcoal, and chemicals), and value might arise by switching production to the most profitable output at any time.

Except for specific cases (like the biomass power plant conversion discussed by Fontoura, Brandão, and Gomes (2015)), the option to switch inputs or outputs in the Brazilian power industry is generally limited. Switching HFO or coal to gas as input for thermal power plants is either technologically challenging or economically unfeasible. It would require a significant change in supply logistics and an environmental license set of approvals commanding a whole new project.

A particular case could be made for the option to switch the target power market (e.g., between ACR and ACL). Caporal et al. (2008) developed a theoretical financial model applied to a small hydropower plant that valued the operational flexibility of selling energy in the spot market or through long-term regulated PPAs, at the sponsor’s discretion. They concluded that this end-market switch option had material value. However, this optionality is limited in practice by two factors: (a) the lack of a supply-and-demand oriented spot market; (b) project financiers require long outstanding PPA’s as a pre-condition to providing large long-term loans. Such features require future cash flow foreseeability and limit the entrepreneur’s ability to switch end markets.

Option to grow. The potential of this option can be assessed by the forecasted growth in the country’s installed generation capacity (as predicted by PDE 2030 and PNE 2050). The implied growth option value assumes the project is well structured (from a land, environmental and EPC/O&M perspective), has a meaningful competitive scale, high-quality PPA counterparts, sufficiently large duration, and financially strong sponsors (to secure adequate long-term financing). A robust internal rate of return would attract potential equity capital investors already at the greenfield stage. However, the growth option poses one relevant challenge to be priced by the equity research analyst: it is frequently tied to private information. For example, the optionality to lease a piece of land for potentially setting a windmill or obtaining a preliminary license to develop a future photovoltaic solar cluster is typically private information. It is made public only when a management decision to implement the project is already mature. As our research is limited to the options associated with the announced growth plans, it may not capture the full value potential beneath the firms analyzed.

Considering the domestic power generation market specifics, we conclude that the growth option is the most valuable to the domestic power generation industry, followed by the abandon option (particularly in connection with infrastructure funds’ exit strategy). The defer, stage, and switch options command less relevant values. The option to change scale should not return a meaningful value.

As highlighted by Fernandes et al. (2011, p. 4493), “these [growth] options are important in all infrastructure-based or strategic industries such as high tech and R&D, industries with multiple product generations or application like pharmaceutical, multinational and strategic acquisitions”. In their empirical research in Latin America, Alonso Bonis et al. (2009, p. 8) highlighted that “[although the option to grow in Brazil] was not the only option acquired by Endesa [when it entered the share capital of the Chilean Enersis in 1997], it is the most important”.

Our decision to build an option valuation model for the 15 listed power generation companies in Brazil, based only on the growth RO, also finds support in Venetsanos et al. (2002, p. 299), for whom “most RO models are limited to a single type of option” and “a more complex model is required to incorporate the interactive effect

[with other RO's] into its formulation”.

The suitability of growth options for the Brazilian power generation market has been growing side by side with the increasing relevance of ACL relative to total power traded in Brazil. As noted by Fernandes et al. (2011, p. 4491), “from the moment that the energy sector started a de-regulation process, with a high level of competitiveness and associated increased market uncertainty, traditional project evaluation techniques alone became insufficient to properly deal with these additional risk and uncertainty factors”. Figure 1 shows the evolution of ACL relative to total power traded.



Figure 1. Volume of energy commercialized per market in Brazil (GW)

Sources: Authors' elaboration using data from Our World in Data, GWEC, Abes, ANEEL, CCEE, ONS, EPE (PNE 2050).

2.3 RO-Based Case Studies in Brazilian Renewable Power Generation

Despite the theoretical reasons to include RO in the valuation of power generation companies and projects, Caporal et al. (2008, p. 118) highlight the scarcity of RO-based case studies in Brazilian renewable generation. This is also the case with local market power generation equity research coverage.

The scenario may, though, change for the Brazilian listed power generation companies since: (i) the significant expected increase in generation capacity in Brazil (50 GW between 2021 and 2030, and 287 GW between 2021 and 2050, according to, respectively, PDE 2030 and PNE 2050) should attract foreign investors, increasing the level of competitiveness in the local power sector; (ii) the significant increase in electricity prices, the overdependence on the hydroelectric power source and the growing environmental restrictions in Brazil over the last couple of decades called for the introduction of wind and solar generation projects. The latter carries more managerial flexibility than traditional hydroelectric power projects; (iii) the continuous migration of large end consumers from ACR to ACL coupled with the swifter construction periods for wind and solar projects (relative to hydroelectric or gas-fired thermal power facilities) have been feeding into a growing liberalized and de-regulated power generation market. This may command a change in sector valuation approach, with analysts expected to segregate the power generation activity (increasingly actively managed) from the distribution and transmission ones (historically defensive and passively managed); (iv) the flexibilization in qualification rules for consumers to become ACL participants should yield an active retail power market, with exponentially higher volatility and return potential. The nature of this ongoing change (and the consequent future ROT adoption forecast) was generally endorsed by Venetsanos et al. (2002, p. 293): “the transition from a highly regulated industry to a competitive environment calls for the readjustment of appraisal methods [other than DCF] for new investments, to take proper account of the introduced uncertainties. Uncertainty creates financial opportunities”; (v) the inexistence of either a supply-and-demand oriented spot power market in Brazil or a centralized power exchange floor (trading companies operate “over the counter” in ACL). This lack of price formation visibility and transparency in the ACL adds another layer of uncertainty to future energy prices; (vi) the ongoing discussions (at the ANEEL level) regarding the convenience of introducing peaking power plants to improve network safety and reliability. Peaking power plants generate most of their earnings during highly volatile peak hours. This business model is unsuitable for DCF-based valuation, making ROT a necessary tool to derive the actual value of such assets (Frayser & Uludere, 2001).

3. Data and Methodology

Sector expansion plan information is sourced from industry presentations on the following websites: CPFL Energia, Engie Brasil Energia, Equatorial Energia, EDP Brasil, CCEE (Electric Energy Commercialization Chamber), EPE (Electric Energy Research Company, from the Brazilian Federal Government), ANEEL (Brazilian power sector regulator), MME (Ministry of Mines and Energy in Brazil), ONS (National System Operator) and from Nouicer (2015).

Equity research reports are sourced through Capital IQ (“CIQ”), brokerage firms covering the Sample Group

companies, Investment Banks, and Private Banking firms. Quantitative research data is sourced from Bloomberg. Weekly data is gathered for each of the fifteen listed power generation companies in Brazil (“Sample Group”) from April 4, 2011 (first business day of that month) until April 26, 2021 (last business day of that month). The data is constituted of: (i) Target Prices (from twenty brokerage firms to each Sample Group company, whenever available); (ii) share prices; (iii) total weekly returns (capital appreciation plus dividend yield); (iv) P/B (price-to-book).

The methodology applies four broad steps: First, we uncover 344 (from a total estimated 368) equity research reports or analyses produced on the Sample Group companies between December 31, 2020, and April 30, 2021, the period during which the Sample Group’s long term growth plans were made public. We investigate to which extent ROT is applied in the valuations following such releases. Second, we calculate the Sample Group’s implied growth from equity research analysts (applying DCF). Third, we estimate the Sample Group’s implied growth (applying ROT). Finally, our fourth and final step is to make a direct comparison between steps 2 and 3 results to conclude on the relevance of the potential misvaluation for the Sample Group.

Because we cannot access the sell-side analysts’ financial models to acknowledge which growth projects were included in their valuations (and, even if we had, it would still be unlikely that all would value the same projects and ignore the remaining others), we chose to apply ROT to all growth projects informed by each of the Sample Group companies for the period 2021-2025 on an equity value basis. We then compare the outcome with the average forecasted DCF-based equity upside (DCF) for each company, as informed by analysts in their reports.

The goal is to test if the resulting gap between both outcomes is material, and we do it by calculating a “Premium Ratio”, as further detailed. Whenever the Premium Ratio for any Sample Group company is materially higher than 1.00x, the value of that company’s announced growth plans applying ROT is significantly larger than the one resulting from the DCF methodologies.

To draw an unbiased Premium Ratio, the main challenge is identifying a “no growth” initial market share value for each Sample Group company. Previous years’ announced growth plans could be argued to “pollute” any specific cut-off period for any Sample Group company.

The solution we apply to address this issue is two-folded: (i) we compare the RO values to their respective DCF-derived equity upside results across multiple periods. A relevant signal is issued as long as the Premium Ratio is materially higher than 1.00x in all periods; (ii) we minimize the “single cut-off period” issue associated with any specific Sample Group company by using average figures (for “premium per share”, “fundamental premium to market”, “option value per share” and “premium ratio”).

It is worth remarking that the most extended period analyzed (“last five years”) has two purposes: (i) consider a period with almost no influence of the most recently divulged growth plans; (ii) skip the recent COVID-19 period, which could potentially distort results. For a summary of the research methodology, see the schematic in Figure 2.

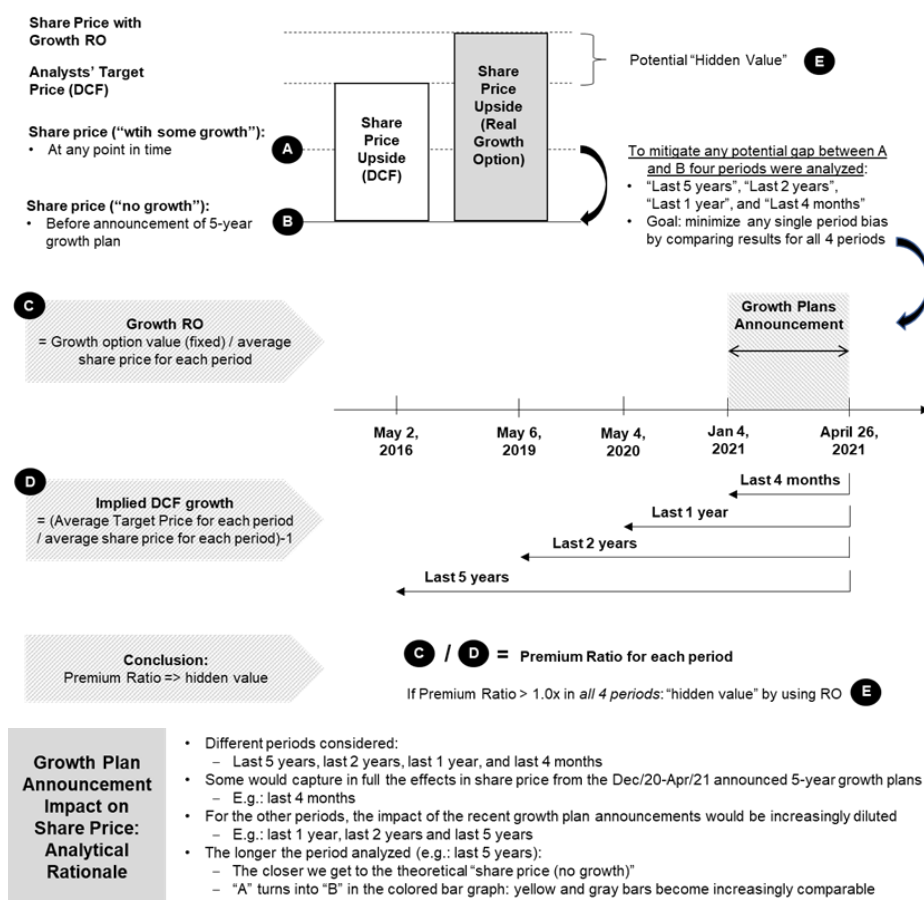


Figure 2. Methodology applied to compare RO and DCF-based valuations

Source: elaborated by the authors.

In step 1: (i) we use CIQ to map out the equity research coverage for the Sample Group and realize approximately 376 equity research reports have been produced between December 31, 2020, and April 30, 2021 (see Appendix, Table A1); (ii) we download the reports available at CIQ and access brokerage firms, Investment Banks and Private Banking firms that may give us access to the missing research reports. We uncover the valuation methodology applied by each brokerage firm in each report. Since several brokerage firms do not publicly report the valuation methodology applied, in all these cases, we contacted the respective research analysts and obtained a written statement on the valuation methodology used ("research analyses"). We also inquired whether ROT was used (see Appendix, Table A2). By doing so, we refined the number of reports and analyses produced by the analysts in the period, arriving at 184 for each quarter (4Q20 or 1Q21) or 368 for both quarters (a close figure to CIQ's 376) (see Appendix, Table A3).

From these 368 reports or analyses, we: (a) uncovered 344 (93%, as in Table A4); (b) identified the valuation methodology for them; (c) acknowledged Free Cash Flow to Equity ("FCFE") is the most used valuation methodology, followed by Free Cash Flow to Firm ("FCFF"), multiples (this one always in conjunction with a DCF methodology) and Dividend Discount Model ("DDM"); (d) realized none of the analysts apply ROT in any report to value the Sample Group companies. Only DCF valuation techniques are used, while multiples are used for comparative purposes. No single reference to ROT is made in any report or research analysis (detailed information is shown in Appendix – Tables A2 and A4). This relevant acknowledgment inspired research steps 2 to 4 to estimate the misvaluation potential.

In step 2: (i) we use the Bloomberg platform to track each Sample Group company's average stock price, on a weekly basis, throughout 4 periods: "last 5 years" (e.g., from May 2, 2016, to April 26, 2021, or simply "5 years"), "last 2 years" (e.g., from May 6, 2019, to April 26, 2021, or simply "2 years"), "last 1 year" (e.g., from May 4, 2020, to April 26, 2021, or simply "1 year") and "last 4 months" (e.g., from January 4, 2021, to April 26, 2021, or "4 months"); (ii) we apply Bloomberg's ANR function to uncover each brokerage firm's Target Price

for each sample company (whenever available), on a weekly basis, from April 4, 2011 (first business day of that month) until April 26, 2021 (last business day of that month), or since the Sample Group company's IPO, whenever IPO occurred after April 4, 2011. Conversely, the average Target Price calculation for each Sample Group company is calculated based on four periods: "last 5 years" (e.g., from May 2, 2016, to April 26, 2021, or simply "5 years"), "last 2 years" (e.g., from May 6, 2019, to April 26, 2021, or simply "2 years"), "last 1 year" (e.g., from May 4, 2020, to April 26, 2021, or simply "1 year") and "last 4 months" (e.g., from January 4, 2021, to April 26, 2021, or "4 months"); (iii) we use the results from step 2(ii) and step 2(i) to derive the average "Average Premium per Share" for each Sample Group company in 4 different periods (last 5 years, last 2 years, last 1 year and last 4 months) (see the Online Appendix for each company's outcome). The "Average Premium per Share" for each Sample Group company is assumed to capture the "growth value potential" behind its announced growth plans, applying a DCF-only valuation. Finally, we also derive consolidated Sample Group results (see Section 4.1).

In step 3, we: (i) map out the set of growth plans for each Sample Group company, and define them as a single growth option; (ii) we apply the Black-Scholes technique to value, on a per share (equity) basis, each Sample Group company's 2021-2025 divulged growth plans, as informed by their respective Senior Management and/or Investor Relations Officer at the time each company's December 2020 or 1Q2021 financial statement is released (see Section 4.2); (iii) use the results from steps 3(ii) and 2(i) to derive the average "Fundamental Premium to Market" for each Sample Group company.

In step 4, we: (i) compare the results from steps 2 and 3 and derive the "Premium Ratio" (for each Sample Group company and for the consolidated Sample Group). This step allows us to conclude the potential mispricing resulting from RO valuation being materially different from DCF; (ii) develop two special cases, narrowing the original Sample Group according to two filters. We calculate the Premium Ratios for each of these two special cases and compare them to the Sample Group's.

The support for the Black-Scholes model choice to value the growth options made public by the Brazilian listed generation companies came from: (i) it models options as if they were of the European style (Karel and Windiati, 2019), which are less valuable than American options. Consequently, research studies indicate that the Black-Scholes model yields more conservative values than Binomial Trees (Damodaran, 2012); (ii) it is formulated for the assessment of specific RO values under fixed and publicly known assumptions. Trigeorgis (1996) indicated that this approach is considered accurate and computationally inexpensive for simple options; (iii) the main advantage of this model is the simplicity with which option values are calculated (Martins et al., 2015), which is particularly suitable to the average well-informed stock exchange investor. The Binomial and Monte Carlo models are more suitable for internal decision-making purposes by the Board of Directors instead of working as effective price formation tools for equity research analysts. As this article's research takes the perspective of outside market observers like domestic equity research analysts (e.g., absent private information), the decision to use a valuation method that combines only public information supports the Black-Scholes model choice; (iv) the Binomial Tree, so does the Monte Carlo method, requires a large amount of private project development inputs to return the value at each node; (v) the Black-Scholes model is more suitable for valuing options in isolation, as opposed to interdependent options.

In summary, the Black-Scholes valuation model is widely used in practice for valuing growth options (Triantis, 2003), in spite of its limitations to our article's research: (i) as a European style option pricing model, the highlighted advantage (conservatism) also becomes a limitation (lower value than otherwise American style options); (ii) its variables are assumed to be normally distributed, which is not the case with some of them, e.g., cost overruns (Martins et al., 2015); (iii) the Black-Scholes formula is a static option pricing model plugged into a dynamic valuation tool (RO) (Damodaran, 2005).

In our research, we customize the Black-Scholes valuation formula to reflect the growth plan specifics of each of the 15 listed Brazilian power generation companies. As opposed to a top-down approach, this methodology allows us first to derive the value of each company's growth option, all of which are subsequently added up for a consolidated power generation industry assessment. It aims to address Bowman and Moskowitz's (2001) critics of using standard RO models in strategic analysis, leading to poor strategic decisions.

3.1 Average Premium Per Share

Comparing share price performance and Target Price evolution for each Sample Group company allows us to derive the "Premium per Share" for different time intervals (5 years, 2 years, 1 year, and 4 months). The Sample Group average market price per share and the average target price per share were calculated using a simple average of the company constituents (see Table 1 for details).

Table 1. Sample group average premium per share

Sample Group Statistics		5 years	2 years	1 year	4 months
Average market price per share	(A)	19.70	24.39	24.53	25.04
Average target price per share	(B)	22.70	27.06	28.51	29.15
Average premium per share	(C) = ((B) / (A)) - 1	15.26%	10.95%	16.21%	16.44%

Note. all values in Brazilian Reais, unless otherwise stated.

Source: Bloomberg. Table elaborated by the authors.

Table 1 shows that: (i) analysts consistently find material “equity value upsides” in the Sample Group companies, factoring growth opportunities in their Target Prices. Average premium per share is positive for all four periods, ranging from 10.95% (2 years) to 16.44% (4 months); (ii) the average premium per share during the last 2-year period incorporates two major elements: market expectations about an economically liberal Federal Government in Brazil following the 2019 Presidential election, and the emergence of the COVID-19 pandemics starting in 2Q2020.

Two special cases to the Sample Group are also made: (i) Special Case # 1 eliminates from the Sample Group the companies that did not publicly disclose growth generation plans between December 31, 2020, and April 30, 2021 (e.g., CESP, Equatorial and Light), resulting in twelve companies; (ii) Special Case # 2 added a further restriction to the previous one: the Sample Group companies, which 1Q21 EBITDA did not come primarily from the power generation activity, were excluded. These joint filters result in six companies (see Table 2 for details on 1Q21 EBITDA breakdown per Sample Group company and business activity, as well as the companies comprising the Sample Group, Special Case # 1 and Special Case # 2).

As logical acknowledgments: (i) the Sample Group encompasses Special Cases # 1 and Special Case # 2. Conversely, Special Case # 1 includes Special Case # 2 (the most restrictive of the three); (ii) the more we drive the spotlight of the analysis from the Sample Group towards Special Case # 2, the more we approach a group of companies most representative of the power generation sector in Brazil (the centerpiece of this research). The latter comes at the expense of a reduced sample size (only six companies), which increases the potential for company-specific bias.

Table 2. Sample Group and Special Cases # 1 and # 2

	Sample Group Company	EBITDA (1Q2021)	EBITDA Breakdown per Business Activity				
			Generation	Distribution	Transmission	Trading	Gas Transportation Telecommunication
● ○	AES Brasil (*)	349	100.0%				
○	Alupar	461	22.9%		77.2%		
○	CEMIG	1,845	45.0%	40.2%		14.9%	
	CESP (*)	282	100.0%				
● ○	Copel (*)	1,303	68.6%	26.2%		1.6%	3.5%
○	CPFL	1,970	33.1%	64.2%		2.8%	
● ○	EDP Brasil (*)	1,049	52.0%	35.0%	13.0%		
○	Eletrobras	3,860	36.0%		64.0%		
○	Energisa	1,310	0.0%	98.6%	1.4%		
● ○	Eneva (*)	446	100.0%				
● ○	Engie (*)	1,740	81.0%		9.0%		10.1%
	Equatorial	1,000	0.0%	97.6%	2.4%		
○	Neoenergia	2,330	14.3%	85.7%			
	Light	420	45.2%	47.1%		7.7%	
● ○	Omega (*)	194	100.0%				

Legend:

(*) Majority generation companies (e.g.: the largest percentage of EBITDA coming from the generation activity).

Companies that did not inform growth plans for the generation activity.

○

Special Case # 1: eliminates from Sample Group the companies that did not disclose growth plans between Dec/20 and Apr/21.

●

Special Case # 2: Sample Group companies, that disclosed growth plans, and with 1Q21 EBITDA primarily from generation.

Note. Table elaborated by the authors. All values in R\$ million, unless otherwise stated.

Source: Sample Group companies' websites and CVM filings.

Table 3 summarizes the results for Special Case # 1 and Special Case # 2, respectively. A company-by-company breakdown is found in Online Appendix.

Table 3. Special Case # 1 and Special Case # 2 Average Premium Per Share

Special Case # 1 Statistics		5 years	2 years	1 year	4 months
Average market price per share	(A)	20.05	24.76	24.89	25.41
Average target price per share	(B)	23.40	27.72	29.31	29.76
Average premium per share	$(C) = ((B) / (A)) - 1$	16.70%	11.96%	17.77%	17.15%

Table 4. Special Case # 2 Average Premium Per Share

Special Case # 2 Statistics		5 years	2 years	1 year	4 months
Average market price per share	(A)	17.21	21.60	22.37	23.47
Average target price per share	(B)	18.87	22.07	24.16	25.48
Average premium per share	$(C) = ((B) / (A)) - 1$	9.66%	2.16%	7.99%	8.56%

Note. all values in Reais, unless otherwise stated.

Source: Bloomberg. Table elaborated by the authors.

Table 3 shows that: (i) in all four periods, Special Case # 1 and Special Case # 2 average premium per share followed the same pattern as the Sample Group's shown in Table 2; (ii) when companies that have not informed growth plans in Dec/20-Apr/21 were eliminated from the Sample Group (Special Case # 1), the average upside potential in all four periods increased (relative to the Sample Group); (iii) in all four periods, analysts found, on average, less upside potential on Special Case # 2 stocks compared to Special Case #1's. This has to do with the fact that most of the power generated by Special Case # 2 constituents has historically been contracted to be sold in ACR, under long-term inflation-protected PPAs, which naturally limits share price upside potential. As discussed before, the ongoing power generation de-regulation is expected to change this picture in the years to come.

3.2 Growth Option Valuation

The parameters we apply to the Black-Scholes formula are discussed below:

Option tenor (T): time frame to execute expansion projects (Bodie et al., 2020), as informed by each Sample Group company to the market (e.g., five years). The five-year fixed tenor made the RO resemble a European option, supporting the choice of the Black-Scholes model;

Volatility (σ): standard deviation of the cash flows associated with informed growth plans. In our research, as we took the equity (as opposed to firm) approach, we applied the standard deviation of stock returns (Venetsanos et al., 2002). To adjust for dividends paid, we considered the standard deviation in the stock's total return (e.g., capital appreciation plus dividend yield). Due to historical data availability purposes, the period considered was the shorter of: the moment the Sample Group company's stock went public or since April 4, 2011. In either case, the last date considered was April 26, 2021. The weekly standard deviation was annualized assuming 52 weeks in a year (e.g., weekly data was multiplied by the square route of 52);

Exercise price (K): either the equity portion of the Capex required to implement the expansion plans (whenever publicly disclosed) or, in the absence of this, an equity percentage of the estimated marginal cost of expansion, based on recently implemented similar projects by that same company or by its Sample Group "peer comparables";

Underlying asset or present value of future cash flows (S): estimated based on the growth plans informed to the market by each Sample Group company. To derive the underlying-equivalent parameter value, and in the absence of each company's projected cash flows associated with their respective growth plans (non-public information), we apply the higher of: (a) the equity value underlying the median multiple valuation (expressed in millions of Reais per installed MW) stemming from "comparable transactions" in the Brazilian power generation sector, between January 01, 2014, and April 30, 2021, with no distinction for the power source. Whenever informed by the companies, we consider the target capital structure for each growth project to derive the equity value. When not reported, we apply a 70/30 debt-to-equity ratio, as a general market practice for infrastructure-related project finance in Brazil. The numerator of the multiple (millions of Reais) was adjusted for accumulated inflation (IPCA index, from IBGE) since transaction announcement month until April 2021; and (b) the equity value obtained applying the average P/B of each Sample Group company to the equity portion of the informed (or inferred) Capex.

The “transaction comparables” valuation technique provides a market sense of value associated with the growth projects. On the other hand, it is low likely that any Sample Group company would divest from those projects after they become operational at an implied P/B lower than that sponsor’s. For data availability purposes, the average P/B is calculated as the shorter of: the moment the Sample Group company went public or from April 4, 2011, up to April 26, 2021;

Risk-free (r): in the literature, United States investors consider the yield on the Treasury Bill or the 10-year US Government bond (Venetsanos et al., 2002). Conversely, we apply the Brazilian yield curve (“CDI curve”) and consider five years (counted from April 30, 2021) as the relevant fixed-rate for the execution tenor of each project. We apply a simple average of the two closest spot rates available (e.g., January 2026 and July 2026), arriving at 8.20% (see Figure 3);

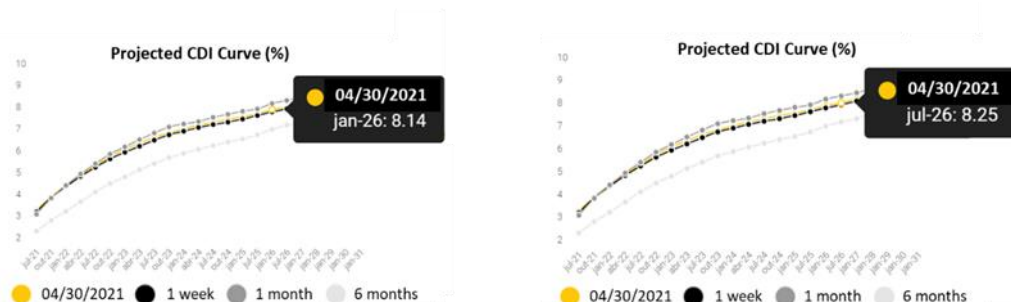


Figure 3. Projected domestic 5-year fixed rates on April 30, 2021

Source: XP, Inc. Information translated to English by the authors.

The growth option value per company follows the standard Black-Scholes formula. As a common feature of growth options, no dividend yield (D) applies. The Sample Group option value was computed as a simple average of all Sample Group companies’ option values.

3.3 Fundamental Premium-To-Market and Premium Ratio

For each Sample Group company: (i) the Fundamental Premium-to-Market was calculated as “Average Option Value per Share” divided by “Market Price per Share”; and (ii) the Premium Ratio was computed as: “Fundamental Premium-to-Market” divided by “Average Premium Per Share”.

Whenever the Premium Ratio is negative for a specific Sample Group company, its associated result is displayed as “n.a.”. These few exceptions to the Sample Group are observed when equity research analysts judge stocks to be overvalued, resulting in a negative average Premium per Share (e.g., AES Brasil and Eneva). This, however, does not affect the Sample Group’s output since the average size of the historical upsides (Target Prices being higher than Market Prices) offset by far the average size of the downsides (Market Prices being higher than Target Prices).

Although the original 15-company-Sample Group was further reduced to 12 (Special Case # 1) and 6 (Special Case # 2) for supplemental analytical purposes, we acknowledge this is reflective of the Brazilian stock market structure, which has a reduced number of listed entities. At the end of April 2021, only 80 companies comprised the IBOVESPA stock index, just 9 of which were Sample Group companies.

4. Results and Discussion

Premium Ratios for the Sample Group are materially higher than 1.00x in all four time periods analyzed, ranging from 1.37x (last 4 months) to 2.11x (last 2 years) – see Table 4 for details. These results suggest that either over the short or the long run, local equity research analysts have, on average, failed to efficiently price the Sample Group’s growth plans by applying only DCF-based valuation models while ignoring ROT (see Online Appendix for detailed results on each Sample Group company).

Some cases underlying the numbers in Table 4 are particularly remarkable: (i) AES Brasil shows a negative average premium per share (from DCF) in 3 out of 4 periods analyzed. When ROT is applied, the average Fundamental Premium to Market is above 73% in all four periods. Its share price reflects the company’s high exposure to hydrology and the end of its hydro concessions in the early 2030s; (ii) Eneva also shows a negative average premium per share (from DCF) in 3 out of 4 periods analyzed. The average Fundamental Premium to Market is also positive in all four periods. The value associated with the optionality to explore new certified gas

reserves auctioned and won by the company (growth RO), in a gas-to-wire business model, was high enough to revert the average downside share price potential foreseen by equity research analysts.

Table 4. Sample Group Fundamental Premium to Market and Premium Ratios

Consolidated Statistics	R\$, % or x	Reference
Average market price per share last 5y (from section 4.1)	19.70	(1)
Average market price per share last 2y (from section 4.1)	24.39	(2)
Average market price per share last 1y (from section 4.1)	24.53	(3)
Average market price per share last 4m (from section 4.1)	25.04	(4)
Average "premium per share" last 5y (from section 4.1)	15.26%	(5)
Average "premium per share" last 2y (from section 4.1)	10.95%	(6)
Average "premium per share" last 1y (from section 4.1)	16.21%	(7)
Average "premium per share" last 4m (from section 4.1)	16.44%	(8)
Average growth option value per share (from section 4.2)	5.65	(9)
Average "fundamental premium to market" (last 5 years)	28.68%	(10) = (9) / (1)
Average "fundamental premium to market" (last 2 years)	23.16%	(11) = (9) / (2)
Average "fundamental premium to market" (last 1 year)	23.03%	(12) = (9) / (3)
Average "fundamental premium to market" (last 4 months)	22.56%	(13) = (9) / (4)
Sample Group Premium Ratio (last 5 years)	1.88x	(14) = (10) / (5)
Sample Group Premium Ratio (last 2 years)	2.12x	(15) = (11) / (6)
Sample Group Premium Ratio (last 1 year)	1.42x	(16) = (12) / (7)
Sample Group Premium Ratio (last 4 months)	1.37x	(17) = (13) / (8)

Source: Bloomberg. Table elaborated by the authors.

These two particular cases (notably Eneva's) find support in relevant academic publications. Venetsanos et al. (2002) applied ROT to the renewable energy field. After evaluating a wind power project using the Black-Scholes model, they compared the results to the traditional DCF technique. They found the option value was conducive to investment, while the DCF approach was not. Furthermore, Frayer and Uludere (2001) also applied the Black-Scholes formula to demonstrate that a peaking gas-fired facility might be more valuable than a coal-fired power plant, which contradicted the traditional DCF results.

A similar conclusion was reached by Alonso Bonis et al. (2009), after running empirical research to conclude there was a material (in this case) positive gap between Endesa's market equity value (which incorporated RO to grow in Brazil) as traded in the New York Stock Exchange, and the estimated equity value attributable to Endesa's assets-in-place (derived from a DCF technique).

Except for AES Brasil and Eneva, results for all other Sample Group companies are consistent in all four periods (e.g., RO value is higher than DCF-based value in all four periods), although with different intensities. The set of Premium Ratios presented in Table 4 is also supported by the literature, which asserts that growth options should account for at least half of a company's value (Pindyck, 1988).

Otto (2012), when referring to a specific emerging market power project valuation, concluded that the 500 MW hydroelectric greenfield facility in Uganda was worth US\$ 1,038 million when RO's are considered, but only US\$ 453 million when not (e.g., RO's accounted for approximately 56% of the project value).

As we move down to Special Case # 1 (Table 5), the average Fundamental Premium to Market and the Premium Ratio increase (relative to the Sample Group figures) in all four analyzed periods. The reason for this pattern relies on the exclusion of companies that did not inform power generation growth plans (CESP, Equatorial, and Light), which, by definition, increases the average Special Case # 1 option value per share relative to the Sample Group's (R\$ 7.06 versus R\$ 5.65 per share).

The Premium Ratio for this group of companies (twelve) was also higher than 1.00x at all four periods analyzed, and to a larger degree than observed in the Sample Group. It ranged from 1.60x (last 1 year) to 2.38x (last 2 years).

Table 5. Special Case # 1 Fundamental Premium to Market and Premium Ratios

Consolidated Statistics	R\$, % or x	Reference
Average market price per share last 5y (from section 4.1)	20.05	(1)
Average market price per share last 2y (from section 4.1)	24.76	(2)
Average market price per share last 1y (from section 4.1)	24.89	(3)
Average market price per share last 4m (from section 4.1)	25.41	(4)
Average "premium per share" last 5y (from section 4.1)	16.70%	(5)
Average "premium per share" last 2y (from section 4.1)	11.96%	(6)
Average "premium per share" last 1y (from section 4.1)	17.77%	(7)
Average "premium per share" last 4m (from section 4.1)	17.15%	(8)
Average growth option value per share (from section 4.2)	7.06	(9)
Average "fundamental premium to market" (last 5 years)	35.22%	(10) = (9) / (1)
Average "fundamental premium to market" (last 2 years)	28.52%	(11) = (9) / (2)
Average "fundamental premium to market" (last 1 year)	28.37%	(12) = (9) / (3)
Average "fundamental premium to market" (last 4 months)	27.80%	(13) = (9) / (4)
Special Case # 1 Premium Ratio (last 5 years)	2.11x	(14) = (10) / (5)
Special Case # 1 Premium Ratio (last 2 years)	2.38x	(15) = (11) / (6)
Special Case # 1 Premium Ratio (last 1 year)	1.60x	(16) = (12) / (7)
Special Case # 1 Premium Ratio (last 4 months)	1.62x	(17) = (13) / (8)

Source: Bloomberg. Table elaborated by the authors.

As expected, Special Case #2's results (Table 6) deepen the conclusions discussed for the Sample Group and Special Case # 1. The average Fundamental Premium to Market and the Premium Ratio for this group of companies (six) are above 1.00x at all four time periods, by an even larger degree than Special Case # 1, ranging from 4.04x (last 4 months) to 17.42x (last 2 years).

Table 6. Special Case # 2 Fundamental Premium to Market and Premium Ratios

Consolidated Statistics	R\$, % or x	Reference
Average market price per share last 5y (from section 4.1)	17.21	(1)
Average market price per share last 2y (from section 4.1)	21.60	(2)
Average market price per share last 1y (from section 4.1)	22.37	(3)
Average market price per share last 4m (from section 4.1)	23.47	(4)
Average "premium per share" last 5y (from section 4.1)	9.66%	(5)
Average "premium per share" last 2y (from section 4.1)	2.16%	(6)
Average "premium per share" last 1y (from section 4.1)	7.99%	(7)
Average "premium per share" last 4m (from section 4.1)	8.56%	(8)
Average growth option value per share (from section 4.2)	8.11	(9)
Average "fundamental premium to market" (last 5 years)	47.14%	(10) = (9) / (1)
Average "fundamental premium to market" (last 2 years)	37.56%	(11) = (9) / (2)
Average "fundamental premium to market" (last 1 year)	36.26%	(12) = (9) / (3)
Average "fundamental premium to market" (last 4 months)	34.57%	(13) = (9) / (4)
Special Case # 2 Premium Ratio (last 5 years)	4.88x	(14) = (10) / (5)
Special Case # 2 Premium Ratio (last 2 years)	17.42x	(15) = (11) / (6)
Special Case # 2 Premium Ratio (last 1 year)	4.54x	(16) = (12) / (7)
Special Case # 2 Premium Ratio (last 4 months)	4.04x	(17) = (13) / (8)

Source: Bloomberg. Table elaborated by the authors.

The reason for this pattern relies on the fact that Special Case # 2 includes only companies whose primary business activity, as measured by their 1Q201 EBITDA's, was power generation. As such, Sample Group companies primarily focused on power distribution (CPFL, Energisa, Equatorial, Neoenergia, and Light) or transmission (Alupar and Eletrobras) were excluded. These non-power generation associated growth plans could be factored in the Sample Group, Special Case # 1, and Special Case #2's DCF valuations, while they are not in our RO valuation exercise – thus, understating results.

4.1 Robustness Tests

Analytical scenarios are developed to stress the model and its parameters. The most relevant ones are discussed below. Their results confirm our conclusions so far.

(i) *Robustness Test #1*: when the risk-free rate is reduced (from 8.20%) to 2% (lowest ever SELIC rate in Brazil), and the volatility for all Sample Group companies is reduced to 50% of the historical average, and Capex goes up (from R\$ 4.5 million / MW) to R\$ 5.5 million / MW, the Sample Group Premiums for "last 4 months" and "last 1 year" closely approach 1.0x (e.g., DCF and RO results are virtually equivalent).

However, in this case, it just takes the average entrepreneur to reduce the level of debt in the capital structure (from 70%) to 50% - a decision totally at his/her discretion -, so all Sample Group Premium ratios materially increase above 1.0x (see Table 7).

Table 7. Sample group premium results for Robustness Test # 1

Consolidated Statistics	R\$, % or x	Reference
Average market price per share last 5y (from section 4.1)	19.70	(1)
Average market price per share last 2y (from section 4.1)	24.39	(2)
Average market price per share last 1y (from section 4.1)	24.53	(3)
Average market price per share last 4m (from section 4.1)	25.04	(4)
Average "premium per share" last 5y (from section 4.1)	15.26%	(5)
Average "premium per share" last 2y (from section 4.1)	10.95%	(6)
Average "premium per share" last 1y (from section 4.1)	16.21%	(7)
Average "premium per share" last 4m (from section 4.1)	16.44%	(8)
Average growth option value per share (from section 4.2)	6.17	(9)
Average "fundamental premium to market" (last 5 years)	31.32%	(10) = (9) / (1)
Average "fundamental premium to market" (last 2 years)	25.30%	(11) = (9) / (2)
Average "fundamental premium to market" (last 1 year)	25.15%	(12) = (9) / (3)
Average "fundamental premium to market" (last 4 months)	24.64%	(13) = (9) / (4)
Sample Group Premium Ratio (last 5 years)	2.05x	(14) = (10) / (5)
Sample Group Premium Ratio (last 2 years)	2.31x	(15) = (11) / (6)
Sample Group Premium Ratio (last 1 year)	1.55x	(16) = (12) / (7)
Sample Group Premium Ratio (last 4 months)	1.50x	(17) = (13) / (8)

Source: Bloomberg. Table elaborated by the authors.

The results found above were amplified in Special Case # 1 (see Table 8) and Special Case # 2 (see Table 9).

Table 8. Special Case # 1 Premium Results for Robustness Test # 1

Consolidated Statistics	R\$, % or x	Reference
Average market price per share last 5y (from section 4.1)	20.05	(1)
Average market price per share last 2y (from section 4.1)	24.76	(2)
Average market price per share last 1y (from section 4.1)	24.89	(3)
Average market price per share last 4m (from section 4.1)	25.41	(4)
Average "premium per share" last 5y (from section 4.1)	16.70%	(5)
Average "premium per share" last 2y (from section 4.1)	11.96%	(6)
Average "premium per share" last 1y (from section 4.1)	17.77%	(7)
Average "premium per share" last 4m (from section 4.1)	17.15%	(8)
Average growth option value per share (from section 4.2)	7.71	(9)
Average "fundamental premium to market" (last 5 years)	38.46%	(10) = (9) / (1)
Average "fundamental premium to market" (last 2 years)	31.14%	(11) = (9) / (2)
Average "fundamental premium to market" (last 1 year)	30.99%	(12) = (9) / (3)
Average "fundamental premium to market" (last 4 months)	30.36%	(13) = (9) / (4)
Special Case # 1 Premium Ratio (last 5 years)	2.30x	(14) = (10) / (5)
Special Case # 1 Premium Ratio (last 2 years)	2.60x	(15) = (11) / (6)
Special Case # 1 Premium Ratio (last 1 year)	1.74x	(16) = (12) / (7)
Special Case # 1 Premium Ratio (last 4 months)	1.77x	(17) = (13) / (8)

Source: Bloomberg. Table elaborated by the authors.

Table 9. Special Case # 2 Premium Results for Robustness Test # 1

Consolidated Statistics	R\$, % or x	Reference
Average market price per share last 5y (from section 4.1)	17.21	(1)
Average market price per share last 2y (from section 4.1)	21.60	(2)
Average market price per share last 1y (from section 4.1)	22.37	(3)
Average market price per share last 4m (from section 4.1)	23.47	(4)
Average "premium per share" last 5y (from section 4.1)	9.66%	(5)
Average "premium per share" last 2y (from section 4.1)	2.16%	(6)
Average "premium per share" last 1y (from section 4.1)	7.99%	(7)
Average "premium per share" last 4m (from section 4.1)	8.56%	(8)
Average growth option value per share (from section 4.2)	11.25	(9)
Average "fundamental premium to market" (last 5 years)	65.35%	(10) = (9) / (1)
Average "fundamental premium to market" (last 2 years)	52.06%	(11) = (9) / (2)
Average "fundamental premium to market" (last 1 year)	50.27%	(12) = (9) / (3)
Average "fundamental premium to market" (last 4 months)	47.92%	(13) = (9) / (4)
Special Case # 2 Premium Ratio (last 5 years)	6.76x	(14) = (10) / (5)
Special Case # 2 Premium Ratio (last 2 years)	24.16x	(15) = (11) / (6)
Special Case # 2 Premium Ratio (last 1 year)	6.29x	(16) = (12) / (7)
Special Case # 2 Premium Ratio (last 4 months)	5.60x	(17) = (13) / (8)

Source: Bloomberg. Table elaborated by the authors.

(ii) *Robustness Test #2*: when the underlying asset value is valued using only the median Transaction Comparables multiple (instead of the higher of the latter or each company's P/B ratio), the Sample Group Premium ratios for "last 4 months" and "last 1 year" fall below 1.0x by approximately 10%. In this case, it only takes the average entrepreneur to reduce debt in the capital structure to 50% (a decision at his/her discretion), so all Sample Group Premium ratios go above 1.0x again.

As expected, results get amplified for Special Case # 1 and Special Case # 2. For the sake of brevity, these results are shown in the Online Appendix. In conclusion, the robustness tests performed allow us to infer that, since the average entrepreneur (option owner) has the prerogative to calibrate the option value through the amount of debt in the greenfield projects' capital structure, except for extremely disruptive scenarios, RO results are reasonably expected to be higher than DCF results.

Taken together, the empirical evidence can be summarized as follows: (i) the average Fundamental Premium-to-Market increases as we move from the Sample Group to Special Case # 1, and from this one to Special Case # 2, the reason being that the power generation growth optionality becomes more representative within the company's total growth plans; (ii) while analysts apply DCF to evaluate only contracted power generation, ROT uncovers the value beyond still uncontracted growth plans; (iii) in all-time intervals analyzed and for all 3 case studies researched (e.g., Sample Group, Special Case # 1 and Special Case # 2) the Premium Ratios resulted materially above 1.00x, having increased as we moved along from the Sample Group towards Special Case # 2. The robustness tests performed also reinforced these results.

4.2 Discussion of Results: Implications and Reasons not to Include Ro In Valuations

Our findings indicate that domestic equity research analysts do not apply ROT in their Sample Group companies' valuations. As a consequence, our research estimates large potential misvaluations, which are quantified in Table 4 (Sample Group), Table 5 (Special Case # 1), and Table 6 (Special Case # 2). Such findings are critical for research analysts and investors interested in the generation power sector.

Selected case studies support our findings, both internationally and locally. On the international front, Frayer and Uludere (2001) concluded that, since DCF assigns a low value to a typical US gas-fired peaking facility, the latter's aggregate value could increase almost seven times if RO's (priced with Black-Scholes) were included. As a result, such a peaking gas-fired facility becomes more valuable than a mid-merit coal-fired plant (even if the latter also accounted for applicable RO's), which had lower marginal costs. This result differs from the one stemming from traditional valuation methodologies, which would favor the coal-fired investment. Furthermore, Venetsanos et al. (2002) also applied the Black-Scholes pricing method to value the available RO's to a windmill project in Greece and concluded that, while the NPV rule was not conducive to an investment, the combination of negative NPV and materially higher (in module) RO values resulted in a positive "expanded NPV", capable of reverting the initial capital budgeting decision. Bakke et al. (2016) concluded the option to switch operations from the spot market to the balanced market in UK and Germany is able to revert the negative value resulting from traditional valuation approaches to battery bank projects, which assume revenues only stem from spot price time arbitrage.

In the Brazilian power industry, two case studies explicitly applied to the Brazilian power sector also validate our conclusions. First, Caporal et al. (2008) proposed an RO-based valuation model to a small hydropower plant and concluded that, whenever the end market switch option value (e.g., the flexibility to choose between selling power in the spot market or through long-term PPA's) is accounted for, firm value increases by approximately 35% (from R\$ 128.4 million to R\$ 173.3 million) relative to the one obtained through traditional DCF methods. Second, Fontoura et al. (2015) also found that, while NPV of investing in an Elephant grass power plant is initially negative, it turns into positive when the value of specific switch options is added. The analyzed project becomes economically feasible and, from a broader sector perspective, the biomass source becomes a viable alternative to fossil fuels to produce fuels and chemicals.

The results and conclusions we discuss in this article, either for the Sample Group or Special Cases # 1 and # 2, could be even more compelling, since: (i) we do not price growth options that were not made public; (ii) we only value options in isolation, refraining from inferring the value of compound options (absent private information to derive them); (iii) we price only growth options. Other RO's may potentially add value to the exercise, mainly if their correlation with the growth options is positive; (iv) we price growth options as if they are European options (e.g., exercise only at the end of 5 years), whereas in practice these resemble American ones, which are more valuable. Results may then be understated; (v) conversely, the choice of the (more conservative) Black-Scholes model, as opposed to the Binomial Tree, to value real growth options can also understate results; (vi) four out of the six companies comprising the most restrictive Special Case # 2 do not operate only in the power generation

business. This means part of the growth value associated with their power distribution, transmission and trading, telecommunications, and/or gas transportation activities can be factored into the brokerage firms' traditional DCF-based valuations but are certainly not in the RO valuation exercise in our research.

4.2.1 Why Analyst Do not Include ROT in Valuations?

Finally, an important discussion is why analysts do not use ROT to evaluate businesses that are likely to have lots of valuable options. Potential equity research analysts' historical reasons for RO underapplication in Brazil can be summarized as follows.

Analytical approach. Analysts historically approached the domestic power sector as a defensive and passive one (this includes the generation activity, in which new projects historically targeted the low volatility and highly predictable ACR revenue stream);

Research coverage prioritization. Contrary to what common sense might predict for an emerging market, the number of listed power generation players in Brazil is limited (15). Moreover, only 9 of these comprised the IBOVESPA stock index in April 2021, having accounted for just 5% of that index's average daily trading volume between January 2019 and April 2021. These figures reduce analysts' attention span to those players while keeping the ongoing power generation de-regulation trend underpriced;

Technical limitations. The challenges of developing customized valuation algorithm models that adequately match the analyzed project characteristics (Bowman and Moskowitz, 2001; and Triantis, 2005), "the mathematical complexity of RO models, the lack of intuition associated with the solution process, or the restrictive assumptions required to obtain analytical solutions" (Brandão, Dyer and Hahn, 2005, p. 69). The analyst would be required to quantify the value of different ROs in isolation and infer the degree of correlation among them. And RO's themselves could have three variations: simple (the six types discussed before), barrier (e.g., ROs capped in value), compound (e.g., option on option), or rainbow (options that address multiple sources of uncertainties, as opposed to one) (Damodaran, 2005). Finally, the choice of the methodology to apply (Binomial Trees, Black-Scholes, or Monte Carlo) also poses challenges.

ROT structural shortcomings. Frayer and Uludere (2001) and Damodaran (2005) elaborate on a list of ROT shortcomings: (i) the underlying asset (source of uncertainty) is not traded. Arbitrage is, therefore, unfeasible; (ii) the underlying asset price movement is assumed to follow a stochastic pattern. This would not be the case with mean-reverting prices; (iii) volatility is assumed to be constant (which does not necessarily apply to mean-reverting prices); (iv) the Black-Scholes model prices only European (not American) options; (v) option exercise is instantaneous (unfeasible for significant capital investments).

Analysts' behavioral biases. Hirshleifer (2020) remarks the following biases: decision fatigue (the tendency for decision quality to decline after an extensive session of decision-making, causing stock market analysts to be more heuristic in their forecasting, either by herding on the market consensus forecast or self-herding); first impressions (the tendency to place undue weight on how the information is initially presented); limited attention (analysts eventually neglect or underreacting to relevant public information signals, mainly when a large number of earnings announcements occur on the same day); and analysts forecasts (the tendency for analysts to place undue weight on recent events than on earlier events). We raise two other behavioral biases as a hypothesis for further research: illusion of control (e.g., the belief that a well-crafted and granular DCF model would be sufficient to develop an accurate valuation view on a project); and social proof bias (e.g., no analyst willing to breach the industry's standard valuation practices), which may also lead to "herding".

5. Conclusions

After reviewing 344 (from a total estimated 368) equity research reports or analyses on Brazilian listed power generation companies produced between December 31, 2020, and April 30, 2021, we conclude the domestic equity research community has systematically failed to recognize a relevant RO-derived value (based on public information to which research analysts are exposed) behind domestic power generation growth plans. Instead, we find that local analysts only apply DCF valuation techniques (some combined with multiples valuation). As a result, large potential misvaluations arise, as we demonstrate.

One potential reason for such a result is analysts' behavioral biases, as much as their limited attention span to the power generation sector (considering its under-representativeness at IBOVESPA), potential technical limitations (to build up intuitive models), and restrictive assumptions required to obtain analytical solutions. On the flip side, project managers that feed research analysts with project valuation information also suffer from behavioral biases and are frequently exposed to reward mechanism misalignment with project owners (resulting in agency problems).

Thinking more broadly, the literature indicates ROT has been increasingly used in the more advanced economies since the early 2000s, not only for more volatile sectors and business models but also for power generation activity. Following this trend, we expect it may become a more disseminated practice in Brazil at some point in the future. Local credit and/or technology fintechs, whose business models are more disruptive, may be stronger candidates to inaugurate this shift in domestic research valuation practices.

The drawback to our research relies on the Brazilian power generation market being limited in size (only 15 listed companies), which reflects the Brazilian stock market structure. In particular, just 80 listed economic groups had shares included at the IBOVESPA stock index at the end of April 2021 (9 of which comprised the Sample Group), and 20% of the IBOVESPA stock index average daily trading volume was concentrated in two stocks (Vale and Petrobras) between January 2019 and April 2021.

The scope of this research can be further expanded to cover other capital-intensive sectors (e.g., oil and gas, toll roads, ports, railways, water and sewage, and airport sectors) either in Brazil or in other Latin American countries (e.g., Mexico, Chile, Colombia, and Peru). Long-term capital budgeting decisions in those emerging markets are frequently taken in a context of high volatility and future cash flow uncertainty, where RO's are most valuable. On the analysts' behavioral biases side, two hypotheses behind RO underapplication in Brazil deserve further research: the illusion of control and social proof biases.

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Conflicts of Interest

The authors declare no conflict of interest.

Supplementary Materials

The following supporting information can be downloaded: Supplemental Online Archive. Average Premium per Company Share; Companies' Summarized Growth Plans in Power Generation; Growth Option Valuation per Company; Fundamental Premium-to-Market and Premium Ratio per Company; Transaction Comparables in Power Generation; Sample Group Relevance in the Ibovespa Index.

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Appendix A

Sample Group Equity Brokerage Coverage

Table A1. Research Coverage Universe

Core Activities				Research Coverage (from Capital IQ on April 30, 2021)																	
Company	Alvira	Banco do Brasil	Bradesco	BTG Pactual	Brasil Plural	BoFA	Citi	Credit Suisse	Eleven	Goldman Sachs	Genial	HSBC	Inter	Itaú-BBA	J.P.Morgan	Morgan Stanley	Safra	Santander	UBS	XP	
Integrated Co.'s																					
Eletrobras	DNC	DNC	No report	Covered	No report	No report	Covered	Covered	Covered	No report	DNC	DNC	DNC	Covered	Covered	No report	Covered	Covered	Covered	DNC	
CPFL	DNC	DNC	No report	Covered	DNC	No report	DNC	Covered	DNC	No report	DNC	DNC	DNC	Covered	Covered	No report	Covered	Covered	Covered	DNC	
Norocenergia	DNC	Covered	No report	DNC	DNC	No report	DNC	Covered	DNC	No report	DNC	No report	DNC	Covered	Covered	DNC	Covered	Covered	Covered	DNC	
CEMIG	DNC	DNC	No report	Covered	No report	No report	Covered	Covered	Covered	No report	DNC	No report	DNC	Covered	Covered	No report	Covered	Covered	Covered	No report	
COPEL	DNC	DNC	No report	Covered	DNC	No report	Covered	Covered	Covered	No report	No report	No report	DNC	Covered	Covered	No report	Covered	Covered	Covered	No report	
EDP	No report	DNC	DNC	Covered	No report	No report	DNC	Covered	Covered	No report	DNC	DNC	No report	Covered	Covered	No report	Covered	Covered	Covered	No report	
Light	No report	DNC	No report	Covered	DNC	No report	DNC	DNC	Covered	No report	DNC	DNC	DNC	Covered	Covered	No report	Covered	Covered	Covered	DNC	
Core Generation																					
Engie	DNC	DNC	No report	Covered	No report	No report	DNC	Covered	Covered	DNC	DNC	No report	DNC	Covered	Covered	DNC	Covered	Covered	DNC	No report	
Enxova	No report	DNC	No report	Covered	DNC	DNC	Covered	DNC	DNC	DNC	DNC	DNC	DNC	Covered	DNC	DNC	DNC	Covered	DNC	DNC	
CEBP	DNC	DNC	No report	Covered	No report	No report	Covered	Covered	Covered	DNC	No report	DNC	DNC	Covered	Covered	No report	Covered	Covered	Covered	No report	
AES Tietê	DNC	Covered	No report	Covered	No report	No report	Covered	Covered	Covered	No report	DNC	DNC	No report	Covered	Covered	No report	Covered	Covered	Covered	DNC	
Omega	DNC	DNC	No report	Covered	DNC	No report	Covered	Covered	DNC	No report	DNC	DNC	No report	Covered	DNC	DNC	DNC	Covered	DNC	No report	
Transmission plus Generation																					
Alupar	DNC	Covered	No report	Covered	No report	No report	DNC	Covered	DNC	No report	DNC	DNC	DNC	Covered	Covered	No report	Covered	Covered	DNC	DNC	
Distribution and Generation																					
Equatorial	DNC	DNC	No report	Covered	No report	No report	No report	Covered	DNC	No report	DNC	No report	DNC	Covered	Covered	No report	Covered	Covered	No report	No report	
Energisa	DNC	DNC	No report	Covered	DNC	No report	No report	Covered	DNC	No report	DNC	DNC	DNC	Covered	Covered	No report	Covered	Covered	Covered	DNC	
														Approximate # of reports (Dec/20)		Approximate # of reports (Mar/21)		Approximate # of total reports (Dec/20 and Mar/21)			
Legend	==>	Covered	Capital IQ ("CIQ") claims to make report available (A)										104	(+)	104	=	208				
		No report	Co. is covered, but CIQ claims to have no access to report (B)										84	(+)	84	=	168				
		DNC	Broker does not cover the company																		
Total (A + B)														188	(+)	188	=	376			

Source: Capital IQ on April 30, 2021. Table elaborated by the authors.

Table A2. Interaction with Analysts: Updated Coverage Universe and Valuation Methodologies Applied

Core Activities				Research Coverage (Valuation Methodologies Applied)																
Company	Alvira	Banco do Brasil	Bradesco	BTG Pactual	Brasil Plural	BoA	Citi	Credit Suisse	Eleven	Goldman Sachs	Genial	HSBC	Inter	Itaú-BBA	J.P.Morgan	Morgan Stanley	Safra	Santander	UBS	XP
Integrated Co.'s																				
Eletrobras	DNC	DNC	FCFE	DNC	DNC	FCFE	DNC	FCFF	DNC	FCFE	DNC	DNC	DNC	FCFE	FCFF	FCFF	FCFF	Multiples	FCFE	DNC
CPFL	DNC	DNC	FCFE	DDM	DNC	FCFE	FCFF; FCFE	FCFF	DNC	FCFE	DNC	DNC	DNC	FCFE	FCFF	FCFF	FCFF	FCFF	FCFE	DNC
Norocenergia	DNC	DNC	FCFE	DNC	DNC	FCFF	FCFF; FCFE	FCFE	No report	FCFE	DNC	No report	DNC	FCFE	FCFF	DNC	FCFF	FCFF	DNC	DNC
CEMIG	DNC	DNC	FCFE	DNC	DNC	FCFE	DNC	DNC	No report	FCFE	FCFE	No report	DNC	FCFE	FCFF	FCFF	FCFF	FCFF	DNC	FCFE; multiples
COPEL	DNC	DNC	FCFE	DNC	DNC	FCFE	DNC	DNC	No report	FCFE	DNC	No report	DNC	FCFE	FCFF	FCFF	FCFF	DNC	FCFE	FCFE; multiples
EDP	FCFF; DDM	DNC	DNC	FCFF; DDM	DNC	FCFE	FCFF; FCFE	FCFE	No report	FCFE	FCFE	DNC	FCFF	FCFE	FCFF	FCFF	FCFF	FCFF	FCFE	FCFE; multiples
Light	FCFF; DDM	DNC	FCFE	DDM	DNC	FCFE	DNC	DNC	No report	FCFE	FCFE	DNC	DNC	FCFE	FCFF	FCFF	FCFF	FCFF	DNC	DNC
Core Generation																				
Engie	DNC	DNC	FCFE	DDM	DNC	FCFE	FCFE	FCFE	No report	FCFE	FCFE	No report	FCFF	FCFE	FCFF	FCFF	FCFF	FCFF	DNC	FCFE; multiples
Enxova	FCFF; DDM	DNC	FCFE	FCFF; FCFE	DNC	DNC	FCFE	DNC	DNC	DNC	DNC	DNC	DNC	FCFE	DNC	DNC	DNC	FCFF	DNC	DNC
CEBP	DNC	DNC	FCFE	DDM	DNC	FCFE	FCFE	FCFE	DNC	FCFE	FCFE	DNC	DNC	FCFE	FCFF	FCFF	FCFF	FCFF	DNC	FCFE; multiples
ABE T&T	DNC	FCFF	FCFE	DDM	DNC	FCFE	FCFE	DNC	No report	FCFE	FCFE	DNC	FCFF	FCFE	FCFF	FCFF	FCFF	FCFF	DNC	FCFE; multiples
Omega	DNC	DNC	FCFE	DDM	DNC	FCFE	FCFE	FCFE	DNC	FCFE	DNC	DNC	FCFF	FCFE	DNC	DNC	DNC	FCFF	DNC	FCFE; multiples
Transmission plus Generation																				
Alupar	DNC	FCFF	FCFE	DDM	DNC	FCFE	DNC	FCFE	DNC	FCFE	FCFE	DNC	FCFF	FCFE	FCFF	FCFF	FCFF	FCFF	DNC	DNC
Distribution and Generation																				
Equatorial	DNC	DNC	FCFE	FCFF; DDM	DNC	FCFE	FCFF	FCFE	No report	FCFE	DNC	No report	FCFF	FCFE	FCFF	FCFF	FCFF	FCFF	DNC	FCFE; multiples
Energisa	DNC	DNC	FCFE	FCFF	DNC	FCFE	FCFF	FCFF	DNC	FCFE	DNC	DNC	DNC	FCFE	FCFF	FCFF	FCFF	FCFF	DNC	DNC
Legend ==>																				
Methodology		(i) Report accessed and valuation methodology disclosed; or (ii) Report not accessed, but analyst emailed confirming valuation methodology used.																		
No report		(i) Report accessed and valuation methodology not disclosed; or (ii) Report not accessed and analyst did not confirm valuation methodology used.																		
DNC		Broker does not cover the company																		
Methodology:		Description:		# of reports																
FCFE		Free Cash Flow to Equity		91																
FCFF		Free Cash Flow to Firm		75																
DDM		Dividend Discount Model		7																
Multiples		Trading Multiples		9																
RO		Real Options		0																

Sources: Brokerage firms, Investment Banks and Private Banking firms. Table elaborated by the authors.

Note. there is overlap among the figures above. As such, they do not add up.

Table A3. Approximate Number of Equity Research Reports Produced per Quarter

	Category	Brokerage Firm	#
# of reports produced on average per quarter	Reports with disclosed valuation methodology	Ativa	3
		Banco do Brasil	2
		BTG	11
		BoFA	14
		Credit Suisse	10
		Goldman Sachs	14
		Inter	6
		Itaú	15
		JP Morgan	13
		Safra	14
		Santander	14
		UBS	4
		XP	8
		Sub-total (C)	128
	Methodology not in reports, but informed by analysts	Bradesco	14
		Citi	10
		Genial	7
		Morgan Stanley	12
		Sub-total (D)	43
	No analyst reply	Eleven	8
		HSBC	5
		Sub-total (E)	13
	Others	Brasil Plural	0
		Sub-total (F)	0
	# of reports produced (C + D + E + F)		184

Note.

- (i) All research reports and analysts' statements are available upon request;
- (ii) Ativa: it was the only broker that informed it may include Real Options as part of its fundamental valuation methodology in the future, but refrained from giving more details. The broker informed that, at present, it uses only FCFF and DDM;
- (iii) Banco do Brasil: the AES 1Q21 report was not available at CIQ and we could not access it through other means.
- (iv) Bradesco: differently from the other brokerage firms, Bradesco does not publish reports every quarter, but when, in their analyst's view, major sector or company events might affect the covered firms;
- (v) Brasil Plural and Genial: since June 2021 all the research materials previously produced either by Brasil Plural or Genial (a brokerage firm controlled by the former) are produced only by Genial. For simplification purposes, we considered all researches produced by them, in 4Q20 and 1Q21, as produced only by Genial.
- (vi) BoFA: it did not cover Alupar on 4Q20. BoFA resumed coverage of this company based on 1Q21's financials. It was restricted to issue reports on: (a) CESP (1Q21); (b) Copel (4Q20); (c) CPFL (4Q20); (d) Energisa (4Q20); (e) Engie (4Q20); (f) Omega (4Q20).
- (vii) Credit Suisse: it was restricted to issue reports on AES (4Q20 and 1Q21) and Copel (1Q21). The broker in-formed it does not cover CEMIG and ENEVA;
- (viii) Eleven: although we obtained all the reports, the analyst did not reply with evidence on the valuation methodology used. It was included in the "no report" category;
- (ix) HSBC: we neither had access to their reports nor got a timely reply from the analyst. It was included in the "no report" category;
- (x) Inter: it did not cover CEMIG in 4Q20 or 1Q21. The broker informed it started covering CEMIG between the 2Q21 and 3Q21;
- (xi) Itaú: it was restricted to issue reports on 4Q20: Eneva, Light, Omega, and Alupar;
- (xii) Safra: it was restricted to issue reports on EDP (4Q20). The broker also did not cover Eneva in 4Q20 or 1Q21;
- (xiii) Santander: it was restricted to issue reports on Copel, Equatorial and Light (4Q20), and Copel and Equatorial (1Q21);
- (xiv) UBS: it initiated coverage of Eletrobras in 1Q21. As such, no reports were issued in 4Q20.

Source: elaborated by the authors.

Table A4. Number of equity research reports and analysis obtained and average access ratio

# of reports and analyses obtained	Company	4Q20	1Q21
	AES	13	14
	Alupar	12	13
	CE MIG	11	11
	CE SP	13	12
	Copel	10	10
	CPFL	11	12
	EDP	16	16
	Eletrobras	9	10
	Energisa	10	11
	Eneva	8	7
	Engie	13	15
	Equatorial	12	14
	Light	11	12
	Neoenergia	9	10
	Omega	9	10
	Sub-totals	167	177
	Total (4Q20 + 1Q21) (G)	344	

Total reports produced according to Capital IQ	Category	4Q20	1Q21	Reports Access Ratio # 1 (L)
	Covered (from Figure 56, A)	104	104	
	No report (from Figure 56, B)	84	84	(G / H)
	Sub-totals	188	188	
	Total (H)	376		91%

Total reports produced according to our research	Category	4Q20	1Q21	Reports Access Ratio # 2 (M)
	Covered (from Figure 58, C + D) (I)	171	171	
	No report (from Figure 58, E + F)	13	13	(G / K)
	Sub-totals (J)	184	184	
	Total (K)	368		93%

==>>	[(L + M) / 2]	(I / J)	(RO from Table 57 / J)
	92%	93%	0%

Source: elaborated by the authors.

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