The Corporate Social Responsibility of Hydropower Companies – A welfare-economic approach with application to Swiss Alpine regions

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Abstract

Hydropower (HP) activities must increasingly be evaluated from a sustainable development (SD) perspective. Corporate social responsibility (CSR) is the principle frequently applied to evaluate corporate contributions in this regard, though there exists no conceptual and theoretical basis that is common to the various approaches. With the present work, we fill into this gap and provide a formal model that integrates the corporate and societal perspectives of HP activities with a welfare-economic and capital theoretic approach. We particularly address the issues of water rights, resource rents and governance, which is particularly important to analyse projects of HP companies with shared private and public ownership; i.e., if external stakeholders are also sensitive shareholders who grant, at the same time, the company the right to operate. Altogether, this shall support better informed decision making on both corporate and policy levels.

Keywords: Hydropower, sustainable development, corporate social responsibility, Alpine regions, Switzerland, welfare economics, capital theory, water fees, governance.

JEL classification: G38, H20, L94, L98, Q01, Q42

1   Introduction

Corporate social responsibility (CSR) is generally defined as the business world's commitment and contribution to sustainable development (OECD, 2001; WBCSD, 2002). It is particularly understood as "the way firms integrate their values, culture, decision making, strategy and operations in a transparent and accountable manner" (Government of Canada, 2006) and as a program where firms "decide voluntarily to contribute to a better society and cleaner environment" (EC, 2001). Accordingly, socially responsible firms must not only ensure returns to shareholders, wages to employees, and products and services to consumers. They also respond to societal concerns and values regarding the social, economic and environmental development of the system we are living in. This implicates a shift away from the pure shareholder perspective of maximizing profits and corporate value to a broader understanding of operation that encompasses various conflicting goals and multi stakeholder concerns. In other words, CSR implicates a welfare perspective of corporate behaviour that aims at internalizing external costs and avoiding distributional conflicts on a voluntary basis (Arrow, 1973; Heal, 2005; Hediger, 2010; McWilliams and Siegel, 2001).

Measuring a firm's CSR performance thus requires a translation of the normative concept of sustainable development (WCED, 1987) to the corporate level, such as to ensure that current decisions and activities do not jeopardize future generations in satisfying their own needs and wants. As pointed out by the European Commission (EC, 2001), this does not make obsolete regulation and legislation about social rights and environmental standards. Rather, CSR calls for shared responsibility between the government (or the regulator) and private businesses. This directly applies to the management of water resources, which is generally regarded as shared responsibility of public and private actors, and thus to activities in the hydropower industry. The latter is likewise influenced by market developments and by the prevailing institutional framework in different countries (cf. Glachant et al., 2015). Accordingly, the CSR of hydropower companies must be evaluated and implemented in the concrete context of their economic, institutional, geographical and political spheres.

A welfare-economic approach can serve to comprehensively address these issues and formally integrate the societal and corporate concerns of hydropower (HP) in the evaluation of a companies performance and contribution to sustainable development (SD). To this end, we proceed as follows. First, we propose in Section 2 the extension of a welfare-economic model of CSR (Hediger, 2010) to the context of HP companies. Then, we present the major challenges of HP in Swiss Alpine regions in Section 3, and the application of our CSR model to HP companies in these regions in Section 4. Building on this background, we complete our analysis by discussing implications of this microeconomic approach with regard to the current debate about water fees and governance of HP companies. Finally, Section 5 concludes.

The aim is to fill into a conceptual and theoretical gap by providing a formal approach that integrates the corporate and societal perspectives of HP activities from a welfare-economic and capital theoretic perspective. This might particularly help to separate issues of efficiency and equity in polit-economic discourses, and to address distributional problems related to resource rents, water fees and taxes, which is currently a political issue in Switzerland (cf. Betz et al., 2016; BFE, 2017b; Meister, 2014; NZZ 2016; Pfammatter and Piot, 2016; SWV, 2017). Altogether, the approach

presented in this this article shall support better informed decision making on both corporate and policy levels, and thus also contribute to the envisaged energy transition.

2 Measuring the CSR of hydropower companies – an analytical framework

In a business context, social responsibility, transparency and accountability are core sustainability principles (IHA, 2010). This involves the concept of CSR and the business's commitment and contribution to SD that must also be applied to HP activities and companies. As emphasized above, this implies various aspects be taken into consideration. In particular, the local and national characteristics of the hydropower system must be taken into account when evaluating the CSR performance of hydropower companies and their contribution to SD.

Though the principle of CSR is frequently applied in the business world, there exists no conceptual and theoretical basis that is common to the various approaches. We fill into this gap by providing an analytical framework and formal approach that a) allows us to evaluate a companies performance from a societal perspective of SD, and that b) takes into account the specificities of HP operations in their socio-economic and institutional realms. Thus, our first focus is on the elaboration of a formal approach to elaborate a HP company's CSR performance from a welfare-economic perspective. This relates to one stream of literature that deals with the welfare-economic foundations of CSR (e.g., Beltratti, 2005; Heal, 2005) and that contrasts the one that is intimately linked to CSR as a strategic management approach (e.g., Baron, 2007; Porter and Kramer, 2006). Furthermore, our second focus is on the implications regarding the problem of water concessions and the distribution of resource rents from a CSR perspective.

2.1 CSR in a Paretean view of the firm

Our approach, which is based on Hediger (2010), starts with the understanding of "CSR as actions that appear to further some social good, beyond the interests of the firm and that which is required by law" (McWilliams and Siegel, 2001) as well as the conclusion that "socially responsible firms do try to maximize profits but at the same time try to improve the welfare of other stakeholders" (Beltratti, 2005). It does not imply that a company must necessarily fulfil this normative criterion and behave in a socially responsible manner. Rather, it allows us to derive a minimum condition and formal definition of CSR from a welfare-economic perspective that corresponds to the standard problem of welfare economics – the problem of *Pareto improvement* for utility maximizing individuals (Lange, 1942) – as applied to the firm level.

In the short run, this can be formalized with the problem of maximizing at any time t a firm j's profit $\pi(\mathbf{x}_{jt})$ as a function of its activity vector $\mathbf{x}_{jt} = \{x_{jit}\}$, with i denoting the firm's activities, subject to the "*CSR constraint*" that some suitably defined measure of social welfare W must not fall under the reference level $\underline{W}_0 = W(\mathbf{z}^\circ)$, which society could enjoy without the firm's activity and which determines the bottom line for the evaluation of the company's CSR performance:

$$\max_{\{x_{jit}\}} \pi(\mathbf{x}_{jt}) \qquad s.t. \quad W(\mathbf{z}(\mathbf{x}_{jt})) \geq W(\mathbf{z}^\circ) \equiv \underline{W}_0 \qquad (1)$$

This gives us a *Paretean view of the firm*, which captures in an operational way the meaning of CSR as expressed by Beltratti (2005) and where social welfare W is a function of $\mathbf{z}(\mathbf{x}_{jt})$, a vector of the attributes that determine individual and social well-being and that can be positively or negatively affected by the firm's activities $\mathbf{x}_{jt}$. These attributes can be thought of as encompassing issues like aggregate levels of income or consumption (beyond the firm's profit), social capital and environmental quality, as well as degrees of macroeconomic stability (cf. Hediger, 2000, and Section 2.3).

The above optimization problem can also be represented by the Langrangean

$$L_{jt} = \pi(\mathbf{x}_{jt}) + \lambda_{jt} \cdot [W(\mathbf{z}(\mathbf{x}_{jt})) - \underline{W}_0] \tag{2}$$

that formally expresses firm j's internal evaluation of its instantaneaous profits and its net contribution to society, with λ_{jt} denoting the implicit price of the CSR constraint. It also represents the firm's marginal opportunity cost of its (voluntary or enforced) commitment to improving social welfare through its own choice of activity. In other words, it is the firm's marginal cost of internalizing externalities and thus providing an additional net benefit to society. The latter is formally defined as the excess of the resulting welfare $W(\mathbf{z}(\mathbf{x}_{jt}))$ above the reference level $\underline{W}_0$:, with E_{jt} denoting the net value of the externalities caused by firm j's current activities $\mathbf{x}_{jt}$:

$$E_{jt} = E(\mathbf{x}_{jt}) \equiv W(\mathbf{z}(\mathbf{x}_{jt})) - \underline{W}_0 \tag{3}$$

The net externality is positive if $W(\mathbf{z}(\mathbf{x}_{jt}))$ exceeds the bottom line $\underline{W}_0$, and it is negative if $W(\mathbf{z}(\mathbf{x}_{jt}))$ is below the reference level.

For Heal (2005), CSR is "a programme of actions to reduce externalized costs and to avoid distributional conflicts", since "almost all conflicts between corporations and society can be traced to one of these two sources – either discrepancies between private and social costs and benefits, or different perceptions of what is fair." Moreover, Heal emphasizes the role of CSR "to anticipate and minimize conflicts between corporations and society and its representatives". Accordingly, CSR can help "to improve corporate profits and guard against reputational risks." This coincides with Beltratti's (2005) emphasis that CSR is positively related to the market value of firms, and the findings of Minor and Morgan (2011) about the role of CSR "as a powerful form of reputation insurance" and the link between a firm's CSR activities and its stock market price following an adverse effect.

Building on Hediger (2010), firm j's reputation R_{jt} is is included in our analytical framework as an asset (reputation capital) that is self-reinforcing – increasing with external benefits and declining with negative externalities generated by the firm's activities:

$$\dot{R}_{jt} = \frac{dR_{jt}}{dt} = \psi(R_{jt}) \cdot \alpha^{-E(\mathbf{x}_{jt})} \cdot E(\mathbf{x}_{jt}) \tag{4}$$

Here, $\psi(R_{jt}) > 0$ ($\psi' > 0$, $\psi'' < 0$) represents the proportional rate of state-dependent impact of the firm's external effects upon its own reputation. The additional term $\alpha^{-E_{jt}}$

($\alpha > 0$) accounts for potential asymmetries between the impact of positive and negative externalities, with $\alpha > 1$ giving a larger weight to the impact of negative externalities on reputation as compared to positive externalities, while the opposite applies for $0 < \alpha < 1$.

2.2 CSR, corporate value and social welfare

The firm's reputation capital constitutes a dynamic element in our CSR framework. It accounts for the past and current externalities and spillover effects in the economic, social and ecological domains, and thus constitutes an interface to the concept of sustainable development, which is further explored below.

First, we formally integrate the accumulation of reputation capital and other assets in our analytical framework. Thus, we shift the scope from the short to the long run, where the CSR problem is that of maximizing the firm's net present value of profit prospects subject to the above CSR constraint. This brings us to

> **Definition 1:** CSR is "a program of action where a firm's objective is to maximize its *corporate value* and, at the same time, to contribute to the improvement of *social welfare*" (Hediger, 2010)

and its formal equivalent:

$$\max_{\{\mathbf{x}_{jt}, y_{jt}\}} \quad V_{j0} = \int_0^T e^{-rt} y_{jt} \, dt + e^{-rT} V(\mathbf{k}_{jT}, R_{jT})$$

$$s.t. \qquad \dot{\mathbf{k}}_{jt} = \frac{d\mathbf{k}_{jt}}{dt} = \mathbf{I}_{jt} - \delta \mathbf{k}_{jt} = \frac{\pi(\mathbf{x}_{jt}, \mathbf{k}_{jt}, R_{jt}) - y_{jt}}{\mathbf{q}_t} - \delta \mathbf{k}_{jt} \quad , \quad \mathbf{k}_{j0} = \mathbf{k}_j(0) \qquad (5)$$

$$\dot{R}_{jt} = \frac{dR_{jt}}{dt} = \psi(R_{jt}) \cdot \alpha^{-E_{jt}} \cdot E(\mathbf{x}_{jt}) \quad , \quad R_{j0} = R_j(0)$$

$$and \qquad W(\mathbf{z}(\mathbf{x}_{jt})) \geq W(\mathbf{z}°) \equiv \underline{W_0} \qquad \qquad \forall t$$

This is a firm's intertemporal allocation problem of maximizing its net present value V_{j0} subject to the above CSR constraint. It formally represents the Paretean comprehension of CSR in its most simple form.

In this intertemporal setting, the firm's net revenue $\pi_{jt} = \pi(\mathbf{x}_{jt}, \mathbf{k}_{jt}, R_{jt})$ is a function π of its current activities $\mathbf{x}_{jt} = f(\mathbf{k}_{jt}, \mathbf{g}_{jt})$ that are generated with the firm's capital stock $\mathbf{k}_{jt}$ and variable inputs $\mathbf{g}_{jt}$. Furthermore, we assume that the instantaneous net revenue is either distributed in the form of dividends y_{jt} to the shareholders or used for investments $\mathbf{I}_{jt}$ in the firm's capital stock, which are purchased at current market prices $\mathbf{q}_t$, such that $\pi_{jt} = y_{jt} + \mathbf{q}_t \mathbf{I}_{jt}$. Moreover, the net capital accumulation $d\mathbf{k}_{jt}/dt$ is the difference between the firm's gross investments $\mathbf{I}_{jt}$ and depreciation $\delta \mathbf{k}_{jt}$, with δ denoting the constant depreciation rate.

Given the constant discount rate (interest rate) r, the corporate value V_{j0} equals the present value of the firm's prospective stream of net shareholder benefits (dividends) over the planning horizon T plus its terminal value $V(\mathbf{k}_{jT})$ of assets (capital stock) $\mathbf{k}_{jT}$ and reputation R_{jT} at terminal time T, while R_{j0} and $\mathbf{k}_{j0}$ denote the initial values of reputation and other assets (production capital), respectively.

Hence, given the formulation of the optimization problem in Eq. (5), the level of corporate value is represented by the current-value Hamiltonian H_{jt}, with φ_{jt} and μ_{jt} denoting the shadow prices (implicit values) of production capital and reputation capital, respectively:

$$H_{jt} = H(\mathbf{x}_{jt}, \mathbf{k}_{jt}, y_{jt}, R_{jt}) = y_{jt} + \varphi_{jt} \cdot \dot{\mathbf{k}}_{jt} + \mu_{jt} \cdot \dot{R}_{jt} \qquad (6)$$

According to definition 1, CSR requires continuous maximization of this function subject to the CSR constraint implied in Eq. (1). Formally, this is comprehended by maximizing for all t the Lagrangean

$$\max \quad L_{jt} = H(\mathbf{x}_{jt}, \mathbf{k}_{jt}, y_{jt}, R_{jt}) + \lambda_{jt} \cdot [W(\mathbf{z}(\mathbf{x}_{jt})) - \underline{W_0}] \qquad \forall t \qquad (7)$$

where λ_{jt} denotes the shadow price of the CSR constraint of non-declining social welfare due to the firm's activities at time t. Thus, given Eq. (3), maximization of the Hamiltonian (6) and compliance with the welfare constraint $[W(\mathbf{z}(\mathbf{x}_{jt})) - \underline{W_0}] \geq 0$ implies that the negative externalities resulting from the firm's activities would be eliminated if the firm would follow a strategy that is coherent with the above definition of CSR. However, this does not necessarily refer to the broader objective of SD, which goes beyond traditional conceptions of welfare economics and ethics.[1] Moreover, our approach does not require all firms behave in a socially responsible manner. Rather, it provides an analytical reference frame (benchmark) for the evaluation of a firm's CSR performance and thus its contribution to SD.

2.3   Integrating the firms' and societal perspectives

Sustainable development (SD) is a normative concept of equality and posterity that integrates concerns across social, economic and ecological system goals (Barbier, 1987) and that satisfies a set of critical limits in the social, economic and ecological realms (WCED, 1987). This has been integrated by Serageldin (1996) in the concept of sensible sustainability and formalized by Hediger (1999, 2000) with the sustainability-based social welfare function

$$W_0 = W(Y, M, S, Q \mid Y_0, M_0, S_0, Q_0; Y_\#, M_\#, S_\#, Q_\#) \qquad (8)$$

The latter defines the reference when evaluating a company's CSR performance from a societal perspective of SD, which depends on a economy's aggregate income Y, its macroeconomic performance M (e.g., full employment, price level stability), social capital S and environmental quality Q. It is defined for a given state of development $\{Y_0, M_0, S_0, Q_0\}$ that would be achieved without the contribution of a specific project or set of activities and accounts for critical boundaries $\{Y_\#, M_\#, S_\#, Q_\#\}$ of economic, social and environmental capital.

A firm contributes to SD if the resulting level of social welfare will not be below the indifference curve that is given by the total differential

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[1] See also Hediger and Knickel (2009) on different epistemological foundations and ethical aspects of sustainable development in the context of agricultural policy and rural development.

$$dW = W_Y dY + W_M dM + W_S dS + W_Q dQ = 0 \tag{9}$$

with W_Y and dY *et cetera* denoting the marginal social utilities of and marginal changes in the respective variables Y, M, S, Q in the social welfare function. Accordingly, SD requires $dW \geq 0$ and thus

$$dY \geq -\left[\frac{W_M}{W_Y} dM + \frac{W_S}{W_Y} dS + \frac{W_Q}{W_Y} dQ\right] = -\left[\beta_M dM + \beta_S dS + \beta_Q dQ\right] \tag{10}$$

The sustainability-based marginal values $\beta_M = W_M/W_Y$, $\beta_S = W_S/W_Y$, and $\beta_Q = W_Q/W_Y$ of marginal changes in M, S and Q, respectively, represent the evaluation of tradeoffs between these variables and the aggregate income from a societal point of view. These values are essential when evaluating a company's performance from a SD and thus CSR perspective. The latter requires that – as specified in Eq. (1) – social welfare W must not fall under the reference level that society could enjoy without the firm's activities. Thus, its contribution to society must be evaluated at the current state of development that is given by $\{Y_0, M_0, S_0, Q_0\}$ and the corresponding indifference curve W_0. In other words, to be consistent with our definition of CSR the firm must contribute with its activities to an increase in social welfare, or at least to maintain it on the current level.

For this evaluation, let us assume that dY_{jt} is company j's contribution at time t to the aggregate income of an economy in a given year, and dM_{jt}, dS_{jt} and dQ_{jt} are the company's contributions to macroeconomic performance (e.g., full employment), social capital and environmental quality. Under these assumptions and under consideration of the requirements of CSR and SD that are given in Eq. (1) and (10), the income a company generates at a given time must satisfy the following term to be judged as a positive net contribution to SD:

$$dY_{jt} \geq -[\beta_M dM_{jt} + \beta_S dS_{jt} + \beta_Q dQ_{jt}] \tag{11}$$

Let us further assume, for a moment, that the firm's total income is exclusively distributed in form of dividends y_{jt} to the shareholders and labor income ω_{jt} to its employees, or retained for the accumulation of productive and reputation capital $\varphi_{jt} \dot{\mathbf{k}}_{jt}$ and $\mu_{jt} \dot{R}_{jt}$, respectively. In this case, we can reformulate Eq. (11) under consideration of Eq. (6), as follows:

$$H_{jt} = y_{jt} + \varphi_{jt} \dot{\mathbf{k}}_{jt} + \mu_{jt} \dot{R}_{jt} \geq -[\omega_{jt} + \beta_M dM_{jt} + \beta_S dS_{jt} + \beta_Q dQ_{jt}] \tag{12}$$

The left-hand side of this inequality represents the firm's total profit prospect (corporate income) at time t, while the right-hand side in this formula corresponds to the external evaluation of the firm's contribution to social welfare, as defined from a societal perspective of SD.

By reformulation, we get the overall value Γ_{jt} of the company's contribution to society that consists of the internal value of the overall profit H_{jt} from a shareholder perspective plus the external value of its direct and indirect contributions to society:

$$\Gamma_{jt} = H_{jt} + [\omega_{jt} + \beta_M dM_{jt} + \beta_S dS_{jt} + \beta_Q dQ_{jt}] \geq 0 \qquad (13)$$

This provides us with a generic approach to CSR, which represents "the overall value of a company's contribution to society that consists of the internal value of the overall profit from a shareholder perspective and the external value of its direct and indirect contribution to society" (Hediger, 2010). It implies, on one side, the firm's implicit prices of capital, φ_{jt} and μ_{jt}, that draw from the intertemporal maximization of corporate value, as formalized in Eq. (5). On the other side, it includes the externally determined accounting prices β_M, β_S and β_Q that, in principle, must be assessed on a societal level and also account for individual preferences and critical limits of SD (cf. Hediger, 2000; Serageldin, 1996).[2]

2.4 *An extension to resource-based companies: the case of hydropower*

When applying the concept of CSR to HP companies one needs to extend the above framework for taking into account the externalities and distributional effects going along with their activites. Those particularly involve the distribution of the *tax payments* and *water resource rents* among different territorial entities as well as the socio-economic and environmental impacts on the local and regional economies in the HP production area.

In general, a *resource rent* is a surplus that results when converting a natural resource (here waterpower) into a marketable product (electricity). This rent is defined as "the difference between the price of a good produced using a natural resource and the unit cost of turning that natural resource into the good" (Hartwick and Olewiler, 1998). These costs include the payments of the capital, labor, material and other inputs that are used in the production process. What remains after these factor costs are netted out is the value of the natural resource – the waterpower. In the first instance, this value (the water resource rent) flows as an income to the holder of property or use rights on that resource – the water.

At this point it is important to notice a fundamental difference between rent and profit. For Ricardo (1817), this distinction was of great importance since the laws that regulate the progress of rent are widely differenct from those that regulate the progress of profits, and they seldom operate in the same direction. Rothman (2000) adds that "rent arises when exploiting a resource that Nature has endowed with a value that is independent of any labor, capital or entrepreneurial effort applied to the resource." As a consequence, resource developers – HP companies in our case – do not earn rent as they earn normal profits (i.e., return on capital). Rather, Rothman emphasizes that "rent is a windfall created by exploiting the bounty of Nature." And "the owner of the natural resource is the owner of the rent." Accordingly, capturing resource rents from the developers and delivering it back to the owners – often the public – is common practice in most resource-based industries, like oil, coal, mining, etc. (Garnaut, 2010; Lund, 2009).

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[2] For the appraisal of the accounting prices β_M, β_S and β_Q – that measure the tradeoffs between macro-economic performance, social capital and environmental quality, on one side, and aggregate income, on the other – an integrated approach is required, which brings together a systemic view of impact assessment and its evaluation from a stakeholder perspective (cf. Gibson, 2006; Hediger and Voegeli, 2016; Toman et al., 1998).

Regarding the situation of HP in mountain areas of Switzerland, the CSR framework must particularly reflect the water fees, water taxes and corporate taxes, the fiscal incidence of these levies, as well as the ownership structure of the HP company. In this context, company j's *net revenue* can be represented by

$$\pi_{jt} = \pi(\mathbf{x}_{jt}, \mathbf{k}_{jt}, R_{jt}) = y_{jt} + \mathbf{q}_t \mathbf{I}_{jt} + \Omega_{jt} + \Psi_{jt} = \mathbf{p}_t \mathbf{x}_{jt} - c(\mathbf{x}_{jt}) \qquad (14)$$

with Ω_{jt} and Ψ_{jt} denoting the water fees and taxes, respectively, paid by company j at time t. Hence, as an extension of Eq. (13), HP plant j's contribution to *corporate value* encompasses three major components:

$$\Gamma_{jt} = \left(y_{jt} + \varphi_{jt} \dot{\mathbf{k}}_{jt} + \mu_{jt} \dot{R}_{jt} \right) + \left\{ \Omega_{jt} + \Psi_{jt} \right\} + \left[\omega_{jt} + \beta_M dM_{jt} + \beta_S dS_{jt} + \beta_Q dQ_{jt} \right] \qquad (15)$$

The terms in the first and third bracket are the same as in our basic model given in Eq. (13). They represent the internal value of the overall profit from a shareholder perspective (first term) and the external value of the company's contributions to society from a stakeholder perspective [third term]. The extension comes with the middle term – {second term} – that encompasses the water fees and taxes paid to the "public hand".

From a theoretical point of view, this implicates that water fees and taxes are elements of revenue sharing among different stakeholder groups rather than cost factors. Indeed, translated from Ricardo (1817) the "produce of HP" – i.e., the value of the water that is derived from using its potential energy by the united application of labor and capital – is divided under the names of rents, profits and wages among the proprietors of the water, the owners of the stock of capital (the investors) and the laborers (employees) by whose industry the the electricity is generated.[3] In addition, through corporate and other taxes, some share of the revenue is generally diverted to the "public hand". In the end, the regulation of this distribution of revenue is an issue of political economics.

Before further discussing the implications of this interpretation and before investigating the application of our theoretical framework the the case of HP companies in the Swiss Alps, we present the specific challenges the industry currently faces in Switzerland.

3   Major challenges for hydropower in Swiss Alpine regions

Located at the heart of the Alps, Switzerland has ideal conditions for the utilisation of HP, which made it the country's most important domestic source of renewable energy. It accounted for almost 90% of domestic electricity production at the beginning of the 1970s, and its share fell to actually about 56% following the authorization of nuclear power plants (SFOE, 2017a). Nonetheless, HP still constitutes the backbone of the electricity supply in Switzerland (Pfammatter, 2012). Today, 604 HP plants exist in Switzerland (593 stations are located on Swiss territory, the rest across the border) with a capacity of at least 300 kW, each (BFE, 2015). Together, these power plants provide

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[3] In the Preface to his semenial book Ricardo (1817) emphasizes: "The produce of the earth – all that is derived from its surface by the united application of labour, machinery, and capital, is divided among three classes of the community; namely, the proprietor of the land, the owner of the stock of capital necessary for its cultivation, and the labourers by whose industry it is cultivated." And he adds that "the proportions of the whole produce of the earth which will be allotted to each of these classes, under the names of rent, profit, and wages".

an installed capacity with an average production of about 36 TWh/a, of which 47,6% is produced in run-of-river plants, 48% in storage plants and approximately 4,4% in pumped-storage plants (SFOE, 2017a). The major part of this production originates from the mountain regions in the Swiss Alps, while another important share is generated along the rivers Aare and Rhine, in the Northern part of the country (cf. Tab. A in the Appendix, and the interactive map on SFOE, 2017c).

Currently, Swiss energy policy and electricity companies face a wide range of challenges that have initiated a debate about future prospects of HP and its role within the envisioned energy transition – the Federal Council's "Energy Strategy 2050" – which particularly aims at phasing out nuclear energy and thus replacing about 40% of the domestic electricity supply (BFE, 2017a; Pfammatter, 2012; SFOE, 2017a). In particular, the Federal Council's Energy Strategy 2050 focuses on the consistent exploitation of the existing energy efficiency potentials and on the balanced use of the potentials of hydropower and new renewable energy sources (SFOE, 2017b). The challenge is to realize these targets, to exploit the remaining hydropower production potential of about 3.2 TWh/a (BFE, 2012), and to cope with the volatility of solar and wind energy production in Europe. To this end, investments are required not only in new energy technologies (e.g., solar, wind, geothermal) but also in the construction of new HP plants, in the retrofitting (renovation and expansion) of existing ones and in the adjustment of HP operations to get higher flexibility (Barry et al., 2015). Especially, storage and pumped-storage plants play a key role in the storage of electricity and the stability of the international network, especially with the increasing production from intermittent energy sources, notably solar and wind energy (Betz et al., 2016; Gaudard et al., 2014; IEA, 2011a, 2011b).

However, given the currently low prices on the European electricity market and the relatively small price differentials between low and high price periods, the pofitability and competitiveness of Swiss HP is under pressure. Accordingly, based on investigations with a questionnaire and a stakeholder workshop, Barry et al. (2015) identified the main challenges of Swiss HP in the domains of market development and regulatory aspects. Furthermore, Betz et al. (2016) point out that in order to recover their competitiveness Swiss energy companies need *a*) to reduce their cost of production and realise efficiency potentials, and *b*) to optimise their trading strategies under consideration of current and future market conditions. Moreover, the institutional arrangements – that are defined by federal and cantonal policy – are currently under reconsideration and subject to public debates. This particularly involves discussions about the regulation of water fees and the process of granting and renewing concessions. In Switzerland, the latter are framed by federal legislation, while the water authority and, thus, the ultimate decision about the concessioning of water resource uses is with the cantons. Moreover, the cantons have the power to fix the applied water fee rate up to the maximum that is defined by the federal authories. The principles for determining this maximum rate are defined in the federal Water Rights Law (Wasserrechtsgesetz, WGR). The legal maximum has been increased several times since the inception of the law in 1918, from initially 8.16 CHF/kW installed capacity to currently 110 CHF/kW; this has primarily been motivated by fiscal reasons (Filippini and Geissmann, 2014; Meister, 2014; Sigg and Röthlisberger, 2002).

Table 1. The receivers of the water fee revenues in Switzerland

	Canton	Districts	Municipalities	Others[a]
Valais (VS), Grisons (GR), St-Gall (SG)	X	-	X	-
Schwyz (SZ)	X	X	X	-
Uri (UR), Obwalden (OW), Glarus (GL)	X	-	-	X
The other 19 cantons	X	-	-	-

a) E.g., water cooperations, private landowner, etc.
Source of information: Sigg and Röthlisberger (2002)

Currently, the annual water fees amount to about 550 Mio CHF in Switzerland (BFE, 2017b; SWV, 2017). About 65% of this amount is paid in the four Alpine cantons Grisons, Ticino, Uri and Valais, where the water fees constitute a major source of fiscal revenue. In numerous municipalities, the water fees constitute between 20 and 40% of the total revenues, in some even more than 40% (Pfammatter and Piot, 2016; SWV, 2017).

Apart of water fees and general taxes, cantons and municipalities further benefit from HP. They also charge one-time concession fees, are shareholders of HP companies, and receive electricity at reduced prices or for free, which can be sold to final consumers or on the market. Finally, the local economies with HP production benefit through additional employment of local people and value-added in the local businesses.

Regarding all these challenges, discussions have been launched in politics, the media and academia (e.g., Banfi and Filippini, 2010; Betz et al., 2016; Filippini and Geissmann, 2014; Gaudard et al., 2016; Glachant et al., 2015; Meister, 2014; Piot and Pfammatter, 2017; SWV, 2012) concerning the exploration of the remaining HP potential that is needed to realise the goals of the federal Energy Strategy 2050, the current lack of profitability that hinders investors from undertaking new projects, and the water fees and governance structure. The solution of these problems is not straightforward, since any modification of the current system of resource rent "taxation" would have substantial consequences on public finance, especially in HP regions, and thus on the equalization payments in the respective cantons and on the federal level. Indeed, water fees and taxes of HP companies are an important source of revenue in many mountain areas. At the same time, given the current situation on the electricity market with low prices and low spreads between peak and off-peak periods, the water fees constitute a substantial burden to HP companies that cannot in general cover their fixed cost. Yet, those companies are mainly owned by non-mountain cantons, who obtain the major share of profits and the remaining resource rents (after taxes and water fees). Thus, the current system of water fees serves the distribution of resource rents among mountain cantons, where most HP comes from, and the owners of the HP companies that are mainly owned by cantons located on the Central Plateau.

Finally, the future of HP is a major challenge for sustainable development (SD), particularly in the Alps, where it constitutes an important local industry and major source of fiscal revenues. But, HP companies and policy also face a series of new challenges, ranging from liberalisation and market conditions over the impacts of climate change to land and water resources management and the environmental impacts

of HP plants: "The reorganization of power generation in Switzerland following the decision by the Swiss parliament and Federal Council to close the country's nuclear power stations, and the attendant expansion of renewable energies, will pose major challenges to nature and the landscape" (ARE, 2012). Moreover, the renewal/reversion of water concessions and the design of future water fee systems constitute major challenges that must carefully and simultaneously be addressed on the federal, cantonal and local scales. Ultimately, this implicates new views on governance and private-public partnership, along with the integrated evaluation of corporate performances from a financial and societal perspective of SD.

4   The CSR of hydropower companies: the case of Swiss mountain areas

When applying our analytical framework and its interpretation to the context of HP in Swiss Alpine areas – the so-called "water tower of Europe" (Blanc and Schädler, 2014; OECD, 2015) –, we must acknowledge that HP is the most important pillar of the current and future energy system (Bundesrat, 2013) and that it is a particularly important local industry and backbone of the local economies in Alpine regions. It generates income and employment to residents as well as important fiscal revenues to cantons and municipalities (AEV, 2009; AG Wasserkraft, 2011; BFE, 2013; Filippini and Geissmann, 2014; Rieder and Caviezel, 2006; Romerio, 2008). In addition, Alpine HP plants with reservoirs provide an important capacity service to the national and international energy system by storing electricity between periods of peak supply and peak demand (Moser, 2014; VSE, 2012, 2014). At the same time, HP companies and regions face various challenges. Those involve the competing use of land and water resources between HP, tourism and agriculture as well as new tasks and uncertainties related to energy markets, climate change and the phasing out of nuclear energy (Barry et al., 2015; Beniston, 2012; BFE, 2008; Gaudard and Romerio, 2014; Gaudard et al., 2013, 2014; Pfammatter, 2012). In addition, the renewal and reversion of water concessions, respectively, as well as the design of future water fees and taxes may induce a new era of HP utilization (Banfi et al., 2004, 2005; SWV, 2012; Wyer, 2008), bring about new institutional settings, and need new forms of governance. Yet, these issues must be analysed both from a public policy and a corporate enterprise perspective that are the most suitably integrated in a CSR framework.

As Heal (2005) underlines, CSR involves actions *a*) *to reduce externalized costs*, which in our model are coverd by the third term in Eq. (15) and partly internalized through the company's reputation capital, and *b*) *to avoid distributional conflicts*. For HP companies in Switzerland, the latter mainly result from the ownership structure, which has already been identified as an important element in the current discussion about the water fees, and the distribution of resource rents through water fees and taxes. Within the mountain cantons of Grisons and Valais, potential distribution conflicts exist between those municipalities with direct water fee revenues and the other municipalities without HP plants. However, in these two cantons, the distributional problem is, in principle, solved by the part of the water fees directly collected by the canton and by the cantonal equalization payment system. The other conflict potential exists between the mountain cantons, where most of the HP plants are located and that get fiscal revenue trough the water fees, and the Central Plateau cantons, who are the main owners of the HP companies and where most of these companies also pay corporate taxes (cf. Filippini and Geissman, 2014, p. 30). Thus, the water fees and taxes paid by the HP

companies have a direct fiscal incidence that a socially responsible firm should be aware of and account for.[4] Moreover, one must take into consideration that a HP plant might have different macroeconomic, societal and environmental impacts at the local, national, federal and even international scale.

Accordingly, we further extend our CSR model by explicitly considering the instantaneous recipients of the water fee and tax payments and by separating the distribution of dividens among the different territorial entities and private investors. In the following, $l = 0$ denotes the private investors, $l = 1$ the municipal level, $l = 2$ the micro regions (districts or local cooperatives), $l = 3$ the canton where the HP plant is located, $l = 4$ the other cantons, and $l = 5$ the federal level. Moreover, regading the impacts of a HP plant that are covered in the third term of Eq. (15), we also consider the international shpere $l = 6$, at least theoretically. Altogether, we can reformulate Eq. (15) as follows:

$$
\Gamma_{jt} = \left(\sum_{l=0}^{4} y_{ljt} + \varphi_{jt} \dot{k}_{jt} + \mu_{jt} \dot{R}_{jt} \right) + \left\{ \sum_{l=1}^{3} \Omega_{ljt} + \sum_{l=1}^{5} \Psi_{ljt} \right\}
$$

$$
+ \sum_{l=1}^{6} \left[\omega_{ljt} + \beta_M dM_{ljt} + \beta_S dS_{ljt} + \beta_Q dQ_{ljt} \right]
$$

(16)

This accounts, in monetary terms, for the contribution to total social net benefit resulting from HP plant j's operation in period t. It encompasses:

1. The plant's contribution to the corporate value, consisting of the *dividends* payed to private and public shareholders (i.e., private investors, municiplaities, districts, local cooperatives, and cantons – cf. Tab. 1), the *revenue kept back* in the company for current and future investments (valued with the shadow prices of capital φ_{jt}), and the valued change of the firm's *reputation* (with the shadow price of reputation μ_{jt}).

2. The public revenue resulting from *water fees* and *taxes* paid to the different public entities, ranging from the municipal to the cantonal and federal levels.

3. The total the *salaries* payed to local, national and international employees, as well as the plant's *contributions to macroeconomic stability, social capital and environmental quality*, valued with the socially-determined accounting prices.

Thus, the direct financial incidence through the distribution of the dividends, water fees and taxes among private investors ($l = 0$) and the different state entities ($l = 1,…,5$) is explicitly covered in the first line of this formulation. The indirect fiscal incidences resulting through public spending in the different regions[5] as well as the spatial impacts of the HP plant are theoretically captured with the third term that represents the social benefits generated by the HP plant at the different spatial scales $l = 1,…,6$.

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[4] See also Tab. A in the Appendix.

[5] Notice that this theoretically also includes the cantons on the Central Plateau, who are the main shareholders of most HP companies in Switzerland (Filippini and Geissman, 2014). However, the share of public revenue generated from HP activites is much smaller than it is in the mountain cantons.

To determine these societal contributions of HP is an issue of regional impact analysis and of sustainability assessment, which is beyond the scope of this article. Rather, our focus is on CSR and the contribution of HP companies to SD. Besides the external benefits (the third term in Eq. 16), the latter encompasses the sharing (the distribution) of the revenues (profits and resource rents) from HP operations among the different "shareholders", including both the investors and the legal owners of the water rights, i.e. the cantons and municipalities. Apparently, this is an issue of governance, which generally refers to the structures and processes "designed to ensure accountability, transparency, responsiveness, rule of law, stability, equity and inclusiveness, empowerment, and broad-based participation", and thus "represents the norms, values and rules of the game through which public affairs are managed in a manner that is transparent, participatory, inclusive and responsive" (UNESCO, 2017). Regarding Swiss HP, this is mainly set by the constitutional and legal framework of the confederation and the cantons as well as by the rules of the European electricity market. Particularly important are the federal Water Rights Law (Wasserrechtsgesetz, WGR), the cantonal legislations and the terms of the individual water concessions that together frame the current water fee system and the distribution of water fees among the different receipients (cf. Tab. 1). Yet, the ownership structure of the mainly public-owned Swiss utilities is an issue of public and corporate governance.

Corporate goverance (CG) involves the classic problems between owners and managers (cf. Shleifer and Vishny, 1997; Tirole, 2001), as well as problems between owners themselves and between stakeholders (Beltratti, 2005): "There is a CG problem whenever one or more groups of stakeholders coordinate their actions in order to increase their benefits at the expense of the benefits of the other stakeholders." Apparently, this relates to the current situation and discussion about water fees and concessions in Switzerland (Betz et al., 2016; BFE, 2017b; NZZ, 2016; Piot and Pfammatter, 2017), on the one hand, and our representation of corporate value in Eq. (16). In other words, CG and CSR are complementary. As emphasized by Beltratti (2005): "They can reinforce each other in the modern vision of the firm as an institution which does not disregard various relevant constituencies in its search for increases in value."

Formally, this is captured by the CSR framework in Eq. (16), which encompasses private (corporate) and the external (societal) values that must be taken into account when evaluating HP investments and the CSR performance of HP companies. More precisely, one should consider the total value TV_{j0} of HP plant j at present time $t=0$, which corresponds to the net present value of its operations over the planning period T (e.g., life-time of the investment, or duration of the concession) plus its terminal value at that point in time, with $r > 0$ denoting the relevant discount factor:

$$TV_{j0} = \int_0^T e^{-rt} \Gamma_{jt} dt + e^{-rT} TV_{jT}$$

$$= \int_0^T e^{-rt} \left(\sum_{l=0}^4 y_{ljt} + \varphi_{jt} \dot{\mathbf{k}}_{jt} \right) dt + \int_0^T e^{-rt} \left\{ \sum_{l=1}^3 \Omega_{ljt} + \sum_{l=1}^5 \Psi_{ljt} \right\} dt + \int_0^T e^{-rt} \mu_{jt} \dot{R}_{jt} dt \qquad (17)$$

$$+ \int_0^T e^{-rt} \sum_{l=1}^6 \left[\omega_{ljt} + \beta_M dM_{ljt} + \beta_S dS_{ljt} + \beta_Q dQ_{ljt} \right] dt + e^{-rT} TV_{jT}$$

This can be decomposed into the private value

$$PV_{j0} = \int_0^T e^{-rt} \left(\sum_{l=0}^4 y_{ljt} + \varphi_{jt} \dot{\mathbf{k}}_{jt} \right) dt + \int_0^T e^{-rt} \mu_{jt} \dot{R}_{jt} dt + e^{-rT} PV_{jT} \qquad (18)$$

and the external value of these HP operations:

$$EV_{j0} = \int_0^T e^{-rt} \left\{ \sum_{l=1}^3 \Omega_{ljt} + \sum_{l=1}^5 \Psi_{ljt} \right\} dt$$

$$+ \int_0^T e^{-rt} \sum_{l=1}^6 \left[\omega_{ljt} + \beta_M dM_{ljt} + \beta_S dS_{ljt} + \beta_Q dQ_{ljt} \right] dt + e^{-rT} EV_{jT} \qquad (19)$$

Altogether, this implicates that a socially responsible firm would not only maximize its private value PV_{j0}, i.e. the return of financial investments, but also take into consideration the external value EV_{j0} of its operation. Along with its socio-economic and environmental performance, the latter also includes the tax and rent payments to the different territorial entities.

Accordingly, investment decisions should be taken from a wider perspective of CSR and SD, which calls for maximizing the *total value of HP* that can be reformulated as follows:

$$TV_{j0} = \int_0^T e^{-rt} \pi_{jt} dt + \int_0^T e^{-rt} \mu_{jt} \dot{R}_{jt} dt$$

$$+ \int_0^T e^{-rt} \sum_{l=1}^6 \left[\omega_{ljt} + \beta_M dM_{ljt} + \beta_S dS_{ljt} + \beta_Q dQ_{ljt} \right] dt + e^{-rT} TV_{jT} \qquad (20)$$

This includes the net present value of the firm's instantaneous net revenues π_{jt} that, according to Eq. (14), also encompasses the water fee and tax payments that are an important source of revenue in some Alpine regions. Hence, investment decisions should primarily be taken from an allocation (efficiency) perspective, rather than involve distributional concerns in the first instance.

Given the currently low elelctricity prices and profitability of HP operations, this implicates that – from a CSR perspective – investments in retrofitting and new plants should be undertaken from a societal point of view even if the private value of the plant PV_{j0} is negative, as long as the external value EV_{j0} exceeds the private value; i.e. if EV_{j0} > PV_{j0} and thus TV_{j0} > 0.

However, the problem remains about attracting investors to engage in projects with long life time and large uncertainties that are typical for HP plants. It involves first the fundamental question of CG that is to assure financiers get a return on their financial investment (Shleifer and Vishny, 1997). Second, governance is not only to set norms, strategic vision and direction and formulate high-level goals and policies. It is also "to ensure that the organization is working in the best interests of the public, and more specifically the stakeholders who are served by the organization's mission" (UNESCO,

2017). As revealed with our formal model, these two perspectives are complementary in their shaping of the objective function and the constraints faced by corporations (Beltratti, 2005). Hence, HP investments must not solely be guided by financial considerations. Rather, from a societal perspective of SD, the external benefits to society that are captured by EV_{j0} must also be taken into account. The so called "public hand" (the confederation and the cantons) as well as philanthropic investors who also care about those societal values might have to play a role as additional investors in HP. This is particularly important for Swiss HP companies with shared private and public ownership, and where external stakeholders (i.e., the confederation, the cantons, and the municipalities) are also sensitive shareholders who grant the company the right to operate.

5   Conclusion

Hydropower (HP) is a key to sustainable development (SD) in many regions, especially in the Alps. Accordingly, the performance of HP companies must be evaluated from a SD perspective and with regard to its contribution to society. Corporate social responsibility (CSR) is the principle for this purpose. It implies a translation of the normative framework of SD to the corporate level; that is, the impacts of a HP company or a single plant on the economy, society and environment. Building on a Paretean view of the firm (Hediger, 2010) and a welfare-economic perspective of SD (Hediger, 2000; Serageldin, 1996), we present an analytical framework to link the concepts of SD and CSR. We adjust it to the specific requirements of evaluating the CSR performance of HP companies. In other words, we extend a welfare-economic approach of CSR to the case of HP companies and apply to an investigation on current policy issues with a special focus on HP in Swiss Alpine regions.

Given the most fundamental understanding of CSR as a program where firms act such as to maximize profits (or, from a long-run perspective, corporate value) and at the same time to improve the welfare of other stakeholders (Beltratti, 2005; Hediger, 2010), CSR is usefully formalized as a constrained optimization problem of Pareto improvement and capital accumulation, including reputation capital. This allows us to assess the opportunity cost of a firm's voluntary or enforced commitment to improve the well-being of other people; i.e., social welfare at large. From a theoretical point of view, social welfare involves externalities and distributional concerns. The former can be seen as related to the firm's reputation capital, whereas the latter involves the distribution of income and property rights, and thus issues about the licence to operate and sharing resource rents. Regarding HP, this particularly concerns the current discussion about HP concessions and water fees that must also be addressed when it comes to the implementation of CSR strategies by HP companies and their CSR reporting. The latter requires a comprehensive assessment of the firm's activity and its impacts upon the social, economic and environmental systems. Moreover, it must be based on corporate and societal accounting prices to weigh those changes form a societal perspective against the financial concerns of the shareholders and other receipients of revenues from the HP company.

In addition, accounting for the prevailing institutional settings and the market environment, the CSR of HP entities must be evaluated and implemented in the concrete context of the economic, institutional and geographical sphere of operation. In

Switzerland, this context particularly involves the system of water fees and taxes that is specific to each canton, and that entails substantial financial revenue to some municipalities in Alpine regions. Moreover, the ownership structure of companies running HP plants must be taken into consideration when evaluating their CSR performance. This is formally integrated in our CSR model that accounts, in monetary terms, for the social benefits of public revenue resulting from water fees and taxes paid by the HP company as well as the spatial impacts of the plant. In our analytical model, these impacts are captured by the social benefits generated by the HP plant on the different territorial levels; i.e., the direct and indirect financial incidence through the distribution of the dividends, water fees and taxes among the different state entities. This aspect is particularly important for HP companies with shared private and public ownership, and where external stakeholders are also sensitive shareholders who grant the company the right to operate.

The latter is an issue of political economics, since it involves tradeoffs between the profitability of HP plants and the distribution of water resource rents. Hence, the discussion about water fees and the granting of HP concessions must involve a discussion about the governance and ownership structure of HP companies, as well as the fiscal incidence of these decisions – especially in mountain areas that substantially depend on water fees as an important source of revenue in their public budget. By addressing those issues, we enter the spheres of corporate and public governance, which widens our perspective to also include institutional and management aspects of corporate responsibility at large. It implicates a shift away from the pure shareholder perspective of maximizing profits and corporate value to a broader understanding of operation that encompasses various conflicting goals and multi-stakeholder concerns.

CSR does not make obsolete regulation and legislation about social rights and environmental standards. Rather, it calls for shared responsibility between the government and corporate enterprises. Moreover, our analysis reveals that private (corporate) and the external (societal) values must be taken into account when evaluating HP investments and the CSR performance of HP companies. Accordingly, the *total value of HP* encompasses (*a*) the internal value of the overall profit prospects from a shareholder perspective and (*b*) the external value of its direct and indirect contribution to society from a community and SD perspective. The latter implies externally determined accounting prices that must, in principle, express individual preferences, community values and risk premiums for the anticipation of potentially irreversible changes (critical limits) at the boundaries of the opportunity space for SD.

Building on this background, investment decisions should primarily be taken from an allocation (efficiency) perspective, rather than involve distributional concerns in the first instance. This implicates that investments into retrofitting and new HP plants should be undertaken from a societal point as long as the total value of HP is positive, even if elelctricity prices and the profitability of HP operations are low, as this currently is the case. As a consequence, discussions about water fees as well as the granting of HP concessions must involve a discussion about the governance and ownership structure of HP companies, as well as investments by public entities and philanthropic investors who also care about the societal values of HP. This is justified by the fact that CSR calls for shared responsibility between the government (or the regulator) and private businesses running HP plants.

All in all, we provide a formal approach that is based on welfare economic and capital theoretic considerations as well as the political-economic issues of water rights and resource rents. It integrates efficiency and equity concerns that are important when it comes to decisions about investments in HP plants from both a corporate and societal (governmental) point of view. Finally, it provides an analytical approach towards the assessment of HP's contribution to SD.

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Appendix

Table A. Swiss hydropower plants

Region	Canton	No of plants	Maximum capacity (MW)				Average expected production (GWh/a)			
			Run-of-river plants	Storage plants	Pumped-storage plants	TOTAL	Run-of-river plants	Storage plants	Pumped-storage plants	TOTAL
Alps	GR	102	595.2	1'910.4	172.5	2'678.0	2'227.9	5'285.7	303.0	7'816.6
	TI	31	276.3	960.7	212.0	1'449.1	938.6	2'481.2	122.8	3'542.6
	UR	23	289.4	204.7		494.0	1'145.6	383.2		1'528.8
	VS	108	873.6	3'433.1	250.7	4'557.4	3'261.9	5'947.4	437.5	9'646.8
	Subtotal	**264**	**2'034.5**	**6'508.9**	**635.2**	**9'178.5**	**7'573.8**	**14'097.5**	**863.3**	**22'534.7**
	(share CH)	*44.5%*	*52%*	*82%*	*35%*	*67%*	*44%*	*81%*	*55%*	*64%*
Pre-Alps	SZ	14	62.4	48.0	118.1	228.4	234.7	60.0	181.4	476.2
	OW	11	35.5	80.8		116.3	152.2	157.9		310.1
	NW	6	30.9	14.4		45.3	127.2	31.8		159.0
	GL	35	103.9	386.0	140.0	629.9	404.0	531.7		935.7
	ZG	6	7.6		14.5	22.1	38.4		30.4	68.8
	FR	13	49.3	124.3	93.9	267.6	157.5	388.4	62.5	608.4
	AI	1	1.4	2.5		3.9	3.1	7.7		10.8
	Subtotal	**86**	**290.9**	**656.0**	**366.5**	**1'313.5**	**1'117.1**	**1'177.5**	**274.3**	**2'569.0**
	(share CH)	*14.5%*	*7%*	*8%*	*20%*	*10%*	*7%*	*7%*	*18%*	*7%*
Bern and Vaud§	BE	65	287.7	674.0	364.0	1'325.7	1'464.8	1'805.0	55.4	3'325.2
	VD	24	159.7	28.9	146.1	334.7	680.2	36.7	97.2	814.0
	Subtotal	**89**	**447.4**	**702.9**	**510.1**	**1'660.4**	**2'145.0**	**1'841.7**	**152.6**	**4'139.2**
	(share CH)	*15.0%*	*11%*	*9%*	*28%*	*12%*	*12%*	*11%*	*10%*	*12%*
Plateau and Jura	ZH	13	79.8		48.4	128.2	491.7		101.2	
	LU	9	8.5			8.5	52.7			52.7
	SO	8	87.3			87.3	543.6			543.6
	BS	0	47.3			47.3	261.6			261.6
	BL	10	53.6			53.6	303.0			303.0
	SH	4	42.5		5.0	47.5	279.6			279.6
	AR	3	8.9			8.9	23.0			23.0
	SG	47	63.2	88.6	274.3	426.1	255.2	181.7	175.9	612.8
	AG	29	541.7			541.7	3'240.8			3'240.8
	TG	11	10.7			10.7	60.4			60.4
	NE	13	34.2			34.2	134.7			134.7
	GE	3	136.2			136.2	646.1			646.1
	JU	4	7.0			7.0	36.6			36.6
	Subtotal	**154**	**1'120.9**	**88.6**	**327.7**	**1'537.2**	**6'328.9**	**181.7**	**277.1**	**6'194.9**
	(share CH)	*26.0%*	*29%*	*1%*	*18%*	*11%*	*37%*	*1%*	*18%*	*17%*
TOTAL	**CH**	**593**	**3'893.7**	**7'956.4**	**1'839.5**	**13'689.6**	**17'164.8**	**17'298.5**	**1'567.3**	**35'437.8**
	(% share)	*100%*	*28%*	*58%*	*13%*	*100%*	*48%*	*49%*	*4%*	*100%*

§ The cantons of Bern and Vaud are separated here, since they both cover areas belonging to the Alps, Pre-Alps, Plateau and Jura.

Source: Statistik der Wasserkraftanlagen der Schweiz, Stand 01.01.2015 (BFE, 2015)