

ENERGY

Using energy as currency: re-establishing the bridge between the financial and the real world

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The introduction of energy as an alternative currency can be a compelling incentive for meeting renewable energy targets while obtaining the benefits to the local economy that alternative currencies provide.

The ability of an economy to grow is predicated on increasing energy availability and decreasing energy intensity. In both cases, thermodynamics limits the extent of change but due to a historical fluke these limits are not reflected in today's financial system. Introducing energy as a complementary currency provides a viable way for realigning economic expectations and the physical world thus establishing a trajectory for a sustainable societal transition. This article investigates the concept of using energy as currency and its broader implications. Cities are responsible for more than two thirds of global primary energy consumption (Table 8.2 (IEA, 2008)) and their density makes them ideal candidates for introduction of alternate currencies. We describe a system – the Ergo – that can be introduced by energy-constrained urban communities.

Free energy and the banking system: the historical fluke

While the boundaries of the physical world that we inhabit are clearly delimited, our civilization has constructed a super-structure that fundamentally defies that reality in the form of the financial system. The beginning of the fossil fuel age marked an era of apparent energy abundance. Its coincidence with technical development allowed Europe to escape the looming fuel shortage from extreme deforestation (Rifkin, 2009) and created the persistent illusion of unlimited economic expansion potential that in turn entered into the fundamental assumptions of the then nascent economic thinking. Indicatively, primary energy consumption per capita rose from 7,000 kWh in 1800 to around 55,000 kWh in 2000 in industrial countries. This abundance precipitated a period of effectively undisrupted economic growth lasting for more than fifteen generations.

The financial system evolved conditioned by this growth and became predicated on the ability to maintain past growth rates of wealth creation. The fractional reserve banking system which is at the core of today's financial system effectively adds to the monetary supply through

loans, and other increasingly more complex instruments, limited by the (variable) regulated reserve ratio. When debt is repaid, this virtual money supply is destroyed but the interest charged is not. Therefore, interest rates above inflation require increases in wealth to be sustainable. In past societies that lacked the benefit of an abundant energy supply and technology to exploit it, the inability of the economy to grow indefinitely was recognized through Jubilee events that cancelled debt and redistributed assets.

Today, the stability of the current financial system is predicated on the ability of the global economy to grow. Alas, since economic growth is strongly correlated to energy (and material) consumption and the energy available to humankind is a finite resource limited by our ability to extract it, the laws of thermodynamics and its impacts on Earth's ecosystems, our society is faced with a day of reckoning to which the ongoing financial crisis is but a rehearsal. This expectation that is in line with long-term simulation analyses like the Limits to Growth which has tracked remarkably global indicators since its introduction in 1970s (Meadows, Randers, and Meadows, 2005).

On the positive side, the financial/monetary system has successfully contributed to technological progress and real wealth creation through its ability to extend credit. A reversion to an arbitrary limit on the monetary supply like the gold standard would certainly be detrimental. It is possible though to index monetary supply not arbitrarily but instead on the key physical parameter that correlates to wealth – energy.

The need: potential lead adopters of an energy currency

The community of Zug in Switzerland along with other communities and cities are engaging in a fundamental debate on whether to strive towards creating a 2000 Watt society. The idea, articulated first at ETH (Marechal, Favrat, and Jochem, 2005), advocates that western societies can and should move towards reducing their energy consumption drastically converging towards the

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estimated global average primary energy consumption per capita. This amounts to a personal 2000W limit or 17,520 kWh / person/year and implies, approximately, a 70% reduction from current energy consumption levels (for Switzerland).

Similarly, cities across the world, the Covenant of Mayors (www.eumayors.eu) provides a good example in the European context, have introduced targets to reduce greenhouse gas emissions including concrete renewable energy and emissions targets. More ambitiously, there are cities like Masdar City in Abu Dhabi, UAE that have set a zero emissions goal (Reiche, 2010). Be it 20% or 30% or 100%, any type of renewable energy target, once it becomes a commitment, places a limit in the actual energy available for consumption based on the capacity of renewable energy generation (existing or planned). Regions that face an energy cap due to actual capacity limitations (e.g. off-grid communities) are an extension of this case.

In the cities described above, meeting the energy constraint is usually approached through incentives for increasing renewable energy penetration and efficiency but without a way for transparently introducing this target and holding accountable for it the end consumer. This gap represents a need for a mechanism that makes energy use transparent and tangible to incentivize behavioral change but that is also flexible and fungible enough to allow individual preferences or energy requirements to be met adequately and equitably. Issuance of a complementary currency that is directly tied to energy availability is one instrument that can be designed to address these needs. Moreover, for cities and regions where liquidity is becoming an issue, an energy currency has the potential to be a more successful alternative to other complementary currency options like LETs and greenbucks as described in (Lietaer, 2001) because it is directly and immediately convertible to something of inherent value (energy).

Energy demand management: objectives and configurations

An energy-based currency is fundamentally a demand management incentive. Broadly, demand management can be considered as having two primary objectives: (i) total demand reduction, and (ii) load shifting for complying with network constraints. Usually, total demand reduction is policy-driven and implies the existence of ample spare capacity (grid-connected) thus representing a 'soft' short-term constraint. The latter, is more compelling for grid-based networks with a firm generation and distribution capacity and limited or expensive storage capacity (i.e. electricity, road transport and, to a lesser, extent water and heating/cooling networks) rather than those with readily available fuel storage (e.g. liquid fuel supply) implying a

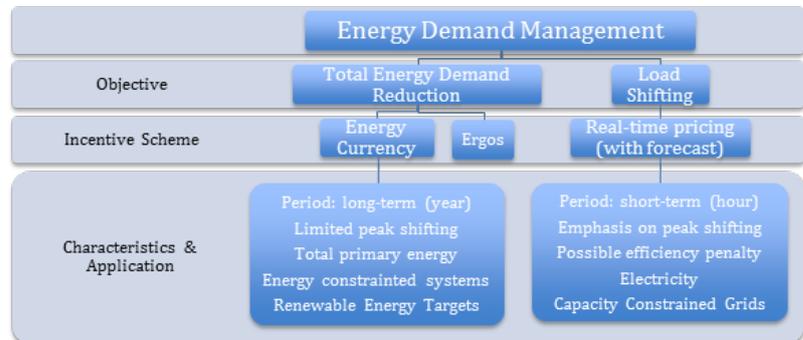


Figure 1 | Relationship of Objectives for Energy Demand Management and Incentive Schemes

'hard' short-term constraint.

While it may seem that qualitatively the objectives differ mainly on the timeframe for the 'integration step', they can in fact be contradicting. Specifically, load-shifting incentives may spur the utilization of less efficient mechanisms (e.g. energy storage when prices are low) with the unintended consequence of increasing the total energy demand of the system.

The bulk of the recent efforts towards developing smart grids, implicitly or explicitly, aim to meet the load shifting objective rather than total energy demand reduction driven by 'hard' short-term, usually hourly, constraints. As a result, real-time pricing and/or direct device control by the utility are the primary incentive schemes employed in smart-grid applications. Total energy management on the other hand requires some kind of exchangeable quota that a credit-based rationing system is better suited to provide (Fleming, 2005; Sgouridis and Kennedy, 2010). The relationship between the demand objectives and incentive schemes is outlined in Figure 1.

Ergo: an alternative currency configuration for energy committed communities

We (Sgouridis and Kennedy, 2010) developed the Ergo concept to address the needs of urban communities that require strict energy accounting in order to stay within a certain energy and emissions budget (Kennedy and Sgouridis, 2011). The Ergo is envisioned to commence as an energy credit system to support energy accounting and meeting energy targets in urban settings. Cities are the key first adopters for Ergo not only due to their percentage in primary energy consumption and clean energy targets mentioned earlier but also because they have the population density and varied economic base to allow for meaningful exchange to occur with a complementary currency. Moreover, cities are establishing smart infrastructure compatible to the Ergo concept and can organically evolve the institutional structure to support it from existing institutions (utilities, municipality, citizens' groups etc).

As the Ergo becomes established, it is anticipated that the community will expand its use to conduct non-energy

related transactions thus turning ergos, the currency unit that has a direct and invariable exchange to a unit of energy (e.g. a kWh), into a full-fledged complementary currency. Since such behavior is emergent and thus will need to be empirically observed to be verified, for this article we focus on the energy credit configuration – specifically issues related to coverage, issuance, allocation, price-setting, and futures.

Transaction coverage

The Ergo system is designed to cover the energy component of transactions (and not material or non-energy value added). As a result, even for transactions that are purely energy consuming (e.g. electricity or hot water consumption) the non-energy component that the utility requires may still be covered by the conventional currency until the Ergo system is generalized enough so that the utility can pay the salaries of its employees in ergos. Initially, transactions covered would be the energy intensive ones (electricity, HVAC services, hot and cold water, transportation etc).

Supply side issuance

Ergos are, in the simplest form, issued based on the total quantity of primary energy available to the community that meets its renewable energy targets. I.e. the community (in collaboration with the producers) estimates the amount of energy that will be produced in the budgeting period (an annual budget would be the norm). To differentiate between processes that need high-grade heat and those that don't the energy budget is adjusted based on enthalpy to disincentivize the use of high-grade energy sources for processes that can be accomplished to the same level of service with low-grade resources. An example would be the substitution of electricity or natural gas boilers for hot water with higher efficiency processes like combined heat and power (CHP) or heat pumps or low-grade resources such solar flat-panel collectors.

Expiration and demand side allocation

Once the desired amount of ergos to be issued over the budgeting period is estimated, ergos have to be allocated over the budgeting period and across the user base. The time allocation could in fact match the demand pattern (i.e. higher allocation during the peak energy demand period of the year) if there is ample spare capacity and/or grid connections, but it would have to match the supply if the application is for an autonomous urban system.

A factor complicating allocation over time is the expiration date - a feature inherent to ergos. The reasons for designing in an expiration are multiple: (i) renewable energy is expensive to store over long periods – this may be less of an issue for cases with high penetration of fossil fuels or cheap storage, (ii) the psychological effect of strong future discounting – it is unlikely that users given their full annual ergo share would be able to provision and

plan for their consumption at the end of the year thus increasing the likelihood of running end of year deficits but they would be more able to do so with a daily or weekly allowance, (iii) a depreciating currency provides the incentive for early utilization rather than hoarding with the added benefit of limiting the potential for a speculative market.

Allocation among users can be equitable or follow a subscription-based system with tiered categories (akin to the cell phone minute allocation).

Price setting: the asymmetric market for ergos

The key to the success of any demand side management system lies with the ability to match the signal to the desired outcome; in this case, staying within a predefined energy budget. Every Ergo user and service provider has a dual account of ergos and conventional currency registered. As the user consumes ergos for energy services throughout the ergo validity period the cumulative consumption is registered in an asymmetric market for ergos operated by the Ergo regulator. When the cumulative demand matches the expected profile of demand scheduled then the price of ergos is stable. As there is divergence, i.e. if ergos are retired earlier than planned then their price rises or conversely if there is a surplus their price is reduced. Since this is a function of cumulative consumption, it presents a slowly varying signal rather than the faster fluctuations of a real-time pricing system.

The individual ergo account is accessible and monitored through a programmable web-enabled interface that can provide information through smart devices (be it smart phones, internet apps, screens, or ambient information devices). The user has complete access to information of current and past prices, ergo balance etc and can set a trading level for when the prices of ergos on the spot market rise above her reservation price. In that case, ergos from the user's account are sold on the market and the monetary price is deposited to the users current account. What makes the market asymmetric is the fact that the user cannot speculatively buy ergos without immediately retiring them for an energy service. In this way, there is a choice for the ergos that will be retired when prices are lower (from the user's account or from the spot market). If the user has entirely drained her ergo account then until the new issuance becomes available she will need to buy ergos at the spot market price.

Ergo debt and futures

In case the original Ergo budget was too optimistic, user demand may push ergo prices higher and higher to the point that is politically unsustainable. In that case, ergos can be issued on a debt basis to effectively place an upper limit cap to the price of ergos. Since ergo issuance is transparent, this 'energetic' balance (debt or surplus) becomes an indication of the sustainability of the community. Debts will need to be covered in the next

budgetary period through additional investment in energy generation.

To facilitate the long-term energy demand, ergo futures could be traded. These are ergos that have a future activation date and represent planned generating capacity expansion. Unlike active ergos, these are traded symmetrically and can be banked. Once they become active they revert to being ordinary ergos. A regulator can adjust capacity planning by monitoring the prices of ergo futures.

Conclusions

The Ergo concept as presented here is a proposal for instituting an energy credit system to address the needs of communities that have set renewable energy or emissions targets. It is only the first step to a fully-fledged energy currency but its institution allows for the critical infrastructure to be in place for the evolution of energy currencies (e.g. the metering devices, the smart devices and readers, algorithm refinement etc) but also, critically, the human awareness of energy's fundamental role in our communities which is currently masked by the numerous and non-transparent energy-related bills. While today very few know the energy component of their electricity, water, transport, or hotel bills, the Ergo system can transform that knowledge and empower users to make energy-wise choices as humanity transitions to more sustainable societal structures. ★

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