1. INTRODUCTION:
ENERGY OPTIMIZATION OF THE BUILDING ENVELOPE
AND DEFICIENCIES IN ENVIRONMENTAL QUALITY

The building envelope, always manifold of performance issues conjugated based on functional habits, regulatory requirements, stylistic trends, should never lose its role as guarantor of the environmental system quality: the comfort of the occupants - bright, thermal, olfactory, acoustic, hygrometric - depends on the opaque and transparent borders.

The instances of energy saving, derived from increasingly stringent standards, have urged for a rethinking of thermo-hygrometric parameters of the horizontal and vertical closures calls to ensuring the hermetic seal and the effective insulation.

In this scenery the window frames, considered the most vulnerable element,
was subjected to technological innovations that have made congruent in time its performance to those wrap opaque. Contextually an evolutionary path has affected the techniques of window-wall correlation to fill up, without performance drop, the solution of continuity of the joint interposed.

A careful reading of this constructive section has highlighted the inaction of the executive design, overpowered by site work practices, resulting in dichotomy liable to have generated, even in the presence of a high energy efficiency wrap (which has required windows frames with increasingly high-performance of air tightness and water; with lack of thermal bridges and prescribed thermal conductivity; with control of vapour diffusion and heat), the emergence of new pathology of the environmental system, due to the air quality, the surface condensation, the proliferation of mould.

Established that, focusing on a misguided innovation, on an appeal to technologically advanced solutions, of which have been evaluated the inherent performance without understanding the consequences produced in confined environments, it has been determined a conflict between environmental system and technological system, we turned to productive system in order to understand if it is ready, with technical solutions in the making or use, to cope with the failures resulting from the excessive tightness of windows and related joints, and to see if there are gaps to be filled as part of the final design in order to reduce the distance between theory and practice looking to the building system as a unicum.

2. STATE-OF-THE-ART: RETROSPECTIVE ON WINDOWS AND CORRELATION TECHNIQUES

The path taken in the productive scenery of windows shows the mutations to which they were subjected by respond to performance demands changing over the time because of regulatory requirements, technological acquisitions, climate change and social evolution.

A chronological analysis reveals that only since 60s of the twentieth century, by virtue of a first industrial awareness, working on the morphology of the components, with favourable outcomes for the wooden doors and windows, in order to ensure greater air tightness through preparation of more bar lines between mobile leaf and fixed frame and with the addition of a base crosspiece it also acts on the interface window-holing, with the insertion of a sub-frame, also in wood, with the aim of facilitating the laying, ensuring horizontal levels and verticals of the hole.

The same performance optimization did not apply to the iron windows,
introduced in those same years, that were precarious for sealing and thermal insulation, and whose reduced durability and resistance to external agents have led to its abandonment.

A real conceptual revolution it is recorded in the end of ‘70s, when the energy crisis, imposing a general rethinking of consumptions and dissipations, has invested an energy-intensive component such as the aluminium frame, undisputed protagonist in during that time; it produced appropriate mutations in components - glass-camera, thermal cutting, open joint - and in the design of the accessories – sub-frames, seals, hinges.

The market of windows in PVC, appeared in the ‘90s, as a marginal and with durability problems related to resistance/deformation, discoloration/finishes of the profiles, has tried to solve its problems, successfully, arriving to contend large bands of market to wood products and aluminium.

In the last decade, all the solutions have been refined pursuing a performance quality prescribed, now widely acquired and certified (CE marking of window frames), which alone has, however, proved to be a guarantee not enough to meet the energy needs of the confined environments; the focus has therefore shifted on the problems of assembly, that are resolved case by case basis, with increasingly varied and complex techniques of pose in work, by specialized installers.

The purpose to realize has concerned the continuity of performance in the transition from the frame, at the junction, to the wall.

The graphic indications of detail, necessary executive design tool, have been superficial for a long time: from the manuals of technology to the product data sheets, the descriptions for the installation of windows frames, but even more the explanatory drawings, would not have guaranteed the realization “in a professional manner” prescribed into the technical elaborates and administrative attached to projects.

The changed nature of windows frames, from glulam to aluminium and from this to PVC, with temperature-humidity performance certified as waterproof, led the same manufacturers to define new mounting criteria addressed to the installers [2], which have taken into account, however, only the window-wall ratio and not the environmental wellbeing of limited spaces. The laying was considered a job category to be solved in the yard, entrusted to the good sense of the expert workers, and has affected so very marginal the executive planning. A focus on the developmental milestones that have affected the correlation techniques, returns the route taken by the underestimation of the issues related to the engagement of responsibility, still partially inadequate.

A first variation has interested the sub-frame, that by necessary component...
“to amortize the hole imperfections and to create a solid support for air-tight attachment of the fixed frame” (reported utterance without distinction in the technical manuals until the beginning of this century ) has become a system of complex morphology more and more oriented to the definition of hole in the wall - of which it has been possible to make the finish regardless from assembly of the window frame - and shaped to accommodate accessories of air-tight and water and less and less thought as resistant element to which entrust the junction. In the first application it’s made of struts and beam in wood or made of cold galvanized steel, has been the subject of material reflection and morphological to ensure the satisfaction of thermal performances (elimination of thermal bridges), hygrometric (to avoid condensation), of water-tightness and air (to prevent infiltration and drafts); an evolution still in progress, to achieve the performance targets set required at the energy performance of new or existing building for 2020. Some companies have repurposed mono-block systems equipped of EPS, or other insulating material, designed to easily solve installation problems in yard giving the energetic response prescribed by law. The true difference in the joining techniques, however, has been introduced by the appearance, since the 80s, of the gaskets, prepared accessories to improve the water tightness performance, air, sound insulation and heat. Different solutions have been preferred to the first formulations plastomeric (PVC compounds to increase elasticity) or elastomeric (silicone elastomer) to respond appropriately to different requirements. With the same purpose they have been added sealants, preformed tapes and / or self-expanding, foams insulation, vapour barriers. A well-established rule in the planning and realization of the correlation coupling thus requires that we should ensure the separation between “external climate” and “internal climate” at room in the more effectively, compensating the movements and tolerances of the contiguous items. In particular, the separation system placed on the internal front must be impermeable to vapour diffusion, to which must be prevented to penetrate and condense on surfaces that can be at below dew temperature. The separation system placed on the external front must be permeable to water vapour, but impermeable and sealed to prevent the action of atmospheric agents, rain and wind. Increasingly widespread, so as to become practice, is furthermore the filling of the space between the two faces with insulating material - foams, strips or panels - to optimize the thermal and acoustic performances [3]. The onset of the condensate and the formation of mildew, as well as the detection of a greater unhealthiness of the air of confined environmental system, has suggested a reflection on the performance design of the building
envelope as a whole. It is understood that each house sealed “hermetically” want a comfortable ventilation, need to be pursued in the presence of thermal and wet environments bridges and circumstance not achievable in the presence of high insulation. A variegated regulatory context [4] requires a value between 0.3 cm / h and 0.7 cm / h for the air change ensured with continuous ventilation. It is a new challenge launched to the frame window, able to provide natural and discontinuous ventilation, but with not more sustainable energy expenditure.

Figure 1. Functional evolution of the sub-frame in the junction between window and wall: from strength guarantees to multi performance component.

3. METHODOLOGY: THE WINDOW AS VENTILATION TOOL

Should be noted that the increasingly manifest unhealthy air inside the rooms, does not depend only by watertight of the window frame; a data tells more than any other consideration, and regards the comparison of air and steam that go through an opaque wall or an air draft, that is, a minimum drain on the edge of the frame, respectively the 2% and the 98%.

The amount of blogs activated on issues arising from the replacement of old windows with the new ones, patented, manufactured and assembled so as to ensure high performance thermo-hygrometric, advocated by state and EU policies promoted to enable energy recovery, it may take as a significant thermometer of a phenomenon that has become a pathology.

More than 25% of families in Italy has taken advantage of the tax incentives for this type of intervention, simple and effective, and it is expected that this figure will continue to grow in the coming years. The data should then give pause.

The issue is also about the low energy new buildings that showed, after a very
few years, the damages consequent to the extreme “sealing” of the building envelope. In recent years, in fact it took place a constructive revolution without that we were ready to accept with awareness the effects, which have occurred as a decrease in environmental “domestic” quality. Paradoxically, is found as oxymoronic comment, who to build worse has determined healthier environments and that an “imperfect” assembly of the frame has guaranteed the building envelope breathability.

Ascertained that arises a ventilation problem and air recirculation, only theoretically trivial and not always solvable with homemade suggestions (but also of CasaClima Agency) that they prompt to ventilate the room at least three times a day for 10-15 minutes, to do it constantly and in addition after a shower and having cooked, and again, not to hang out the laundry at home, we must tackle the problem more “scientific” looking for: technical solutions already in production to be applied; trends to encourage; options to consider with weighting; or to understand whether it is a brand new issue to be addressed.

Technological innovation proposes some remedies that seem specimens but that, being very recent products and under constant revision in order to optimize their performance, require a comparative assessment to identify the environmental impacts, constructive, performance and not least economic. The alternative solutions, if the permeability of windows and/or the external inlet air and/or the breathability of the opaque walls, are not able to guarantee the achievement of the air changes prescribed (from 0.3 mc / 0.7 mc / h) are grafted on the opportunities offered by the Controlled Mechanical Ventilation systems (VMC), from the centralized to punctual ones and from these to ones integrable/embedded in windows frames.

In recent years the legislation has tried to systematize a design approach yet fully entrusted to producers.

Move around in this market sector, in a professional environment, presents some difficulties related to the lack of an established terminology capable to unify types, performance and parameters (for sizing energetic were conceived some certified repertoires, available online, from which to draw the necessary data to compare the ventilation units: on the public database of the English government site www.ncm-pcdb.org.uk are accessible the actual values and not commercial, of thermic performance and of electric consumption - efficiency aerolics - of surveyed products; the Agency has Casaclima prepared a similar list for VMC with heat recovery, constantly updated, which shows the energy parameters certified by the producers at an institution / lab accredited).

Based on some indicators, deemed unavoidable, I carried out an internal alte prestazioni termo-igrometriche, caldeggiata dalle politiche statali e comunitarie promosse per attivare il risanamento energetico, può assumersi come termometro significativo di un fenomeno che si è tradotto in patologia. Più del 25% di famiglie in Italia ha una vita di debito delle incentivazioni fiscali per questo tipo di intervento, semplice ed efficace, e si prevede che questo valore continuerà a crescere nei prossimi anni. Il dato dovrebbe quindi far riflettere. La problematica riguarda anche gli edifici di nuova costruzione a basso consumo energetico che hanno mostrato, dopo un ridottissimo numero di anni, i guasti conseguenti alla mancanza di ventilazione. Negli ultimi anni è avvenuta infatti una rinascita costruttiva senza che fossero pronti ad accoglierne con consapevolezza gli effetti, che si sono manifestati come diminuzione della qualità ambientale “domestica”. Paradossalmente, si viene ad osservare come ossimorico commento, che costruire peggio determinava ambienti più salubri e un “imperfetto” montaggio del serramento garantiva la traspirabilità dell’involvero. Apparato che si pone un problema di ventilazione e di ricircolo dell’aria, solo teseamente banale e non sempre risolvibile con i suggerimenti “casalinghi” (ma anche di Agenzia CasaClima) a dare il locale almeno tre volte al giorno per 10/15 minuti, di farlo sempre e in aggiunta dopo doccia e cucina e di non tenere la biancheria a casa, occhiore affrontare il problema con maggiore “scientificità” alla ricerca di soluzioni già in produzione da applicare, tendenze da favorire, opzioni da valutare con ponderazione o per comprendere se si tratta di una inedita questione da affrontare. L’innovazione tecnologica propone alcuni rimedi che appaiono esemplari ma che, trattandosi di prodotti assai recenti e tesi in fase di constante revisione per ottimizzare le loro prestazioni, richiedono una valutazione comparativa, per individuarne gli impatti ambientali, costruttivi, prestazionali e non ultimo economici. Le soluzioni alternative, qualora la permeabilità degli infissi e/o le prese d’aria esterna e/o la traspirabilità delle pareti opache non riescano a garantire il raggiungimento dei ricambi d’aria prescritti (da 0,3 mc/h a 0,7 mc/h) si innescano sulle opportunità offerte dai sistemi di Ventilazione Meccanica Controllata (VMC), dai centralizzati ai puntuali e da questi a quelli integrabili/integrati nei serramenti. Negli ultimi anni la normativa ha provato a sistematizzare un approccio progettuale ancora interamente affidato ai produttori. Muoversi in questo settore merceologico in ambito professionale presenta qualche difficoltà connessa principalmente alla mancanza di una terminologia consolidata capace di unificare tipi, prestazioni e parametri (per il dimensionamento energetico sono stati concepiti alcuni repertori certificati, consultabili online, dai quali attingere i dati necessari per comparare le unità di ventilazione: sul database pubblico del sito governativo Inglese www.ncm-pcdb.org.uk sono accessibili i valori reali, e non commerciali, di rendimento termico e consumo

Based on some indicators, deemed unavoidable, I carried out an internal
comparison to each of the three categories proposed by the technological innovation: VMC decentralized systems (or punctual); VMC decentralized systems integrable in traditional windows; windows frames with integrated VMC. That to facilitate the understanding of some selection criteria and to bring out specificity and acquisitions of the commercially available products.

3.1 VMC DECENTRALIZED SYSTEMS

Among the different types that denote the operation of the ventilation units - single-flow, simple or alternate, dual-flow, simple or alternate - referring to a regulatory context in the making, to the production repertoire and to the active debate among experts in the field, were selected, in this phase of study, only those models that, based on specific identified parameters, they have provided the most convincing answers in the case of energy restoration operations to be performed or to cope with failures already produced by the replacement of drafty windows frames with hermetic ones.

An indispensable function of distinction and selection, to meet the energy and environmental sustainability, is certainly the exhaust air heat recovery and its entities. Equally important is the aeraulic efficiency (SFP), an energetic indicator among others prescribed by the UNI 13142: 2013 [5], which measures the specific energy consumption, i.e. that absorbed to enliven a given air flow. Along with these two parameters were assessed: quality of design / size quality; comfort noise (15 dB-normal breath silent; 20 dB-rustling of leaves down; 30 dB-whispered conversation; 40 dB-noise dwelling during normal day; 50 dB-normal conversation; 60 dB-noisy animated discussion; from 70 to 120 dB-from noisy to unbearable); available filters (“G Group” = coarse dust filter - G1-G4; Group “F” = fine dust filters - F5 through F9) [6]; default sensors; ease of installation and minimal invasiveness; operating mode (wireless control, maximum number of control units). The repertoire developed, far from complete, it is only the debut of an instrument that it is considered necessary to support a design choice.

The performance thresholds, assumed to select the VMC systems in single alternating flow, estimated for a reference flow rate of about 20 m³ / h, were: LpA <20 dB noise level (rustling leaves low); SPF=0.10 W / (mc / h); heat recovery extent of between 80% and 90% (were excluded from the comparison Quantum HR100 command CTRL-S Aerauliga products; Nano Air 50 Aldes; RECUPERA ONE10 Emmeti; RUC-T Brofer; Recupero plus Nicoli, because do not meet the thresholds established for the defined performance parameters). For VMC dual-flow systems, since we are observed slightly lower performance, the comparative values established as a boundary,
for a reference flow rate of about 30 cubic meters / h, were: LpA≤24 dB noise level (rustling leaves low); SPF≤0.17 W / (m³ / h); the amount of heat recovery, smaller, between 70% and 76%; (were excluded from the comparison Vitovent 200 D HRM 55 Viessmann; AERA Smart Maeco, because not satisfying the thresholds established for the defined performance parameters). With reference to this indicator it was considered appropriate, for both types, indicate if the value is declared or tested / certified. The search for a careful design, of minimal invasiveness (circular telescopic duct with reduced diameter) and of the wireless management and programmable, has further driven the selection.

Within a fairly wide production, it has been observed a continuous updating of technical data sheets that clearly coincides with product improvements, as well as the use of certifications derived from the addresses provided by the German or European standards DIN ISO. The greater preference registered to systems at single or double alternating flow compared to those double flow

Within a fairly wide production, it has been observed a continuous updating of technical data sheets that clearly coincides with product improvements, as well as the use of certifications derived from the addresses provided by the German or European standards DIN ISO. The greater preference registered to systems at single or double alternating flow compared to those double flow
depends on a heat recovery more effective and by a higher aeraulic efficiency; for sound data, even if the values are better in the alternating flow systems, the user declares a slight discomfort due to the noise discontinuous related to the interruption of aeration every 60-70 seconds.

It would be desirable for rapid adaptation in this field of technical supports, procedural and regulatory, indispensable to guide constructively the industry operators, from manufacturers to installers, to designers [7].

3.2 VMC DECENTRALIZED SYSTEMS INTEGRABLE IN TRADITIONAL WINDOWS (AND / OR EXISTING)

An alternative technique more appropriate to the subject is represented by the ability to integrate aerators simple on the mobile frame or on the double-glazing of windows frames, new or existing, but of the traditional conception, to ensure an air exchange operated with a manually adjustment, or activated by the difference in internal-external pressure or by relative humidity variation (“eko-okna windows” currently markets all the aerators in production of the Aerco line, Ventair, Renson and Glazpart) [8].

The searched indicators to start a comparison between the products in the market have, with reference to the functional parameters, slight variations compared to those made for the previous alternative. The threshold values instead for energy parameters were affected from the productive panorama that still shows some performance limits and a very small consistency in order to make restricted selections.

A constructive parameter considered relevant for choosing it was identified in the unit’s location of ventilation relative to the window recess: below the sill or

![Figure 2. Some of VMC systems in single flow alternate and in double flow with constructive parameters, functional, energetic, optimized.](image)
flanked to the jamb they appear locations less invasive and more appropriated, especially as part of restructuring, compared to the area architrave; the collocation between mobile frame and glass, only observed for simple aerators, could have wide dissemination for work on existing window frames. The proposed solutions declare heat recoveries, when provided, between 60 and 75% and lower aeraulic efficiencies and with large excursions, compared to punctual VMC systems, which for a flow rate of about 20 m³/h, ranging from 0.16 to 0.52 W/(cm/h); the noise maintains, for the same air velocity, a sound level LpA <20 dB (rustling leaves low).

They are few and being improved, some as transformation of the model without heat recovery, their main advantage is that to be independent by the choice of the window, and to be able to intervene when the installation is already occurred.

### 3.3 WINDOW FRAMES WITH INTEGRATED VMC

Aerate is very different thing that ventilate. The second operation requires continuity of the process and an accurate design that depends on differences in pressure and temperature. Open the window, also with constant rhythms, determines a temporary air exchange that can cause thermal shock and do not remove the exhausted and contaminated air always adequately. From this sprang the commercial research aimed to integrate in various ways in the window frames a controlled mechanical ventilation system.

The parameter identification to be compared for this category has highlighted, even in the presence of a repertoire developing, the difficulties arising from the recent placing on the market of the products that therefore are not always equipped with exhaustive technical sheets. Certainly important for the selection it is deemed the integration flexibility with respect to installation of the window frames, and, how it will say, this constructive parameter has oriented a recent trend. The proposed solutions guarantee heat recoveries...
variables with minimum peaks of 45% and maximum peaks of 89%, as well as variables are the aeraulic efficiencies with excursions, estimated for a flow rate of about 15 cm / h, ranging from 0.13 to 0.53 W / (m³ / h); the acoustic performance is characterized, for the same air speed, from a value of the sound level LpA> 22 dB (rustling leaves low) and presented a higher noise level than other categories, reaching 40 dB (Domestic noise during the normal day) for flow rates of 30 cm / h.
A problem that needs to be addressed for a broader dissemination.

The survey showed that, only in one case, the window frame has been designed to accommodate a VMC system, while the orientation, which seems
to prevail is one of these: to add, in a production line maintained unchanged, an accessory that recovers the abolished tightness, or to consider it an integral part of a subframe, which has become a monoblock component, to which entrust multiple performances; an evident simplification for correlation techniques and for the maintenance of the window frames.

4. CONCLUSION:
PROJECTION ON THE NEXT WINDOW FRAMES

The comparison carried out has highlighted some of the strengths of the changes that will affect the window frames in the years to come, the trends that are maturing and the path that remains to be done at different levels - productive, regulatory, professional - for a more conscious use in the building system.

We can include among the acquisitions that affect the option of integrating a VMC system into window frames:

• the solution to failures resulting by excessive “sealing” of the involucres with a single category of work that it may relate to the renovations and the new buildings;
• the possibility of making an energy recovery not only taking advantage potentiality of the thermal insulation, now acquired, offered by the window frames, but making unnecessary the discontinuous aeration and the energy loss that it entails inevitably.

Among identified shortages we highlight:

• the incompleteness of technical data provided by the manufacturers requires an investigation way laborious and not always decisive; hardly ever the indicators values are certified;
• the absence of guidelines on the installation which wrongly carried would negate the energy advantages achieved with the choice of the window-VMC integrated system and the praxis to abdicate to the producers or to the construction site the definition of solutions-types that might make us lose sight of the building system’s complexity;

A critical reflection is dedicated to the latter consideration and to the information found in the technical sheets of the companies when:

• the ventilation unit is an integral part of the frame vertically, and the installation is executed with the only note: “it is necessary to pay attention to the window hole and to its finish coat on the side of the aerator; moreover, the casing must not come into contact directly with the masonry to minimize the transmission of vibration”; • the ventilation unit occupies the upper area or lower at the horizontal

one diffusion più estesa. L’indagine condotta ha evidenziato che solo in un caso il serramento è stato predisposto per accogliere un sistema di VMC, mentre si sta affermando l’orientamento, che sembra prevalere, di affidare a una linea in produzione, mantenuta immutata, un accessorio che si oppone alla soprappaglia etmeticità, o di considerarlo parte integrante di un controtelaio, diventato un componente monoblocco con affidare molteplici prestazioni; un evidente semplificazione per le tecniche di correlazione e la manutenzione dei serramenti.

4. CONCLUSIONI: PROIEZIONE SUI SERRAMENTI FUTURI

La comparazione effettuata ha evidenziato alcuni punti di forza delle trasformazioni che interesseranno i serramenti dei prossimi anni, le tendenze che stanno maturando e il percorso che deve ancora essere compiuto a diversi livelli – produttivo, normativo, professionale – per un più consapevole impiego nel sistema edilizio.

Fra le acquisizioni che riguardano l’opzione di integrare un sistema di VMC ai serramenti possiamo annoverare:

• la soluzione ai guasti conseguenti l’eccessiva “ermetizzazione” degli involucri con un’unica categoria di lavoro che può riguardare sia le riistrutturazioni che le nuove costruzioni;
• la possibilità di effettuare un ritiramento energetico non soltanto sfruttando le potenzialità di isolamento termico, ormai acquisite, offerte dal serramento, ma rendendo superfluo l’aerazione discontinua e le dispersioni energetiche che inevitabilmente comporterebbero una perdita di efficacia.

Fra le lacunarietà riscontrate si evidenziano:

• l’incompleta di dati tecnici forniti dai produttori, che richiedono un lavoro, sempre risolutivo, per correggere indicazioni non sempre corrette, che non sono sempre corrette; non sempre ce ne sono certificazioni;
• l’assenza di linee guida relative al montaggio, che erroneamente, effettuato vanificherebbe i vantaggi energetici conseguiti con la scelta di integrare serramento-VMC e la prassi di abdicare ai produttori o al cantierista la definizione di soluzioni tipo che potrebbero far perdere di vista la complessità del sistema edilizio.

Una riflessione critica è dedicata a quest’ultima considerazione e alle indicazioni trovate nei quaderni tecnici delle aziende quando:

• l’unità di ventilazione è parte integrante del traverso verticale, e la posa in opera si esaurisce con l’unica postilla: “è necessario porre attenzione al vano finestra e relativo rivestimento di finitura sul lato dell’arretrato; inoltre l’involucro non deve entrare in contatto direttamente con la muratura per minimizzare la trasmissione di vibrazioni”;
• l’unità di ventilazione occupa la zona superiore o inferiore al traverso orizzontale e in un solo
frame and in only case, without requiring documents specifically direct to the installers, an executive detail illustrates a hypothesis of mounting that, supplemented by other, could serve as an exemplary reference for the executive design.

Figure 4. Different approaches to the correlation problems of integrated VMC systems to window frames production.

- The state of the art returned requires a subsequent phase of deepening, not so much on aspects implant of the integrated systems, which seem geared towards the performance optimization, but rather on some functional aspects - flow rates and acoustic data - and primarily on aspects technical constructive concerning to insertion in the involucre, that should converge into the final design of the junction. This is, indeed an essential construction detail in checking the congruence of the window frames with the choices made for the adjoining technical alternatives, in order to avoid performance reductions in the involucre, but even more, as is happening in the process of improving energy of real estate assets, ensuring not to overlook the quality of the environmental system.

5. REFERENCES

formation; Regulation on energy savings EnEV (DIN 1946 parts 6).


