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STATIC AND DYNAMIC DAYLIGHT CONTROL SYSTEMS: SHADING DEVICES AND ELECTROCHROMIC WINDOWS

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ABSTRACT

This paper analyses the office demand connected to the use of different dynamic window and lighting control systems with the aim to optimize their usage aspects and characteristics from both visual and energy efficiency viewpoints. The approach is based on an improvement of the non-commercial hourly simulation program IENUS. Results are referred to a typical office located in Mediterranean climate.

INTRODUCTION

Shading devices always represented fundamental systems to control the incoming of the natural light with two main purposes: improving indoor visual and thermal comfort, reducing HVACs and artificial light systems energy consumption.

Industries in these last years have developed and produced different types of transparent materials and lighting control systems to take full advantage of the energy saving potential coming from daylight.

ElectroChromic (EC) "dynamic" windows, that can change their transparency properties in response to control parameters integrated in a natural and artificial lighting control system, could represent a way to improve both environmental quality and energy use efficiency. The possibility to integrate EC materials in building windows, as a part of a commercial light control system, appears nowadays very promising, as EC devices seem to be ready for commercialization (Granqvist, 1993, Granqvist et al., 1998, Lampert, 2000).

Different lighting control systems are used to control lamp light outputs and natural light. Natural lighting controls by automatic mini-internal blinds to large exterior rolling louvered shutter systems are available and popular in office buildings due to their adjustability and ability to reflect light. While artificial light systems are dimmed or switched following daylight variation to keep design lighting levels as constant as possible during all the maintenance cycle of the lamps. Commercial control systems can operate with algorithms that can realize either a closed-loop integral control or an open-loop proportional control.

ElectroChromic (EC) and light control systems try to realise indoor comfort and energy saving by approaches, that are different in complexity, costs and results. Besides, a good coordination among them could produce better performances.

Several research groups all over the world have developed a lot of studies over the last decade. The aim was generally to characterise the possibilities and the improvements introduced by these new technologies (Moeck et al., 1998, Sullivan et al., 1994 and 1996, Yoong and Tulloch, 2000, Karlsson et al., 2000, and Karlsson, 2001, Gugliermetti and Bisegna, 2003, 2005). But a study on both the visual comfort and energy efficiency aspects, considered in comparison with traditional window systems equipped with internal shadings controlled by a linear strategy, is still lacking, as it is still lacking a guideline for the selection of the proper window system considering all the possible visual and energy aspects.

This paper analyses the office space energy demand connected to the use of different EC and light control systems for office buildings located in Mediterranean climate, with the aim to optimise their usage aspects and characteristics from both visual and energy efficiency viewpoints. On/off and linear control strategies to change the transparency of EC systems from clear to dark state, and to close the indoor curtains are here presented. Dimming and on/off control strategies are also considered for managing the artificial lights. The paper represents only a step of a wide research aimed at defining several guidelines for the selection of the proper window system, also considering innovative windows, for each specific situation.

The approach is based on an improvement of the hourly simulation program IENUS (Integrated ENergy Use Simulation), a non–commercial program developed to assess the building energy demand of simple spaces, taking into account the integration between visual and thermal aspects.

ELECTROCHROMIC (EC) AND LIGHT CONTROL SYSTEMS

Light control systems try to take advantage of the natural light to reach both good energy saving and acceptable environmental conditions.

Studies devoted to the optimization of incoming light with switchable windows underline that EC control triggered on sunlight and daylight impinging on windows (Karlsson et alt. 2000) are more efficient then those based on temperature and thermal space loads. The latter can produce discomfort as the window can be in its colored state when it is hot outside, regardless the level of "darkness". The window instead should not be colored when it is dark outside and vice versa.

Control systems must also provide the required amount of artificial light, when needed, and minimize electrical energy consumption. Control actions based on the daylight-following approach, in which the electric lights are dimmed to correspond with the amount of available daylight, are largely applied in office and commercial buildings for their good performances. This kind of action is particularly appreciable with open-loop proportional algorithms (light sensors detect only daylight and are insensitive to the electric light). Closed-loop integral controller (sensors detect both electric and natural light) tends, with the currently available systems, to supply too little illumination (Caddett 1991, CEC-EPRI 1993). Lumen maintenance strategies in a closed-loop, eventually integrated with a daylight-following control, can be a good choice, also if they require specially-configured sensors and group re-lamping. Multi-zone dimming maximize energy savings, but it increases the complexity of the light control system.

In Mediterranean climate, for a few people office space, a good compromise to save electric energy is to share and operate the dimming action in more than one zone parallel to the window wall. Building energy saving increases for double glazed windows with low-e layer, versus an on/off regulation, of about 38% for a one zone dimming, 46% for a two zones dimming and it reaches 48% for a three zone dimming.

On/off and linear control strategies can be adopted to manage the natural light entering into the environment. The on/off control strategy operates by reversing rapidly the EC device from the bleached to the coloured state when the total solar radiation I_w impinging on the external surface of the window is greater than the set point I_{wset} of the regulator. While in the linear control strategy the controller requires two set points (I_{wset1}, I_{wset2}), to define the range in which the EC transparency varies (see Figure 1).

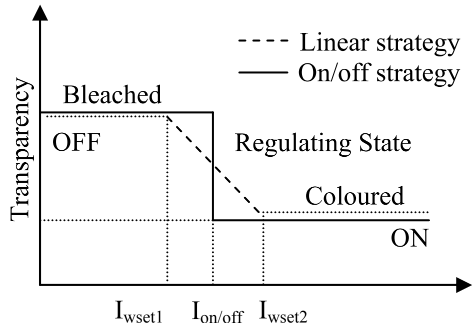

Figure 1. On/off and Linear control strategies

On-off and linear strategies can be also used to control motorized indoor shading devices.

I_{wset} and (I_{wset1}, I_{wset2}) values should be chosen to combine energy savings and indoor comfort, taking into account location, shading situation, window orientation and type, and building characteristics.

Optimal linear strategy set points mainly oriented to minimize energy requirements are reported for EC window systems by Karlsson (2001), while Gugliermetti and Bisegna (2003) proposed two approaches, a comfort and an energetic approach, aimed at minimizing total yearly energy requirements and maximizing indoor visual comfort, specifically for a Mediterranean climate.

For window systems equipped with internal shading devices, only a comfort based on-off control strategy for a Mediterranean climate, reported in Gugliermetti et al. (2001), exists. It suggests that closing the shading devices when the direct solar radiation transmitted by the glazed system exceeds 30 W/m^2 is necessary to reduce direct and indirect glare.

CALCULATION HYPOTHESIS

Results are reported for a typical 5m x 7m x 3m office room with a 5m x 3m external wall, which presents a central 3m x 2m window opening with its centre at 1.8 m from the floor and without external shading devices. The adjoining spaces are conditioned and kept at the same design temperature. Artificial light is represented by fluorescent lamps with recessed, not vented fixtures, from 8:00 AM to 20.00 PM, modulated by the light system control with a constant efficacy of 0.833 lumen/Watt. Other room features and HVAC design aspects are reported in Table 1. Thermostat throttling range is up to 1°C. Outside the period of people occupancy, EC window systems are always in the bleached state, and the artificial light is off. The design illuminance required on the working plane, 0.8m above the floor, is generally fixed at 500 lx, according to EN 12464 – 1.

Table 1.
Some room features and HVAC design aspects.

ROOM		
Envelope construction weight	200	kg/m^2
External wall thermal transmittance	0.8	$W/(m^2K)$
Ground reflectance	0.2	%
Internal wall visible reflectance	50	%
Floor visible reflectance	20	%
Ceiling visible reflectance	80	%
Room furnishing: ordinary, no carpets	-	-
HVAC		
People occupancy: everyday 8.00 AM-20.00 PM	3	-
People sensible heat (50% convective, 50% radiative)	50	W/p
HVAC running period: everyday 6.00 AM-21.00 PM	-	-
Equipment thermal load: everyday 8.00 AM-20.00 PM	800	W
Latent loads not considered	-	-
Ventilation not considered	-	-
Infiltration not considered	-	-

In this paper, we considered systems operating either with an on/off or a linear strategy, integrated with a daylight-following lumen maintenance on/off or dimming control of the artificial lighting system, in order to maximize energy saving and visual comfort. A three equal zones dimming strategy for the artificial light was the best strategy we considered to operate to maximise energy savings. The possibility for the occupants of overriding the EC control system, to adjust indoor conditions to suit their own comfort requirements, was not considered because not entirely predictable, although it is one of is the main cause of the increase of energy consumption.

Different double glazed window systems, all built with a 75mm aluminium frame, were considered: 1) a double glazed system made of two clear glass panels, the external one coated with an EC device layer (EC1); 2) a double glazed system consisting of an external clear glass panel coated with an EC device layer, and an internal clear glass panel coated with a low-e layer (EC2); 3) a reference clear double glazed system (REF). EC window systems are assembled with Al divider elements of 75mm width, realizing three central glass panels each of 0.9m x 1.85m. REF glazed systems were equipped with different internal motorized shading devices. The first window system REF1 had a shading device with a normal–normal visual transparency of 50%, while the direct light transmitted diffusively was 10%. The second one, REF2, had a normal–normal visual transparency of 25% and 0% of direct light transmitted diffusively. The third one, REF3, was characterised instead respectively by 0% and 25%.

The REF1 system was more transparent in respect to the considered EC systems, even when the EC1 was in the bleached state, and the curtain of REF1 was in the closed position. REF2 and REF3 instead had transparencies comparable with EC1 in the coloured state. From a practical point of view, the indoor shading devices can be considered as vertical blinds.

The EC device is of WO_3 type with a V_2O_5 counter electrode and lithium aluminium fluoride as electrolyte. Its angular and spectral characteristics can be found in Maccari et al. (1998).

Optical and thermal characteristics of glazing systems, calculated with WINDOW software, are reported in Table 2.

Table 2.
Characteristics of central glazing systems.

Cod.	EC state	τ_{snh}	τ_{vnh}	U [$W/(m^2K)$]
REF	------	0.604	0.781	1.80
EC1	Bleached	0.329	0.455	2.64
	Coloured	0.125	0.195	
EC2	Bleached	0.106	0.211	2.04
	Coloured	0.040	0.090	

On/off and linear strategies to manage daylight with both motorized internal curtains and EC devices have been considered.

Several window orientations are analyzed for three Italian cities (Rome, RM, latitude 42°, Bolzano, BZ, latitude 46°,Catania, CT, latitude 37°) that represent the typical different outdoor conditions that can be met in Mediterranean climate. Bolzano has a continental climate, Catania shows a hot and quite dry climate, Rome is characterized by a mild climate.

The non-commercial simulation package, IENUS, implemented by Gugliermetti et al. (2001) to study dynamically the integration of thermal and luminous aspects of the environment, is used as work tool, while TMYs (Typical Meteorological Years, Mazzarella, 1997) are assumed as input of hourly outdoor data. Ashrae method (Ashrae 1993) with a ground reflectance of 0.2 is followed to calculate vertical irradiation on the base of TMYs data.

PARAMETERS AND SET-POINTS

On/off and linear control strategies have been adopted to control daylight.

For EC window systems, two approaches have been considered. The energetic approach is based on energy efficiency considerations developed in Gugliermetti and Bisegna (2003). In some cases for EC1 the optimal values of I_{wset2} are quite bigger than the corresponding vertical sun radiations. This means that EC device does not fully use its variable light transmittance range, as its colored state results too dark. On the contrary EC2 window does not produce any energetic advantage respect to a static window, as its regulation begins for too high values of solar radiation, its use can be justified only for its potential environment control, reachable with a changing in control settings and a penalty in energy consumption. The environmental approach, based on a visual comfort criterion, presents other values of set-point parameters (Gugliermetti and Bisegna, 2003). It is based on the indoor acceptable comfort quality, moving away from control settings linked only to the minimum primary energy total requirements. Fundamental parameters for selecting the set-point values are in this case the possibility of avoiding glare situations, for I_{wset2}, and reducing at minimum the risk of seclusion feeling, that means reducing the number of hours during which the window is shaded, for I_{wset2}. The optimal regulation ranges for both linear and on/off strategies have been found among those settings that reach a good compromise between reduction in occupants' glare and seclusion feeling, that depends on the window state in an opposite way. The glare and the visual contact decrease when the EC window changes toward its colored state.

For what concerns REF windows, in the on/off regulation the internal curtain was closed to reduce direct and indirect glare when the direct solar radiation transmitted by the glazed system exceeded 30 W/m^2. At present, no studies on optimising linear strategy setting points to control motorized internal curtains are available for the climate under consideration. Nevertheless, in an environment based criterion to fully use the regulation range it seems reasonable to start the linear regulation at the first appearance of glare, and reach the complete closure of the curtain when the direct sunlight passing through the glass reaches high values, following the scheme proposed for the EC environmental criterion. This means choosing I_{wset1} in the range 20 W/m^2 to 40 W/m^2 and I_{wset2} in the range 100 W/m^2 to 200 W/m^2 of direct radiation crossing the glass system. Passing from direct to total radiation, it can be considered a starting value of regulation 45 W/m^2 of total radiation entering into the environment, following the same approach used for EC windows. Instead I_{wset2} can be chosen by fixing the percentage of the yearly working time in which the system is in a fully shaded situation (%Hcol), that seems to be acceptable when it is in the range of 10-20% ((Karlsson et al., 2000) to avoid excessive seclusion feelings. Then, I_{wset2} values can be individuated on the base of the cumulative frequency levels I_{wx} of the impinging vertical solar radiations that have been exceeded for a prefixed time x of the yearly working hours (that are 4380 h):

$$I_{wx} \cdot \tau_{vnh} = I_{wset2}$$

In Table 3, the values of solar radiation exceeded for 10% (I_{w10}), and 20% (I_{w20}), with the maximum vertical irradiations (I_{wmax}), are reported for different orientations and cities. Then, if we assume Iwx equal to Iw10 or I_{w20}, the curtains are closed respectively for 438 or 876 hours in the year. Percentages lower than 10% increase the range of regulation, but can produce a lost in glare control for the lowest sun irradiance. Window systems with small transmittances in their colored state should be regulated with higher I_{wset2}, to extend glare control to the highest sun radiations. Nevertheless the optimal relationship between the solar transmittance of windows and the choice of I_{wset2} should be identified by experimental studies on occupants' comfort and it is not considered in this discussion.

While the definition of I_{wset1} is very similar for the two considered systems, I_{wset2} is quite different. With this definition, we have sufficiently higher values of I_{wset2} than in the EC cases. But here we have still to consider the shading action of the curtain and, more, that the EC systems are generally sensibly darker than traditional window systems.

In this paper, only a traditional window system has been considered (REF). So, we have only one I_{wset2} value, that is up to 470 W/m^2.

RESULTS

The reported results are: a) the yearly energy consumption, expressed as the difference between the studied situations and a reference case (ΔTep), b) the cooling/heating loads and the electric light consumption (expressed in ΔGJ), c) the percentage of the yearly working time in which the EC device is in its colored state, or the windows are fully shaded, (%Hcol), or in linear regulation (%Hlin). The reference case is represented by the system REF without sun shading devices.

Yearly energy total requirements take into account both the cooling/heating loads and the electric light consumptions and are converted to primary energy source, expressed as equivalent tons (10^3 kg) of petroleum (tep), on the base of the following conversion coefficients: a) Electric cooling system Coefficient of Performance COP=3.2, b) Heating system efficiency η=0.8, c) Artificial lighting system Ballast Factor BF=0.8, with constant efficacy, d) Electric Energy Conversion EEC= 2.5x10-^{4} tep/kWh.

The very small quantity of energy required to switch the EC devices, about 0.08 kWh per m^2 of window every year (Yoong and Tulloch, 2000), is not considered.

EC windows results are here presented only for the 3 dimming zone solution, as previous papers show the ineffectiveness of these solutions with less flexible artificial light control algorithms.

Table 4, 5, and 6 show all the results concerning the energetic aspects, and the information on %Hcol and %Hlin. In the tables, EC O means EC with on/off strategy, EC L states for EC with linear strategy, while D concerns the dimming action: D0 states for on/off, D1 and D3 for one or three zones dimming. Only results related to the comfort based approach are here showed.

Almost all the analysed solutions show, respect to the reference case, a good performance, that reaches its lowest value in energy saving for REF2 also if the visual aspects %Hcol and %Hlin are not greatly penalized. The higher reduction of energy consumption is in RM East, REF3, and it is associated to a very high value of %Hlin. This fact means that it represents the best solution among the ones here considered, as it assures the best performances in terms of both energy savings and visual comfort, as the linear control should assure a good control of glare and seclusion aspects. Considering the South orientation, it is interesting to note that energy savings increase going towards South (from BZ to CT) and that the EC systems show an improvement of their performances higher than REF systems. From an energy efficiency point of view, in fact, we have respectively for BZ, RM, CT an improvement near to 0.30, 0.35, 0.34 for the best system REF3, and of about 0.16 (EC1 O), 0.22 and 0.24 for EC1. From a visual comfort point of view, we have the same tendency, passing from 6% – 69% (%Hcol – %Hlin) of BZ, 6% – 71% of RM and 7% – 71% of CT, for REF systems, to the couples 10% – 60%, 11% – 62%, 9% – 64% for EC1 L. Values are really close, and this is an encouraging fact, considering that EC is still a new technology. While we cannot consider EC2 a good solution, as it always presents low energy savings, being the low percentages of linear control and close position due to the darkness of the system also in the bleached state.

Linear is quite always better than on/off regulation, as proved by all these results. This is true specifically for the EC solutions, but also for REF systems, that by this way could improve their behaviour of sun control from both thermal and visual viewpoints. The introduction of a linear control in fact also for the traditional window systems should improve the actual situation, waiting for new and more efficient technologies.

CONCLUSIONS

The aim of the paper was basically to introduce the possibilities of linear regulation to control daylight and solar radiation, coupled with new and traditional window systems. To evaluate the performances of the several situations studied, two basic aspects have been considered: energy efficiency and visual comfort.

The introduction of a linear control also for the traditional window systems should improve the actual situation, waiting for new and more efficient technologies.

The differences between the visual performances of REF and EC systems are due to the different characteristics of the systems, as well as to the different setting parameters for daylight control. Although we developed an algorithm working on the same conditions for the two systems, the integration achieved with an EC system is really difficult to reach with a traditional window system. This means that we have a different way of treating the radiation impinging on the window surface, and so inside the controlled environment we have lighting conditions generally different for the same external climatic conditions. What is lacking, so far, is a thorough analysis of daylight control in terms of control setting parameters. We used the same values of external parameters, calculated basing on the behaviour of the EC system, to control the radiation, but we obviously obtain a different radiation entering the environment. More, the yearly cumulative daylight illuminance distribution is still to be evaluated and compared to obtain a complete and integrated analysis of all these systems. This could be used as a tool to select the best window system when cumulative values are fixed before as a design goal. Last, a lot of innovative systems are still to be studied with an integrated thermal – visual analysis to allow a comparison and the development of new integrated design tools. The final aim of all this research (of which this paper is only an intermediate step) is to define some guidelines for the selection of the proper window system, also considering innovative windows, for each specific situation. A design methodology that should be based on two charts, one developed optimizing the energy performance, the other the visual comfort, the integration of whom should lead to a Window System Integrated Sustainable Design Optimal Methodology (WISDOM), capable of considering complete systems consisting of window, shading device and the presence of artificial light.

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NOMENCLATURE

τ: transmittance

I [W/m^2]: solar irradiance

U [W/(m^2 K)]: thermal transmittance

lin: linear control strategy

on/off: on/off control strategy

REF: reference clear double glazed system

EC: electrochromic window

Indices

1: starting value of linear control

2: final value of linear control

n: normal

h: hemispherical

w: referred to window, vertical

v: visible

s: solar

set: setting value

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Table 3.
Levels of vertical solar radiation.

[W/m^2]	***BZ***			***RM***			***CT***		
	S	E/W	N	S	E/W	N	S	E/W	N
I_{wmax}	987	1002	372	899	998	441	980	1073	470
I_{w10}	598	425	180	610	600	190	610	640	193
I_{w20}	495	395	157	500	435	169	485	485	170
I_{w10*}	600	450	200	600	600	200	600	650	200

Table 4.
Energetic and Visual Aspects: BZ South.

Configuration			***C [GJ]***	***H [GJ]***	***L [GJ]***	***T [Tep]***	***%Hcol***	***%Hlin***
BZ South	D0	REF1	-9,14	1,06	0,51	-0,1188	5,75	69,09
		REF2	-8,63	1,00	1,11	-0,0582		
		REF3	-9,23	1,07	0,40	-0,1305		
	D1	REF1	-10,19	1,52	-1,13	-0,2696		
		REF2	-10,08	1,50	-0,99	-0,2554		
		REF3	-10,19	1,52	-1,13	-0,2694		
	D3	REF1	-10,36	1,64	-1,45	-0,2971		
		REF2	-10,30	1,63	-1,38	-0,2899		
		REF3	-10,35	1,65	-1,44	-0,2956		
	D3	EC1 L	-10,38	1,31	0,33	-0,1540	9,90	60,00
		EC1 O	-10,30	1,26	0,30	-0,1559	29,70	---
		EC2 L	-9,27	0,32	2,29	0,0089	0,90	46,30
		EC2 O	-9,19	0,33	2,39	0,0194	19,40	---

Table 5.
Energetic and Visual Aspects: CT South.

Configuration			***C [GJ]***	***H [GJ]***	***L [GJ]***	***T [Tep]***	***%Hcol***	***%Hlin***
CT South	D0	REF1	-10,47	0,15	0,29	-0,1974	6,83	70,84
		REF2	-10,17	0,14	0,63	-0,1620		
		REF3	-10,47	0,15	0,29	-0,1976		
	D1	REF1	-11,53	0,21	-0,88	-0,3204		
		REF2	-11,48	0,20	-0,82	-0,3138		
		REF3	-11,53	0,21	-0,88	-0,3203		
	D3	REF1	-11,73	0,23	-1,10	-0,3435		
		REF2	-11,71	0,22	-1,07	-0,3404		
		REF3	-11,73	0,23	-1,10	-0,3433		
	D3	EC1 L	-12,04	0,15	0,23	-0,2369	9,40	64,20
		EC1 O	-11,91	0,14	0,25	-0,2327	31,60	---
		EC2 L	-10,84	0,06	2,34	-0,0307	1,60	51,30
		EC2 O	-10,82	0,06	2,37	-0,0277	17,90	---

Table 6.
Energetic and Visual Aspects: RM.

Configuration			***C [GJ]***	***H [GJ]***	***L [GJ]***	***T [Tep]***	***%Hcol***	***%Hlin***
RM South	D0	REF1	-11,14	0,46	0,40	-0,1917	6,14	70,71
		REF2	-10,52	0,38	0,93	-0,1354		
		REF3	-11,21	0,46	0,32	-0,2006		
	D1	REF1	-12,20	0,62	-0,90	-0,3228		
		REF2	-12,11	0,60	-0,81	-0,3130		
		REF3	-12,19	0,61	-0,90	-0,3230		
	D3	REF1	-12,38	0,67	-1,15	-0,3463		
		REF2	-12,34	0,66	-1,10	-0,3416		
		REF3	-12,37	0,66	-1,14	-0,3459		
	D3	EC1 L	-12,52	0,42	0,39	-0,2237	11,00	61,70
		EC1 O	-12,43	0,42	0,39	-0,2217	34,00	---
		EC2 L	-11,19	0,12	2,44	-0,0267	0,50	53,30
		EC2 O	-11,11	0,12	2,53	-0,0172	20,40	---
RM North	D0	REF1	-1,28	0,06	2,75	0,2130	1,12	67,72
		REF2	-1,28	0,06	2,75	0,2130		
		REF3	-1,28	0,06	2,75	0,2130		
	D1	REF1	-5,41	0,33	-1,99	-0,2788		
		REF2	-5,41	0,33	-1,98	-0,2786		
		REF3	-5,41	0,33	-1,99	-0,2791		
	D3	REF1	-6,23	0,48	-3,03	-0,3825		
		REF2	-6,23	0,48	-3,03	-0,3823		
		REF3	-6,23	0,48	-3,03	-0,3829		
	D3	EC1 L	-7,40	0,82	-0,32	-0,1617	6,90	47,60
		EC1 O	-7,34	0,83	-0,26	-0,1551	30,10	---
		EC2 L	-6,00	0,13	0,92	-0,0456	0,50	0,20
		EC2 O	-6,00	0,13	0,92	-0,0456	0,80	---
RM East	D0	REF1	-7,15	0,09	0,79	-0,0843	4,27	65,23
		REF2	-7,13	0,09	0,80	-0,0827		
		REF3	-7,16	0,09	0,77	-0,0859		
	D1	REF1	-10,36	0,20	-2,78	-0,4597		
		REF2	-10,19	0,20	-2,61	-0,4413		
		REF3	-10,61	0,21	-3,04	-0,4873		
	D3	REF1	-11,02	0,24	-3,51	-0,5364		
		REF2	-10,87	0,26	-3,38	-0,5214		
		REF3	-11,29	0,28	-3,83	-0,5683		
	D3	EC1 L	-13,19	0,61	-1,04	-0,3665	6,20	53,40
		EC1 O	-13,41	0,34	-1,01	-0,3680	23,50	---
		EC2 L	-11,73	0,07	0,60	-0,2002	0,00	26,90
		EC2 O	-11,70	0,07	0,70	-0,1911	17,50	---