The effects of the energy transition on the distribution network

Bridging the gap between research and industry

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Background

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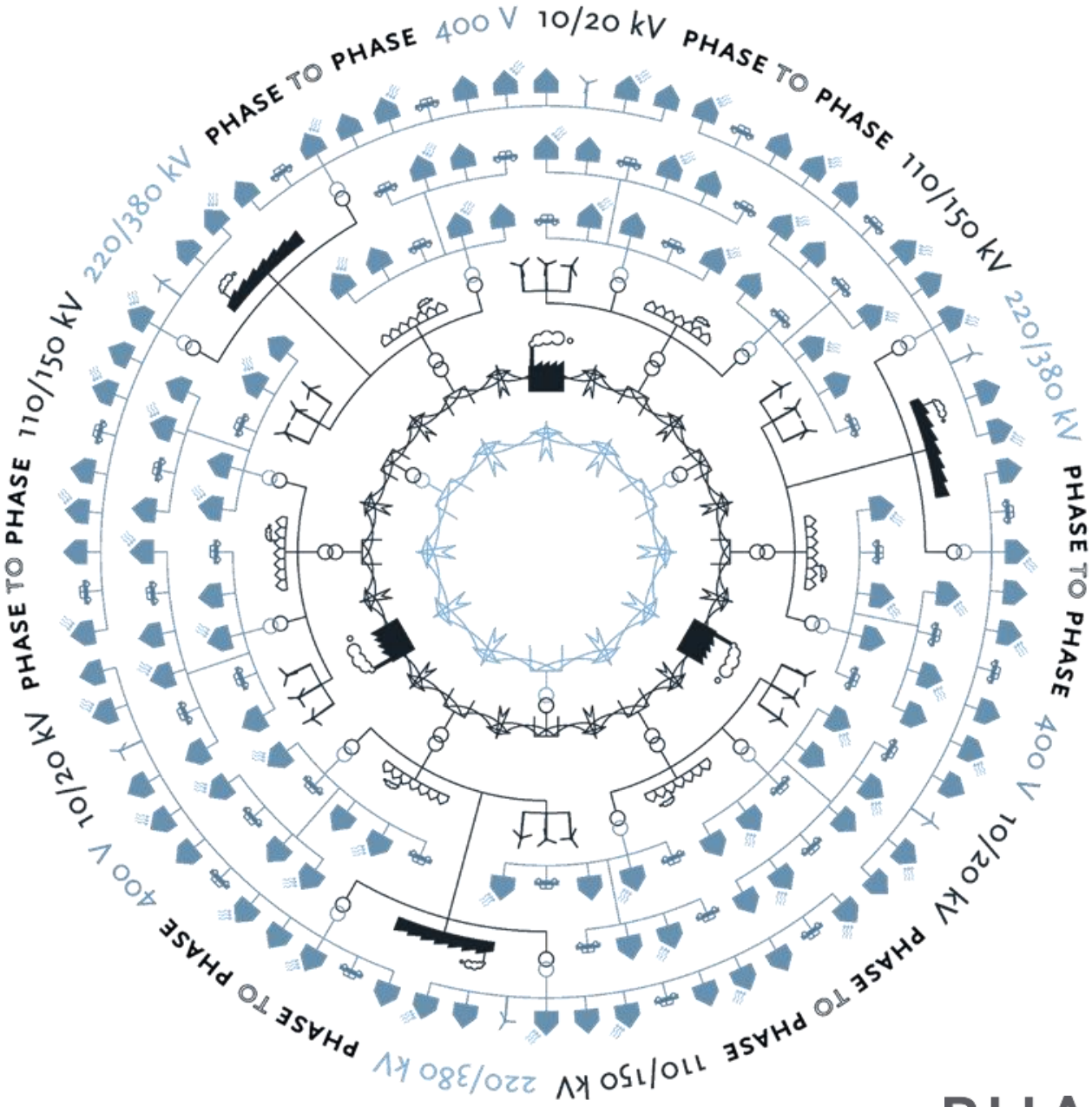
Phase to Phase



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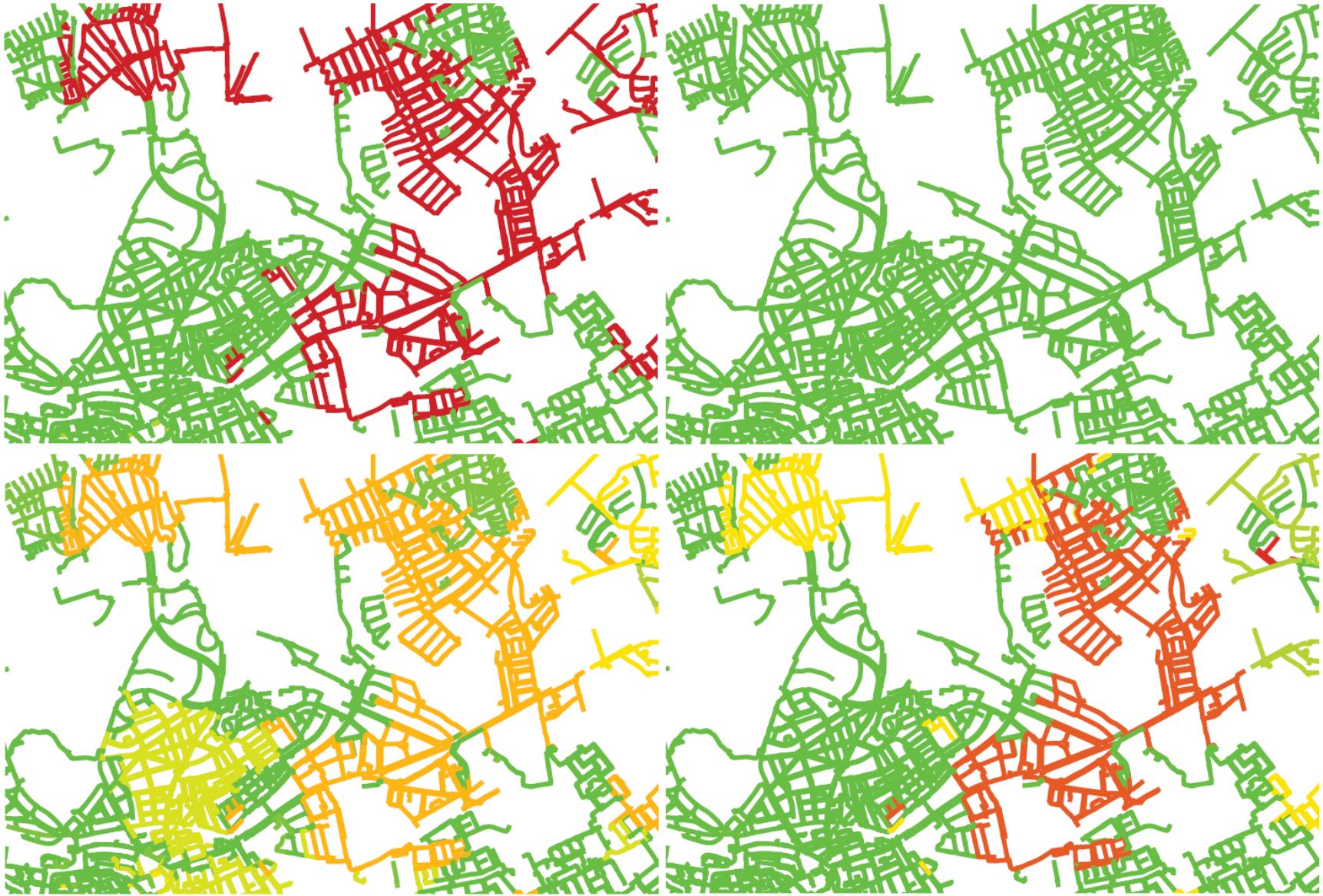

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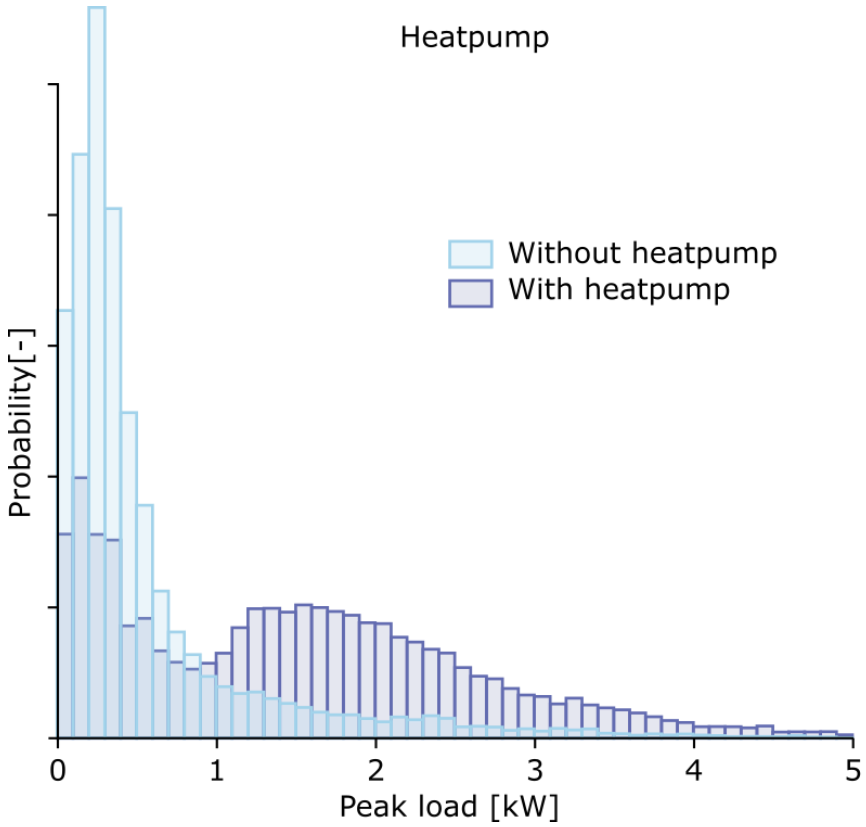
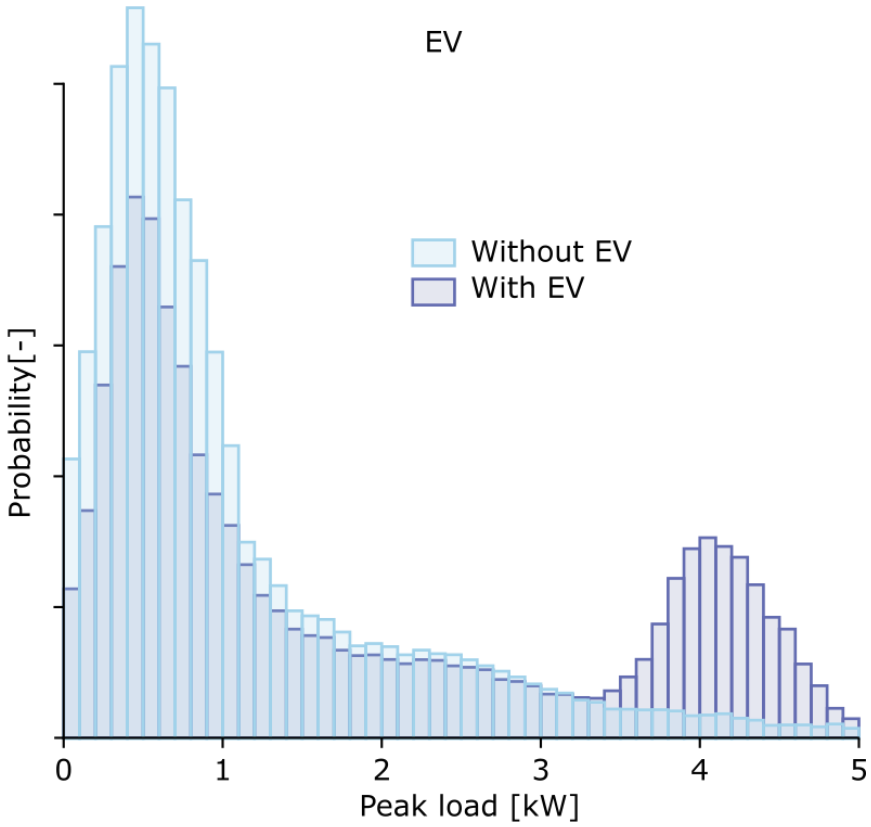
Load modelling

$$S = \alpha V + \beta \sqrt{\frac{V}{n}}$$

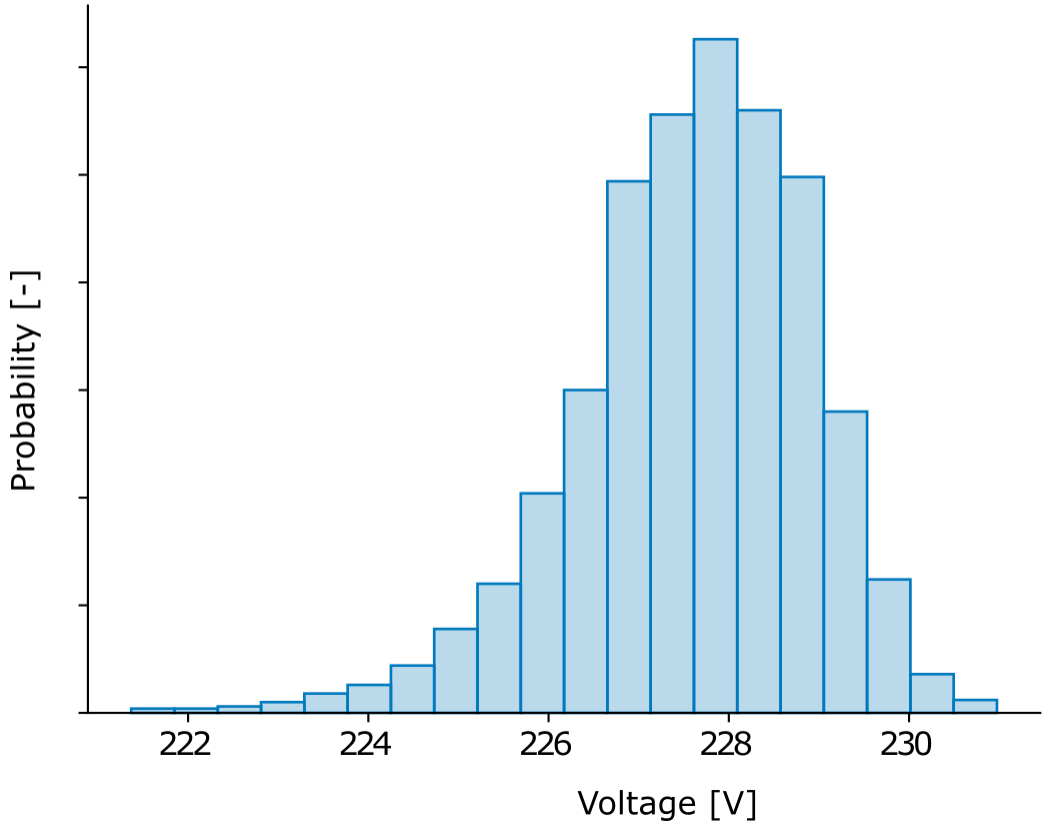
$$\mathrm{P}(S|\omega, \mu, \sigma) = \sum_{i=1}^{n} \omega_i \frac{1}{\sqrt{2\pi\sigma_i^2}} e^{-\frac{(S-\mu_i)^2}{2\sigma_i^2}}$$

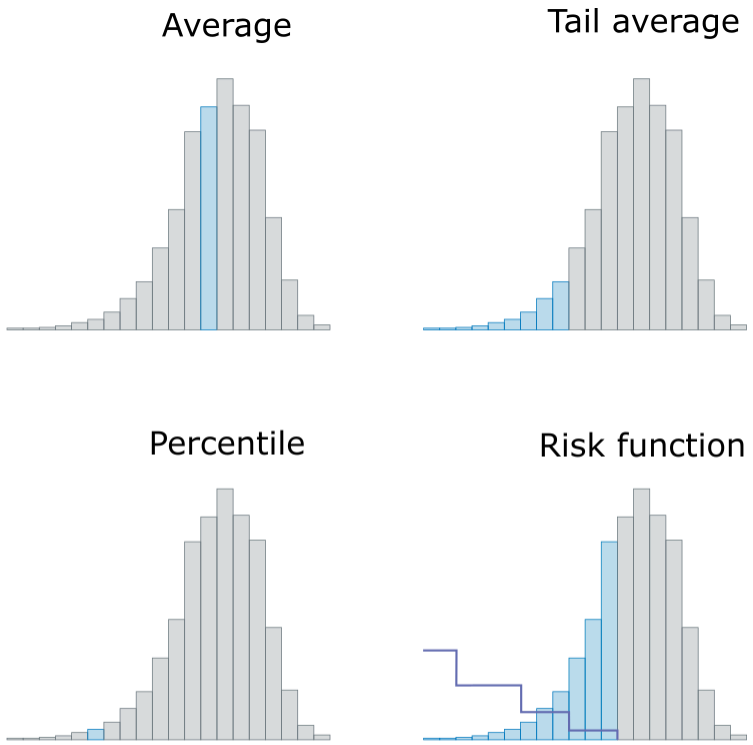
Load modelling



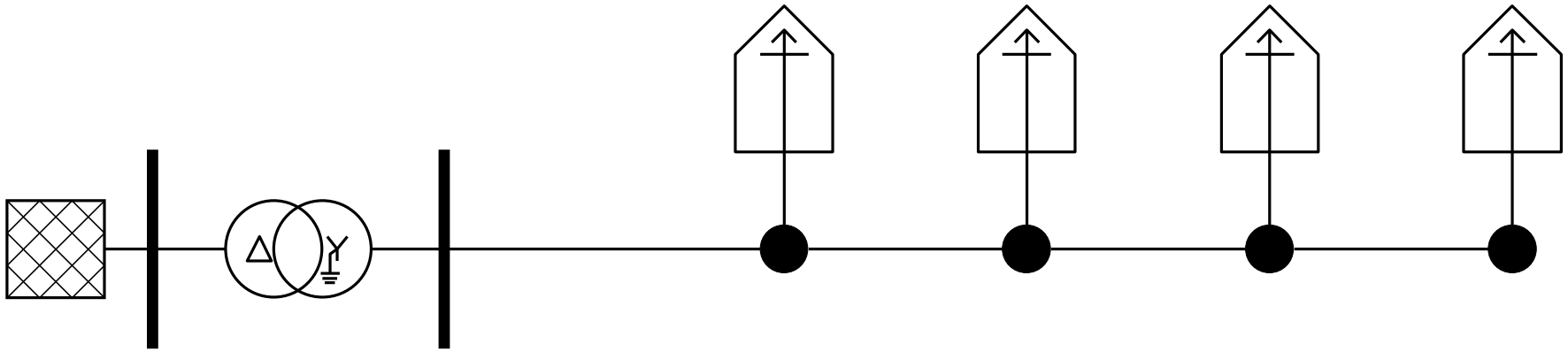


Load modelling

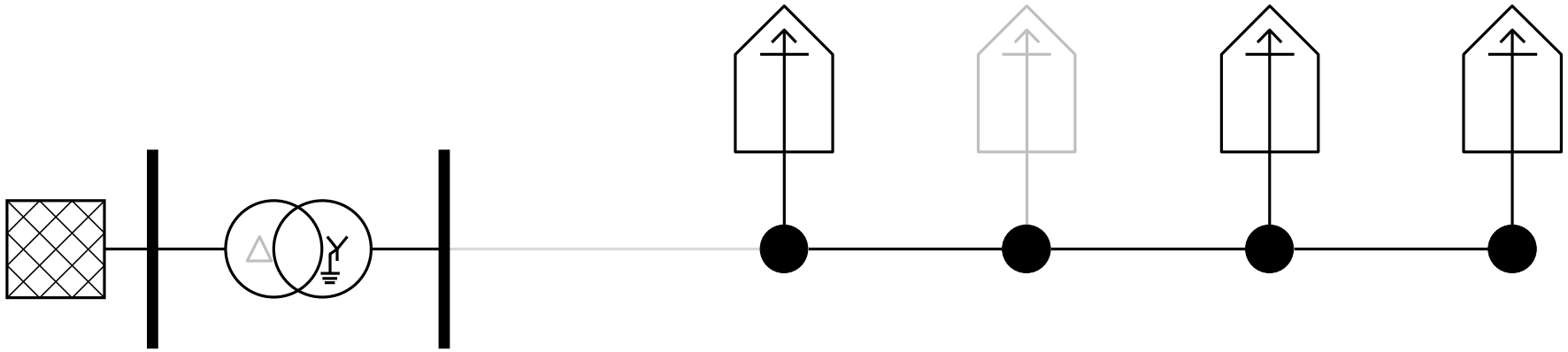




Loadflow



Loadflow



Loadflow

Loadflow

```
function c13tc33 ( A: TCY13; B: TCY33 ) : TCY13;
// comp[1,3] := comp[1,3] x comp[3,3]
var j, k: integer;
c : Tcomplex;
begin
for j := 1 to 3 do
begin
c := zero;
for k := 1 to 3 do c := cpc( c , ctc(A[1,k],B[k,j]) );
c13tc33[1,j] := c;
end;
end;

function c13tc31 ( A: TCY13; B: TCY31 ) : TComplex;
// complex := comp[1,3] x comp[3,1]
var k: integer;
c: Tcomplex;
begin
c := zero;
for k := 1 to 3 do c := cpc( c , ctc(A[1,k],B[k,1]) );
c13tc31 := c;
end;

function ProfielTijdTrapstand(ProfielTijd:TDateTime):integer;
var Error:boolean;
r:Double;
begin
Result:=aTrafo.Trapstand;
if ProfielTijd>0 then
if Assigned(aTrafo.TrapstandProfiel) then
begin
r:=ProfielTijdWaarde(aTrafo.TrapstandProfiel,ProfielTijd,Error);
if not Error then Result:=ROUND(r);
end;
end;

var i, j: integer;
wortel3: double;
a, a2, a3: Tcomplex;
n: double; // spoeloverzetverhouding
nplusabs: double; // |n+|
n0: double; // n0
nplus, nmin: Tcomplex; // n+, n-
factor: double; // vermenigvuldigingsfactor
om n uit |n+| te bepalen
z, r, x: double; // langsimpedantie normale
systeem
y, g, b: double; // dwarsadmittantie normale
systeem
R0, X0: double; // homopolaire weerstand en
reactantie
Y0: Tcomplex; // homopolaire admittantie
a11, a12, a21, a22, a31, a32, b11: integer; // parameters voor de
transformatortypen
Y0la, Y0dw: Tcomplex; // modelimpedanties homopolair
Y1la, Y1dw: Tcomplex; // modelimpedanties normaal
Y2la, Y2dw: Tcomplex; // modelimpedanties invers
Y012: TCY33; //
componentdeeladmittantiematrix
AA, AAinv: TCY33; // [A] en [A]^-1
M11,M12,M21,M22: TCY33; // hulpadmittantiematrices
E:TCY31; // eenheidsvector
aCY31:TCY31;
aCY13:TCY13;
Yne,hulp:TComplex;
Unom1,Unom2:Double;
M22CY99 : T22CY99;

begin
wortel3 := sqrt(3);
a := cexp(cmplx(0,pi*2/3));
a2 := cexp(cmplx(0,pi*4/3));
E[1,1]:=One;
E[2,1]:=One;
E[3,1]:=One;
a3 := cdr(One,wortel3);
for i := 1 to 3 do for j := 1 to 3 do begin AA[i,j] := a3; AAinv[i,j] := a3;
end;
AA[2,2] := cdr(a2,wortel3); AA[2,3] := cdr(a,wortel3);
AA[3,2] := cdr(a,wortel3); AA[3,3] := cdr(a2,wortel3);
AAinv[2,2] := cdr(a,wortel3); AAinv[2,3] := cdr(a2,wortel3);
AAinv[3,2] := cdr(a2,wortel3); AAinv[3,3] := cdr(a,wortel3);

// Overzetverhouding:

TrafoUnomsBijTapstand(aTrafo,ProfielTijdTrapstand(PatroonTijd),Unom1,Unom2)
;
nplusabs := Unom1 / Unom2; //
|n+| = Unom1/Unom2

// Langsadmittanties:
z := ( aTrafo.TrafoType.Uk / 100 ) * SQR( aTrafo.TrafoType.Unom2 ) /
aTrafo.TrafoType.Snom;
r := ( aTrafo.TrafoType.Pk / 1000 ) * SQR( aTrafo.TrafoType.Unom2 ) / SQR(
aTrafo.TrafoType.Snom );
x := SQRT( SQR( z ) - SQR( r ) ); if IsNan(x) or
(x<1e-6) then x:=1e-6; //testje toegevoegd op 30-9-2013 en
IsNan op 28-8-2017
r := r;
x := x;
Y1la := rdc( 1 , cmplx( r, x ) );
//Y1la := cmplx(-Ylink,-Ylink); // t.b.v. test voor ideale trafo
Y2la := Y1la;
X0 := SQRT( SQR(aTrafo.TrafoType.Z0) - SQR(aTrafo.TrafoType.R0) );
R0 := aTrafo.TrafoType.R0;
if ( aTrafo.TrafoType.Z0 = 0 ) then
// Y0 := cmplx(0,1e4) // Vision methode beveiliging van Z0=0
Y0 := cdr( Y1la , 0.95 ) // Gaia methode beveiliging van Z0=0
else
Y0 := rdc( 1 , cmplx( R0, X0 ) );
//Y0 := cdr(Y1la,3); // t.b.v. test voor ideale trafo
//Y0 := Y1la; // t.b.v. test voor ideale trafo
//Y0 := zero; // t.b.v. test voor ideale trafo

// Dwarsadmittanties:
g := aTrafo.TrafoType.Pnul / ( 1000 * SQR(aTrafo.TrafoType.Unom2) ); //
dwarsgeleiding voor driefasig (nullast)ijzerverlies
y := aTrafo.TrafoType.Inul / ( 1000 * aTrafo.TrafoType.Unom2/SQRT(3) ); //
dwarsadmittantie voor eenfasige nullaststroom
if SQR(y)-SQR(g)>0 then b := -SQRT( SQR(y) - SQR(g) )
else b := 0;
Y1dw := cmplx( g, b );

//Y1dw := zero; // t.b.v. test voor ideale trafo
Y2dw := Y1dw;
Y0dw := Zero;

// Toepassing tabellen schakeltypen; default = Dd
factor := 1; n := nplusabs;
a11 := 0; a12 := 0; a21 := 0; a22 := 0; a31 := 0; a32 := 0; b11 := 3;
Y0la := zero; Y0dw := zero;
n0 := 1e8;
if aTrafo.TrafoType.Klok = 0 then nplus := cmplx(n,0) else nplus :=
cmplx(-n,0);
if aTrafo.TrafoType.Schak1 = sD then
begin
if aTrafo.TrafoType.Schak2 in [sY,sYN] then
begin // Dy5 en Dy11
factor := wortel3; n := factor * nplusabs;
a22 := 1; a32 := 1;
Y0la := Y0;
b11 := 1;
if aTrafo.TrafoType.Klok = 5 then nplus := neg(rdc(n,cmc(one,a2))) else
nplus := (rdc(n,cmc(one,a2)));
end;
if aTrafo.TrafoType.Schak2 in [sZ,sZN] then
begin // Dz0 en Dz6
factor := 3/2; n := factor * nplusabs;
a22 := 1; a32 := 1;
Y0dw := Y0;
b11 := 1;
if aTrafo.TrafoType.Klok = 0 then nplus := cmplx(2*n/3,0) else nplus :=
cmplx(-2*n/3,0);
end;
end;
if aTrafo.TrafoType.Schak1 in [sY,sYN] then
begin
if aTrafo.TrafoType.Schak2 = sD then
begin // Yd5 en Yd11
factor := 1/wortel3; n := factor * nplusabs;
a11 := 1; a31 := 1;
Y0la := Y0;
// if aTrafo.TrafoType.Klok = 5 then n0 := n else n0 := -n;
// Conform voorstel R_advies vgl 4.31
if aTrafo.TrafoType.Klok = 5 then n0 := 1 else n0 := -1;
// Conform Vision
if aTrafo.TrafoType.Klok = 5 then nplus := neg(rdc(3*n,cmc(one,a2)))
else nplus := (rdc(3*n,cmc(one,a2)));
end;
if aTrafo.TrafoType.Schak2 in [sY,sYN] then
begin // Yy0 en Yy6
a11 := 1; a12 := 1; a21 := 1; a22 := 1; a31 := 1; a32 := 1;
Y0la := cdr(Y0,2);
Y0dw := cdr(Y0,2);
if aTrafo.TrafoType.Klok = 0 then n0 := n else n0 := -n;
b11 := 1;
if aTrafo.TrafoType.Klok = 0 then nplus := cmplx(n,0) else nplus :=
cmplx(-n,0);
end;
if aTrafo.TrafoType.Schak2 in [sZ,sZN] then
```

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